

Facility Dynamics

ENGINEERING

Controlling Analog Processes

Guidelines for Tuning Loops (and Functional Testing)
(Supplemental)

Presented By:

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Just because you CAN do PID doesn't mean you SHOULD do PID

Use proportional only control in situations where high precision is not required or warranted by operational or economic concerns

- Space temperature control
- Limit functions
- Cascaded or highly interactive loops

Add integral action in situations where precision is required

Add integral action in situations where the proportional offset associated with a proportional only loop will result in significant energy waste

Think hard before adding derivative action to a control loop

Before Jumping to What Seems to Be the Obvious Solution ...

Make sure you understand the problem

- Root cause
- Underlying theory
- Underlying technology

Dig a little deeper

- Perform cross checks
- Look at related indicators

General Rules for Tuning Control Loops (And Commissioning in General)

The **Natural Period** will be about 4 times the apparent dead time

Periodic disturbances can significantly impact a loop's ability to control

- Disturbance faster than the **Natural Period** – Control will not help
- Disturbance at or near the **Natural Period** – Resonance

For optimum performance, be just on the stable side of the ultimate gain point

The ultimate gain of the system will change as the characteristics of the system change

- Seasonal effects
- Aging and wear

General Rules for Tuning Control Loops (And Commissioning in General)

Be a little conservative

- HVAC systems see many variations in operating conditions
- First year is critical

Have an idea of what you expect to happen

- What you hope happens
- What you fear could happen

Know and agree about how far you will let things go

- How will you shut down the test in an emergency?
- Who will do what?
- Rehearse failure for critical systems

General Rules for Tuning Control Loops (And Commissioning in General)

Test and set all safety systems first

- Protect equipment
- Protect people

Schedule your testing

- Protect the load served from unnecessary disturbance
- Protect the load served from a crisis

Be available later

Document everything

Proceed slowly

Related Considerations

Non-linearity can influence ease of tuning.

- Input side
 - Thermistors
 - Differential pressure based flow sensors.
- Output side
 - Linkage arrangements
 - Velocity limiting

Loop interactions

- Very common in HVAC

Hysteresis and dead band effects

Auto tuning

- Not a panacea
- Not all algorithms will work the same



Controlling Analog Processes

Tab 12-5 Supplement

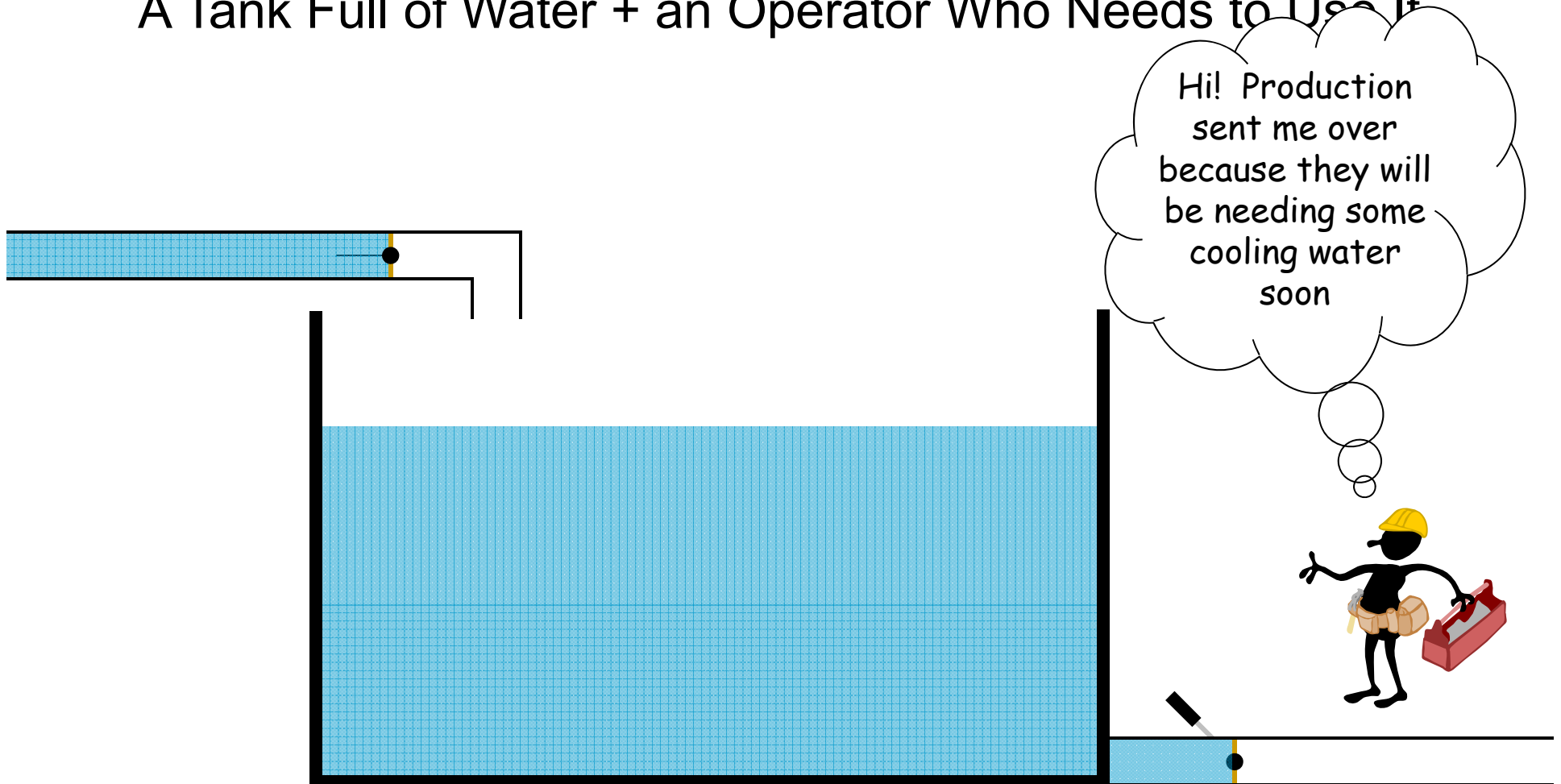
*Proportional Control, PID, and Floating Control, the
Action Packed Video with Surround Sound (or at least
Sound)*

