SYSTEMS THINKING

Complete, easy-language study guide based on ST 1, ST 2 and ST 3

What this guide contains

Plain-language explanations • drawn diagrams • worked examples • common mistakes • 80 practice questions • diagram-drawing questions

How to study: Read one topic, redraw its diagram without looking, explain it aloud in your own words, then answer the 10 practice questions. If you cannot explain an arrow or loop, revisit that section.

Source note: The three uploaded lecture PDFs are slide-based and some small labels were not readable. This guide follows the clearly identifiable topics, terminology and examples in the slides; it does not claim to reproduce unreadable labels exactly.

1. The big idea: What is Systems Thinking?

A system is a group of connected parts that interact and together produce a pattern or result. Examples include a school, a business, a road network, a fish population, or the climate.

Systems thinking means looking at the whole connected situation—not only one event or one person. You ask: What influences what? What happens later? Does the result feed back and change the original situation?

Example: A road is congested. An event-only view says, “Build another lane.” A systems view also asks whether the wider road makes driving more attractive, brings more trips, and eventually creates congestion again.

Why do we need it?

• Problems are connected and change over time.
• A quick fix can create side effects.
• Policies sometimes fail or produce the opposite of what was intended.
• People often see only a small part of the system and miss feedback or delays.

Structure creates behaviour

The way a system is arranged—its physical resources, information, decision rules, and mental models—helps generate its behaviour. If the structure stays the same, changing one person may not change the repeated pattern.

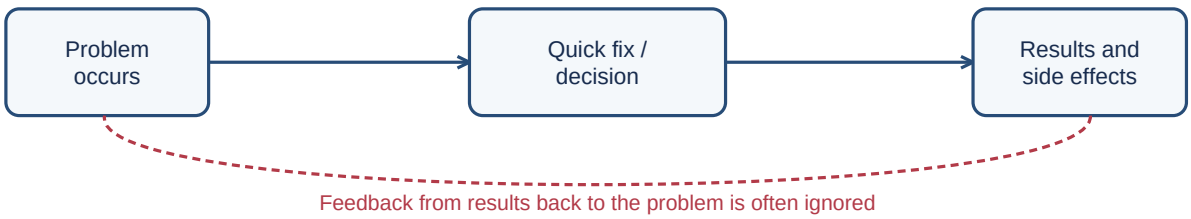
Mental model: an internal belief or picture of how the world works. For example, “Every delay is caused by lazy workers.” That belief may lead a manager to punish staff while ignoring a broken process or unrealistic workload.

Fundamental attribution error: the tendency to blame individuals’ character while underestimating the situation or system around them. The slides describe this as often leading to a low-leverage response.

Policy resistance

Policy resistance occurs when a well-intended action is weakened, avoided, or reversed by the system’s response. A policy can change behaviour in ways that were not anticipated. The slides use birth-rate policy and wage/price controls as examples of policy resistance.

Diagram: event-only thinking versus feedback thinking



Remember: systems thinking does not mean ignoring individual responsibility. It means checking both people and the structures, incentives, information, and delays that shape their choices.

Topic 1 — 10 practice questions

1. Define a system and give two examples.

2. Explain systems thinking in your own words.

3. State three reasons why systems thinking is useful.

4. What is a mental model? Give one example.

5. Explain the fundamental attribution error.

6. What is policy resistance?

7. Why can a quick fix fail to solve a recurring problem?

8. Compare an event-oriented view with a feedback-oriented view of traffic congestion.

9. Diagram question: Draw a simple event → decision → result chain and show where feedback could be added.

10. Application question: A school's exam results fall. List three system factors you would investigate before blaming students.

2. Event-oriented thinking and feedback thinking

An **event-oriented view** focuses on what just happened and chooses a fix for that event. The problem is treated as if it arrived from outside the system. This can encourage repeated, separate fixes.

Examples in the lecture slides include responding to traffic congestion by deploying more officers, opening more lanes, or changing infrastructure. These actions may help in the short term, but the system's response may be ignored.

A **feedback view** recognises circular causality: decisions change the environment, the environment changes later decisions, and those decisions create further effects. The solution is one part of a larger web of interactions.

