1. Balance in a synthetic water reservoir

This short lesson is synthetic material for EducateAI development validation. It contains no learner or production data. All numerical examples describe an imaginary water reservoir used to teach conservation and feedback.

A reservoir stores water. Its stored volume changes according to inflow minus outflow. If five liters enter every minute and three liters leave every minute, the volume increases by two liters per minute. Starting at ten liters, the reservoir therefore contains twenty liters after five minutes, provided both flow rates remain constant.

A steady state means that the stored volume does not change with time. Inflow equals outflow at steady state. Equal flow rates do not imply an empty reservoir. A reservoir can maintain any permitted volume while equal amounts of water enter and leave.

A useful model names its assumptions. This example assumes that there are no leaks, no evaporation, and enough storage capacity. The calculation applies only while the tank is neither empty nor overflowing. If a hidden leak removes one liter per minute, the same visible flows produce a net increase of one liter per minute instead of two.

A balance equation is an accounting rule, not a control strategy. It predicts how storage changes under specified flows. It does not explain how a valve should respond when a measured volume differs from the desired volume. That question belongs to feedback control, introduced on page two.

Practice: state the balance rule in words, calculate the net flow for five liters in and three liters out, and explain why equal inflow and outflow can coexist with a nonzero stored volume.

2. Negative feedback and a target volume

A feedback controller compares a measured state with a target and changes an input in response to the difference. In this synthetic example, a sensor measures the reservoir volume and an adjustable valve controls the inflow. The target is thirty liters.

Define the error as target volume minus measured volume. A measured volume of twenty-four liters gives a positive error of six liters. A negative-feedback controller responds by increasing inflow. If the volume rises above thirty liters, the error becomes negative and the controller reduces inflow. These responses oppose the original deviation.

Feedback is different from merely observing a sensor. A dashboard can display the measured volume without changing the valve. A closed feedback loop requires a measurement, comparison with a target, a control decision, and an action that influences the measured system.

Feedback does not remove the balance rule from page one. The volume still changes according to inflow minus outflow. The controller changes the inflow, and the balance equation describes the resulting change in storage. A sustained increase in outflow is a disturbance that the controller can try to counteract.

A delay can cause the controller to react to an outdated measurement. Excessively strong changes to the valve can then make the volume alternate above and below the target. This example illustrates why faster or stronger action is not automatically better. An appropriate response depends on the system dynamics and measurement delay.

Review: identify the target, measured state, error and controlled input. Explain the difference between a steady state and a feedback mechanism. Use the thirty-liter target and twenty-four-liter measurement to calculate the error and state the correct direction of the inflow adjustment.