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Facility Dynamics Engineering

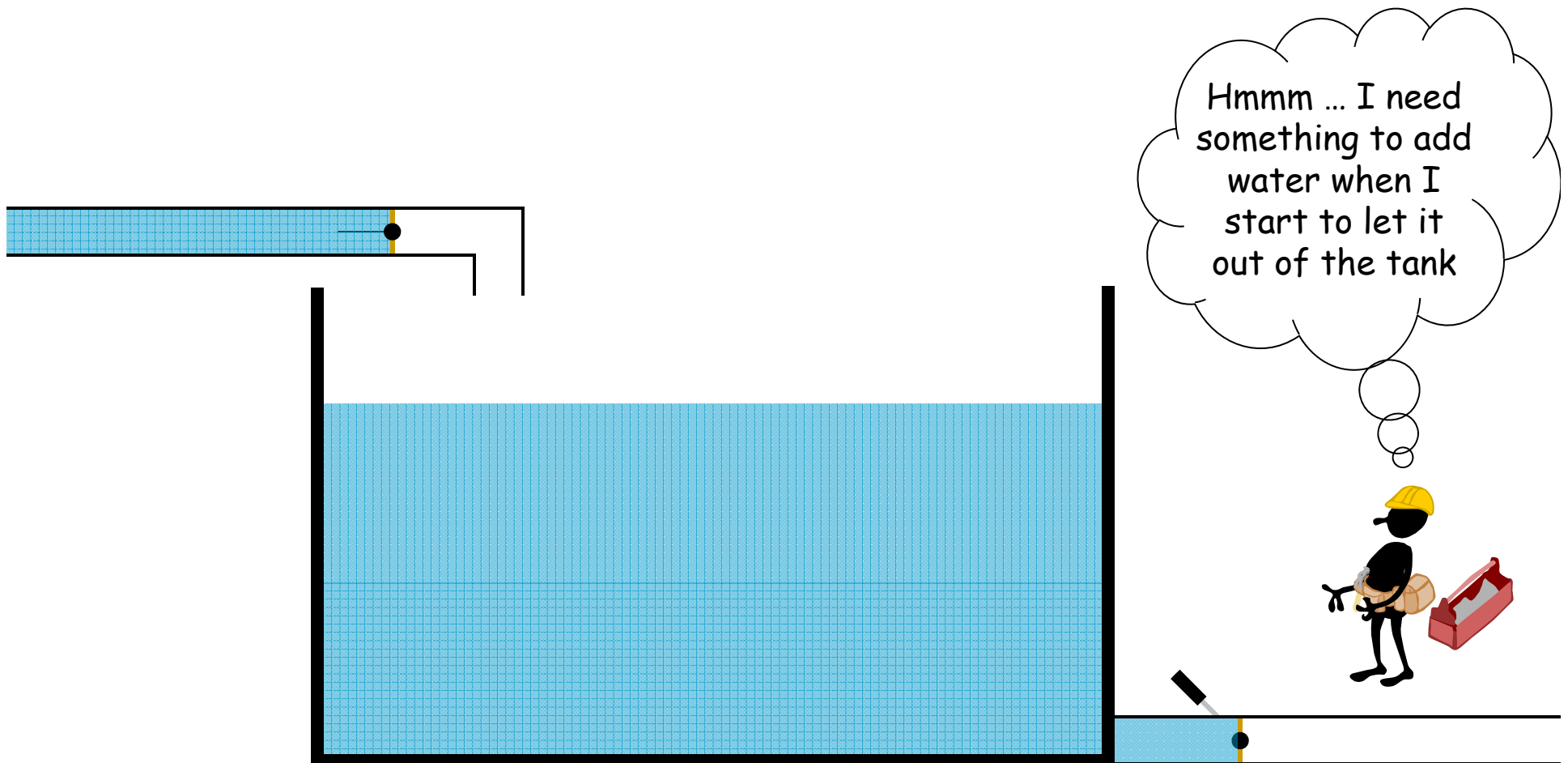


A Simple Control System

A Tank Full of Water + an Operator Who Needs to Use It