A simple feedback chain



Example links: more spend → more awareness → more sales (simplified)

In the simplified example, marketing spend may increase awareness, which may increase sales. If sales generate a larger budget for marketing, the effect can loop back and reinforce the initial change. Real systems may also contain limits, delays, costs, and competing feedback loops.

Why people fail to learn from repeated problems

The slides highlight several reasons: people focus on short-term decisions; feedback arrives late; managers may be rewarded before the negative consequences appear; and people may blame outside factors rather than recognising their own system's contribution. Mental models can make people notice only evidence that fits their existing explanation.

Topic 2 — 10 practice questions

1. What is event-oriented thinking?

2. What does circular causality mean?

3. Give one benefit and one limitation of a quick fix.

4. Explain why time delays can stop managers learning from their decisions.

5. Why might a manager believe a policy worked even when it caused later problems?

6. Describe how a road expansion might affect travel behaviour as well as road capacity.

7. How can a narrow mental model make a recurring problem harder to solve?

8. Explain the difference between a linear chain and a feedback loop.

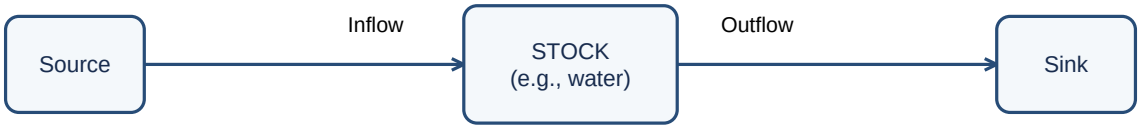
9. Diagram question: Draw a feedback loop for traffic congestion that includes road capacity, attractiveness of driving, number of trips, and congestion. Add + or – signs where appropriate and explain each.

10. Application question: A company repeatedly hires extra staff to fix late orders, but delays return. Compare an event-only explanation with a systems explanation.

3. Stocks and flows

A **stock** is an amount that has accumulated. It is measured at a point in time. Examples: water in a tank, fish in a lake, cash in a bank account, inventory at a shop, or the number of people in a population.

A **flow** is a rate that changes a stock over time. An inflow adds to a stock; an outflow removes from it. Examples: water entering/leaving a tank, births/deaths in a population, or cars produced/sold.



Stock changes by inflow minus outflow

Core rule from the slides: rate of change of stock = inflow – outflow. If inflow is greater than outflow, the stock rises. If outflow is greater than inflow, it falls. If they are equal, the stock stays constant.

Worked example: A shop begins with 100 bicycles in inventory. It receives 30 bicycles during a week and sells 25. End inventory = 100 + 30 – 25 = 105 bicycles. The stock is inventory; deliveries and sales are flows.

Important distinction: a stock is not the same as a flow. “Fish in the lake” is a stock; “new fish per year” and “fish deaths per year” are flows. Flow rates must use units that include time, such as litres per minute or cars per month.

Natural fishery example

The lecture slides show fish stock affected by new fish per year, net regeneration, fish density, and maximum fishery size. The number of fish is a stock. Births and losses are flows. Population can grow when births exceed losses, but density and environmental limits affect how the system behaves.

Topic 3 — 10 practice questions

1. Define a stock and give three examples.

2. Define a flow and give three examples.

3. State the stock-change equation.

4. A tank contains 500 litres. Inflow is 12 L/min and outflow is 9 L/min. What happens to the stock each minute?

5. A shop has 240 items, receives 65, and sells 80. Calculate ending inventory.

6. In a fish population, identify one stock and two flows.

7. Explain why “fish per year” is a flow rather than a stock.

8. What happens to a stock when inflow equals outflow?

9. Diagram question: Draw a stock-and-flow diagram for a bank account with deposits and withdrawals. Label the stock and both flows.

10. Diagram/application question: Draw a fish stock with births entering and deaths leaving. Explain two factors that could affect the rates.

4. Causal Loop Diagrams (CLDs)

A **causal loop diagram** is a map of how variables influence one another. A variable is something that can change and can be measured or described with a clear scale. Arrows show causal influence, not merely that two things happen together.