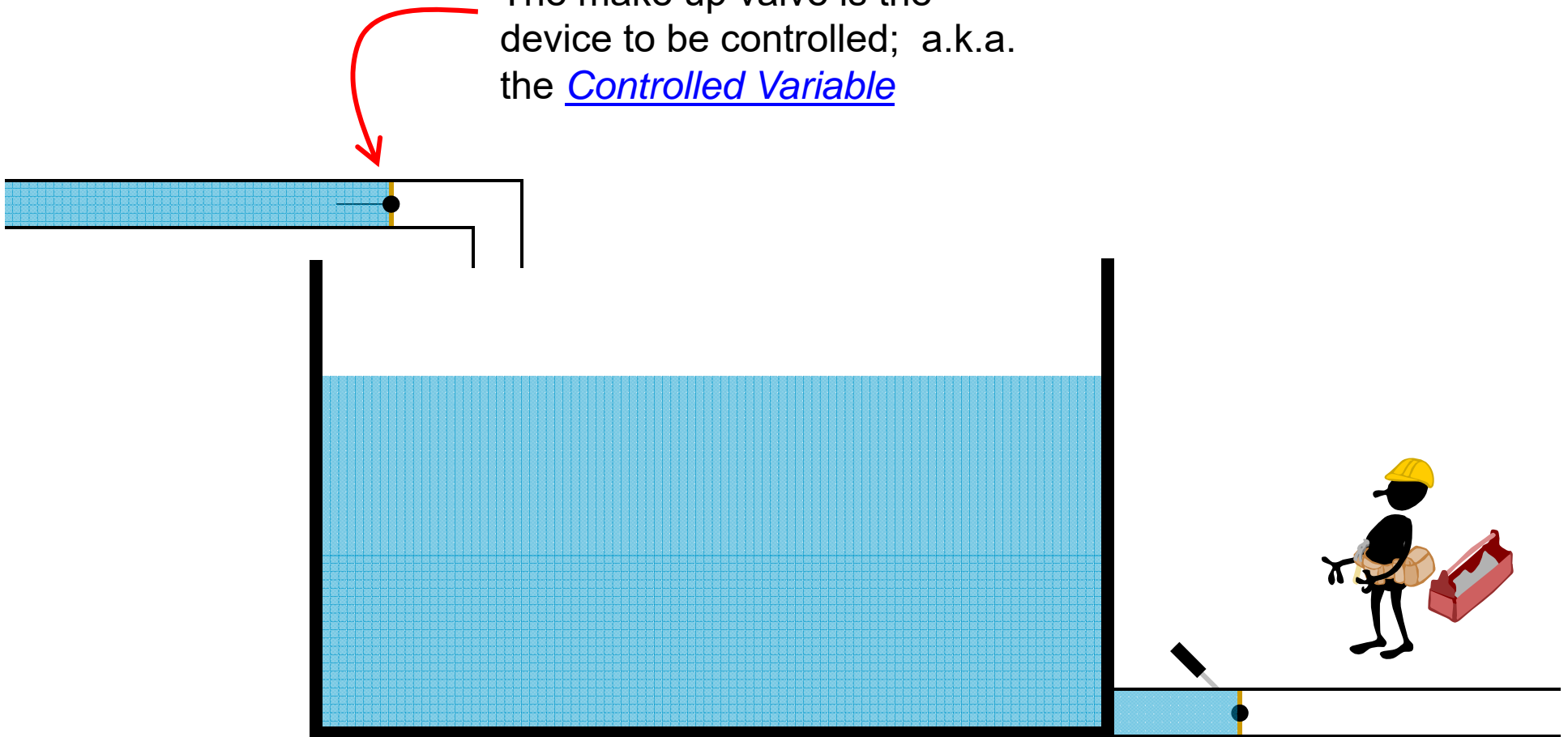


A Simple Control System

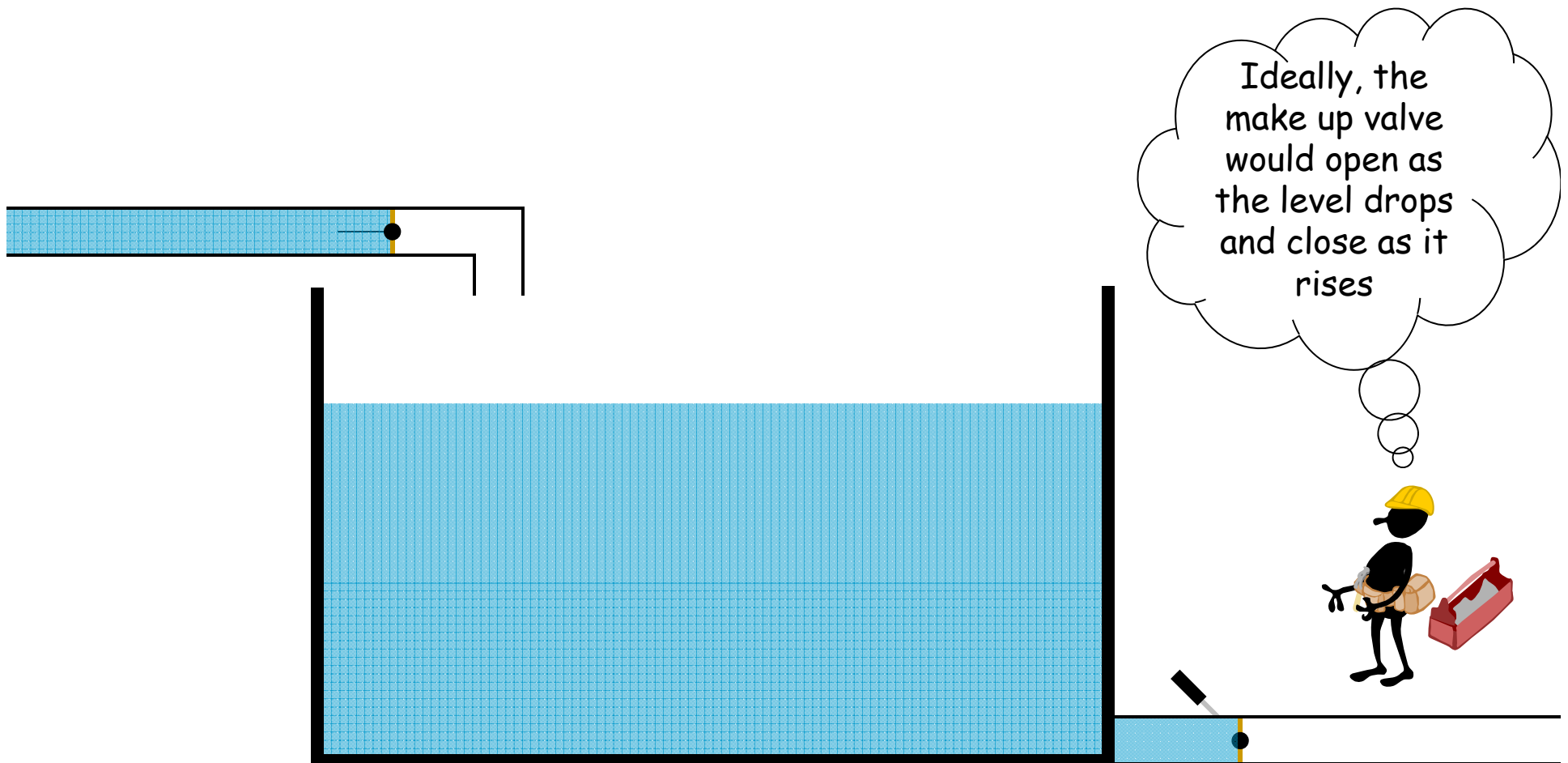


A Simple Control System

The make up valve is the device to be controlled; a.k.a. the Controlled Variable



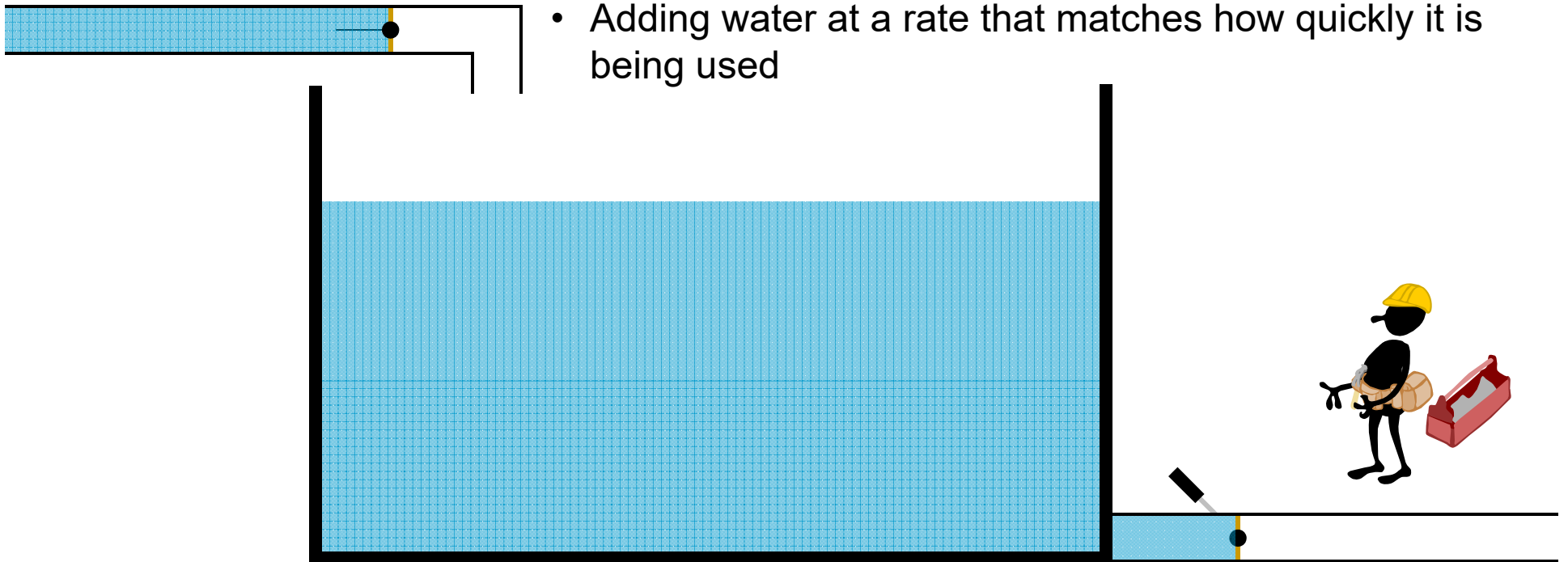
A Simple Control System



A Simple Control System

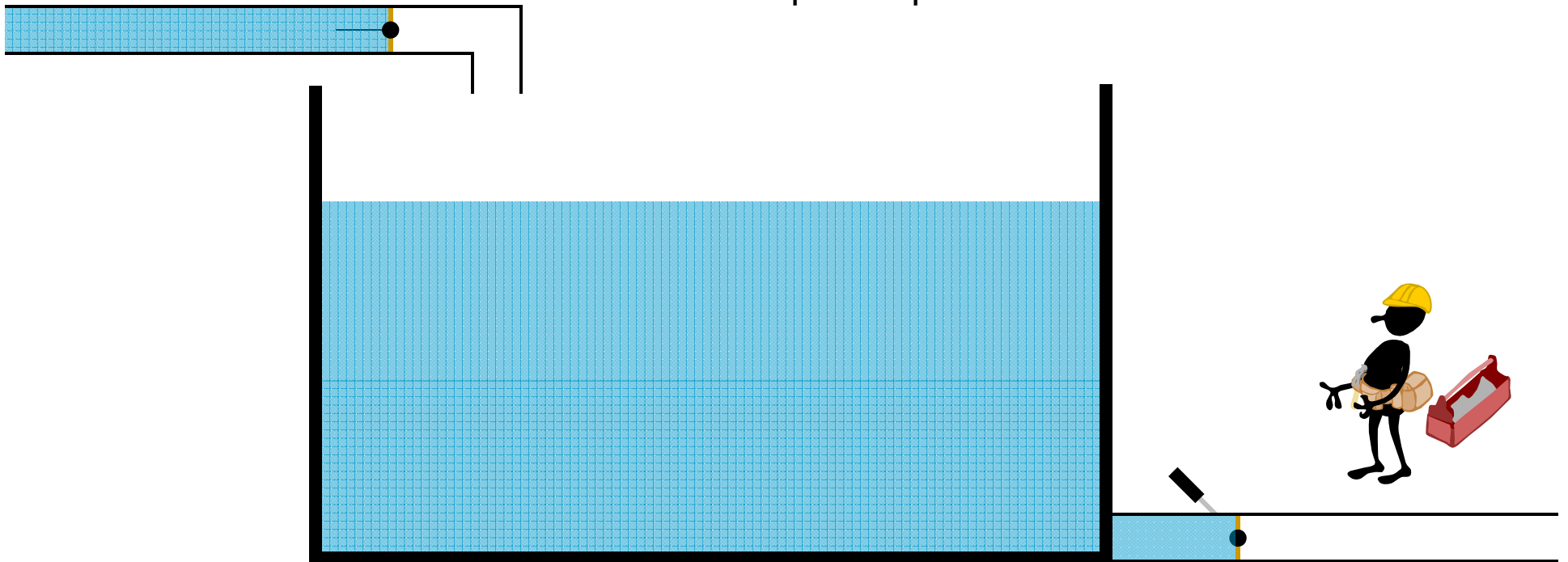
Because the tank acts as a flywheel in the system, it would be possible to serve the load by:

- Adding water when the level drops to a certain point
- Adding water at a rate that matches how quickly it is being used