The arrow sign describes the direction of influence:

Positive (+) link: if the cause increases, the effect becomes higher than it otherwise would have been; if the cause decreases, the effect tends to become lower than it otherwise would have been. The variables move in the same direction.

Negative (–) link: if the cause increases, the effect becomes lower than it otherwise would have been; if the cause decreases, the effect tends to become higher. The variables move in opposite directions.



Example links: more spend → more awareness → more sales (simplified)

Examples: more practice → more skill is usually a positive link. More price → fewer purchases is often a negative link, all else equal. A + sign does not mean “good”; a – sign does not mean “bad.”

Choosing good variable names

The slides recommend nouns or noun phrases, clear meaning and a clear sense of direction. Prefer “number of customers” over “customers increase”; prefer “sales rate” over “selling more.” Avoid verbs or directional labels that bake the answer into the variable. Variables should ideally be measurable.

Causation versus correlation

Two variables can change together because one affects the other, because the second affects the first, or because a third variable affects both. A causal loop diagram should represent a proposed causal explanation—not simply a correlation.

Topic 4 — 10 practice questions

1. What does an arrow mean in a causal loop diagram?

2. What does a + link mean?

3. What does a – link mean?

4. Why do + and – not mean good and bad?

5. Rewrite “customers are buying more” as a suitable variable name.

6. Why should variable names imply a clear sense of direction?

7. Explain the difference between causation and correlation.

8. Give an example of a common cause that could make two variables rise together.

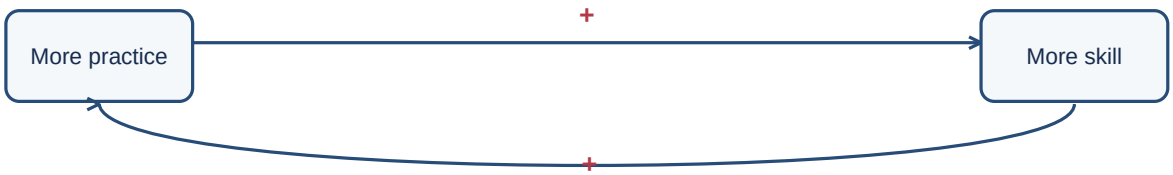
9. Diagram question: Draw a CLD with marketing budget → customer awareness → sales. Label each link and state the assumptions.

10. Diagram question: Draw a negative link between product price and number of units purchased. Explain what the – sign means.

5. Reinforcing and balancing feedback loops

A **feedback loop** exists when a chain of causal links eventually returns to influence its starting variable. A loop helps explain patterns over time.

Reinforcing feedback (R): change creates more change in the same direction. It can produce growth or decline that accelerates. It is sometimes called positive feedback, a snowball effect, or a vicious/virtuous cycle. “Positive” describes the loop’s structure, not whether its outcome is good.



R = reinforcing loop (change amplifies itself)

Example: more practice → more skill → better results → more motivation → more practice. Each step can strengthen the next. Another reinforcing loop can be harmful, such as rumour spreading: more people share it, more people hear it, and more people share it.

Balancing feedback (B): the system responds to a gap or change by pushing toward a target or resisting change. It is also called negative feedback or counteracting feedback. It can stabilise a system, though delays may cause overshoot or oscillation.



B: as temperature approaches target, heating reduces

Example: a thermostat detects that room temperature is below the target, increases heating, and the room warms. As temperature approaches the target, heating is reduced. The loop counteracts the gap.

How to determine loop type

Count the negative (–) links around the closed loop. An even number (including zero) means a reinforcing loop. An odd number means a balancing loop. The slides use R for reinforcing and B for balancing; some notations use C for counteracting.

Topic 5 — 10 practice questions

1. Define a feedback loop.

2. What is a reinforcing loop? Give an example.

3. What is a balancing loop? Give an example.

4. Why can a reinforcing loop create rapid growth?

5. Why is negative feedback often useful?

6. A loop has three positive links. Is it reinforcing or balancing? Explain.

7. A loop has two negative links and one positive link. Is it reinforcing or balancing? Explain.

8. Explain the difference between a vicious cycle and a virtuous cycle.

9. Diagram question: Draw a reinforcing loop for learning/practice/skill and label every link.

10. Diagram question: Draw a balancing thermostat loop with desired temperature, actual temperature, and heating power. Explain how it reduces the gap.

6. Delays and unintended consequences

A **delay** means that a cause and its effect are separated in time. The effect may be real but not visible immediately. In a causal loop diagram, delays are often marked with two short lines across a causal arrow or described in a note.



The effect appears later, not immediately

Example: training takes time to improve productivity. If a manager expects instant results, they may stop the training too soon. Similarly, a road expansion may improve traffic at first, but changes in driving behaviour may take time to appear.

Delays can make people overreact. They may keep increasing an action because the expected result has not appeared yet, then discover that several earlier actions are still working their way through the system. This can contribute to oscillation or overshoot.

A useful systems-thinking habit is to ask: What else will this action change? When will the effects appear? What feedback might return later? Who receives the benefit now, and who experiences the cost later?

Topic 6 — 10 practice questions

1. Define a delay in a system.

2. How can a delay make a policy look successful at first?

3. Explain how delays can lead to overreaction.

4. Give two examples of delayed effects in an organisation or community.

5. What symbol or annotation may be used to show a delay on a causal link?

6. Why might training not immediately change productivity?

7. Explain how delayed feedback could contribute to oscillation.

8. What questions should a decision-maker ask before implementing a policy?

9. Diagram question: Draw a causal link from training to productivity and mark a delay. Explain why the delay matters.

10. Application question: A city adds road capacity, traffic improves, and then congestion returns months later. Give a plausible feedback explanation and identify a delay.

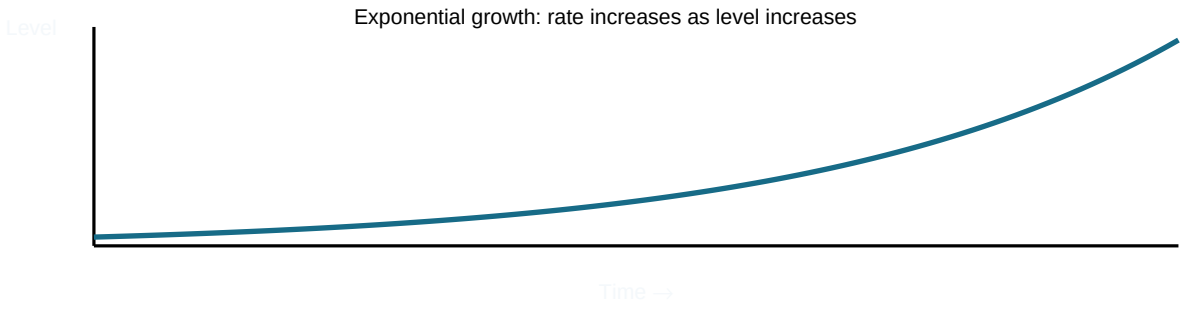
7. Behavior-Over-Time (BOT) graphs and dynamic patterns

A **Behavior-Over-Time graph** shows how one or more variables change through time. Time is usually on the horizontal (x) axis; the variable or level is on the vertical (y) axis. It helps people compare patterns and discuss what forces may have produced them.

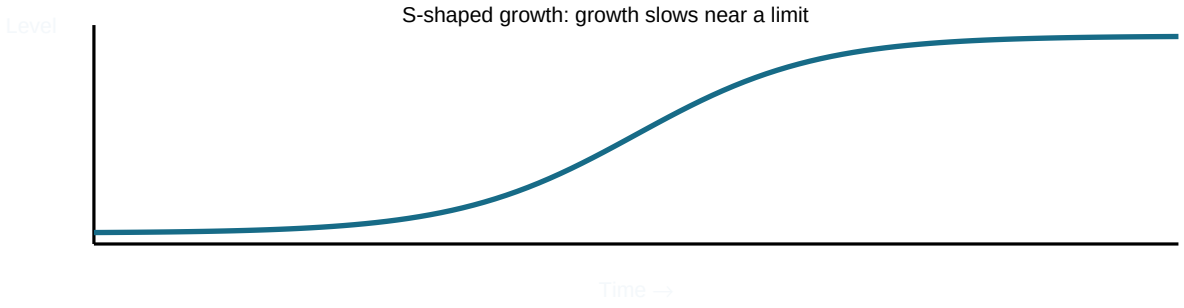
When drawing one, label both axes, state the variable and units, show the time period, and mark important events or policy changes when relevant. A graph shows a pattern; a causal explanation requires additional reasoning.