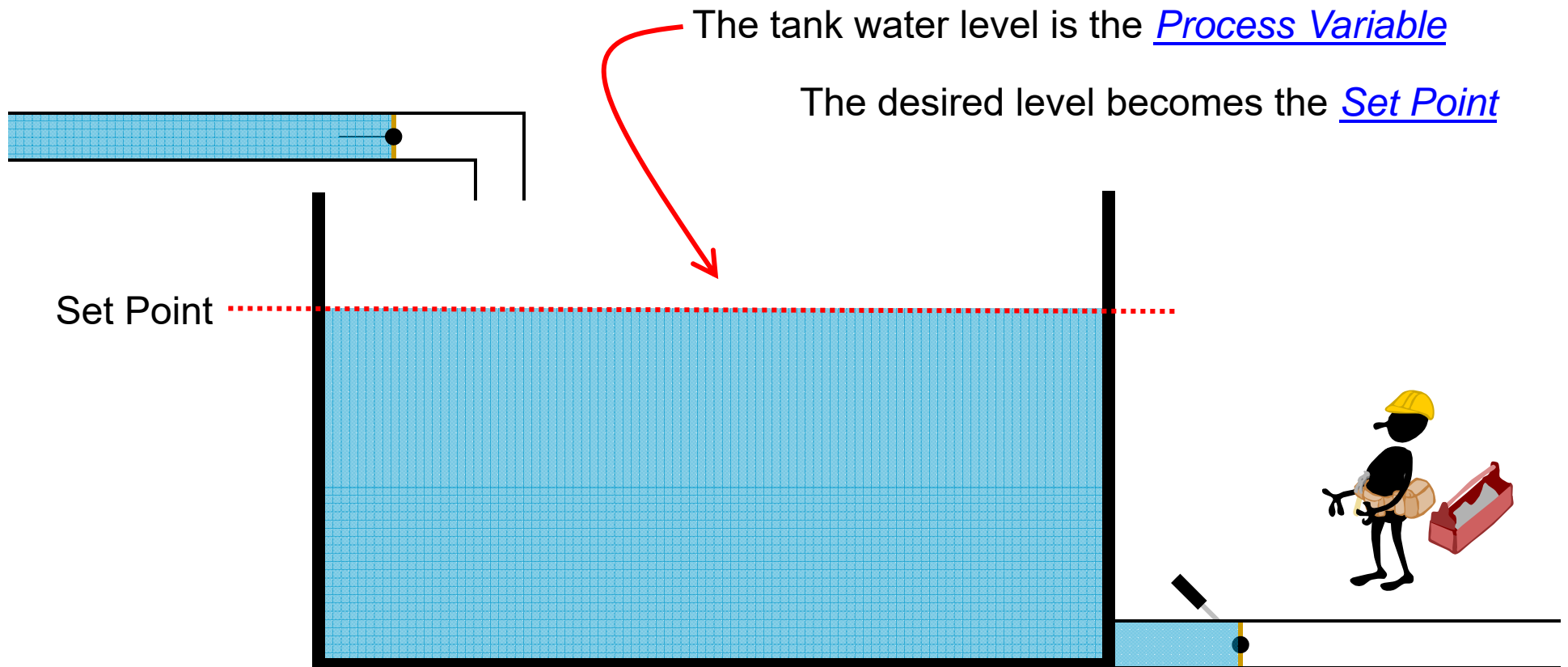


A Simple Control System

Monitoring the tank water level will allow