Common patterns in the lecture slides

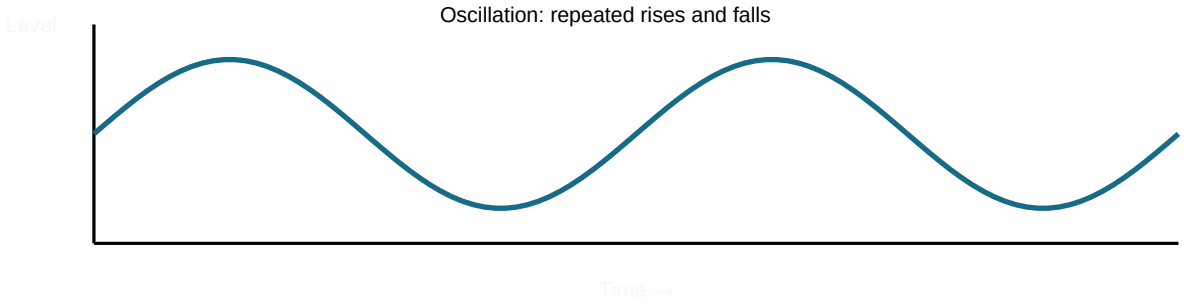
Exponential growth: growth becomes faster as the level gets larger. A reinforcing loop can generate this pattern.



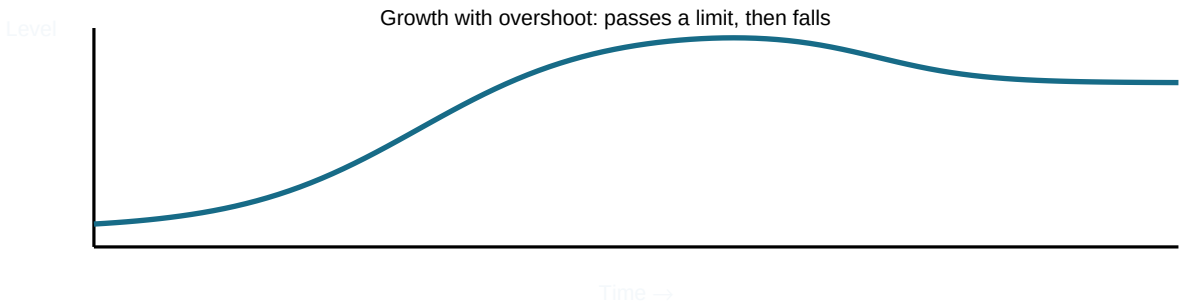
S-shaped growth: growth begins slowly, speeds up, then slows as a limit is approached. The combination of reinforcing growth and balancing constraints can create this pattern.



Oscillation: a variable repeatedly rises and falls. Delays and corrective responses are common contributors.



Growth with overshoot: a level grows beyond a desired or sustainable level before falling or adjusting. The system's response may arrive too late or be too weak at first.



The slides also discuss coupled showers as an example of how the same dynamic structure can appear in different settings. Understanding one system can help explain another that has similar feedback relationships.

Topic 7 — 10 practice questions

1. What is a behavior-over-time graph used for?

2. Which variable usually belongs on the x-axis and which on the y-axis?

3. Describe exponential growth.

4. Describe S-shaped growth and explain why growth eventually slows.

5. What is oscillation? Give one real-life example.

6. What is growth with overshoot?

7. How can delays contribute to overshoot?

8. Why does a BOT graph show a pattern but not automatically prove its cause?

9. Diagram question: Draw an S-shaped growth curve and label the early, rapid-growth, and limiting phases.

10. Diagram question: Draw an oscillating BOT graph. Label axes and describe one possible feedback explanation.

8. Applying systems thinking: roads, markets, fishery and climate

The lecture slides use real-world examples to show that systems thinking is not limited to one subject.

Road congestion: a simplistic view may focus only on road capacity and congestion. A broader view can include travel time, attractiveness of driving, discretionary trips, and decisions to reduce or expand capacity. The result depends on how these factors feed back over time.

Automobile market: inventory at dealerships is a stock. Car production adds to inventory; retail sales remove cars. Inventory levels and market prices may influence production and sales decisions. A delayed response can produce fluctuations or escalation.

Home heating: energy content in a room is affected by furnace heat and heat loss. A thermostat compares room temperature with a target and changes heating. This is a balancing control process.

Fishery: fish stock changes through births and losses. Population density and the maximum size the environment can support affect regeneration. A stock can grow, stabilise, or decline depending on these relationships.

Climate and En-ROADS: the slides show model-based scenarios for net emissions by region and primary energy demand from renewables, coal, oil, and natural gas. These are examples of using models to explore how choices and assumptions may change long-term trends. The graphs are scenarios/comparisons, not guaranteed predictions.

How to analyse a system in an exam

1. State the problem and the pattern over time.
2. Identify key variables as nouns/noun phrases.
3. Identify stocks and flows, if present.
4. Draw causal links and label +/– signs.
5. Find loops; count negative links to classify them.
6. Identify delays and limits.
7. Explain how the loop structure could generate the observed pattern.
8. Suggest a policy and mention possible side effects.

Topic 8 — 10 practice questions

1. In a car dealership, identify the stock, one inflow, and one outflow.

2. Explain the feedback process in a thermostat-controlled heating system.

3. How might a road-capacity policy change the attractiveness of driving?

4. What variables could be included in a systems map of traffic congestion?

5. Explain why fish population is a stock and births/deaths are flows.

6. What role can population density play in a fishery system?

7. What types of energy demand are compared in the En-ROADS-related slides?

8. Why should a model scenario not be treated as a guaranteed prediction?

9. Diagram question: Draw an automobile inventory stock with car production as inflow and retail sales as outflow. Add one possible feedback from inventory to production.

10. Diagram question: Sketch a BOT graph for net emissions that rise, peak, and then fall. Label axes and describe two policy or system factors that could influence the curve.

Quick revision sheet

System: connected parts that interact.
Systems thinking: consider the whole system, feedback, delays and unintended consequences.
Mental model: belief about how the world works.
Policy resistance: the system response weakens or reverses the intended effect.
Stock: accumulated amount.
Flow: rate changing a stock.
Stock change: inflow – outflow.
Positive causal link: cause and effect move in the same direction.
Negative causal link: cause and effect move in opposite directions.
Reinforcing loop (R): amplifies change; even number of negative links.
Balancing loop (B): counteracts change; odd number of negative links.
Delay: effect occurs later than the cause.
BOT graph: variable versus time.
Exponential growth: increasingly rapid growth.
S-shaped growth: growth slows near a limit.
Oscillation: repeated rises and falls.
Overshoot: passes a limit or target before adjusting.

Diagram checklist

When drawing a diagram, include a clear title, readable variable names, arrows in the correct direction, +/– signs on causal links, R/B labels for loops, delay marks where relevant, and axis labels/units for graphs. Add one or two sentences explaining what the diagram means.

Self-test: Can you answer these without notes?

- ■ Explain why a solution can create a new problem.
- ■ Calculate a stock change from inflow and outflow.
- ■ Distinguish a positive link from a reinforcing loop.
- ■ Classify a loop by counting negative links.
- ■ Explain why delay can cause overshoot or oscillation.
- ■ Draw exponential, S-shaped, oscillating and overshoot curves.
- ■ Apply the method to a new example, not only the lecture examples.

End of study guide. Suggested practice method: answer the 80 questions in writing, then redraw each diagram from memory. For diagram questions, marks are often earned for labels and explanation as well as the drawing.