us to gauge how much make up we need to add as demand picks up

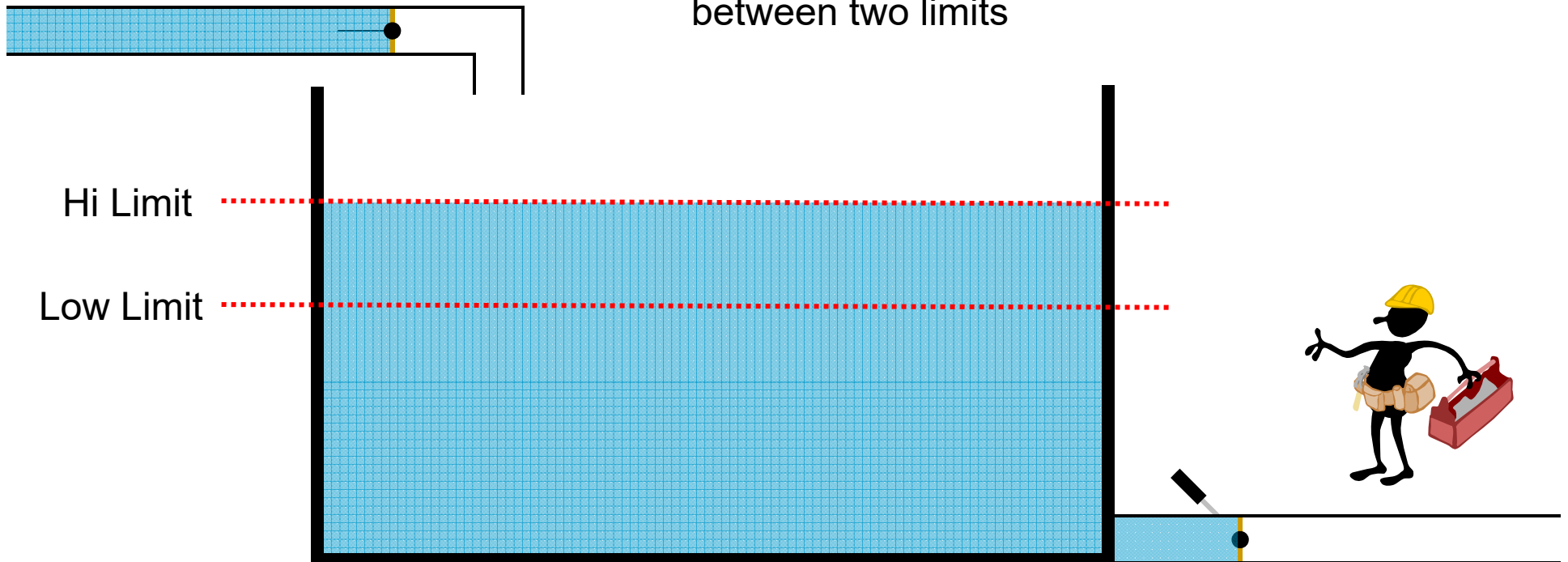


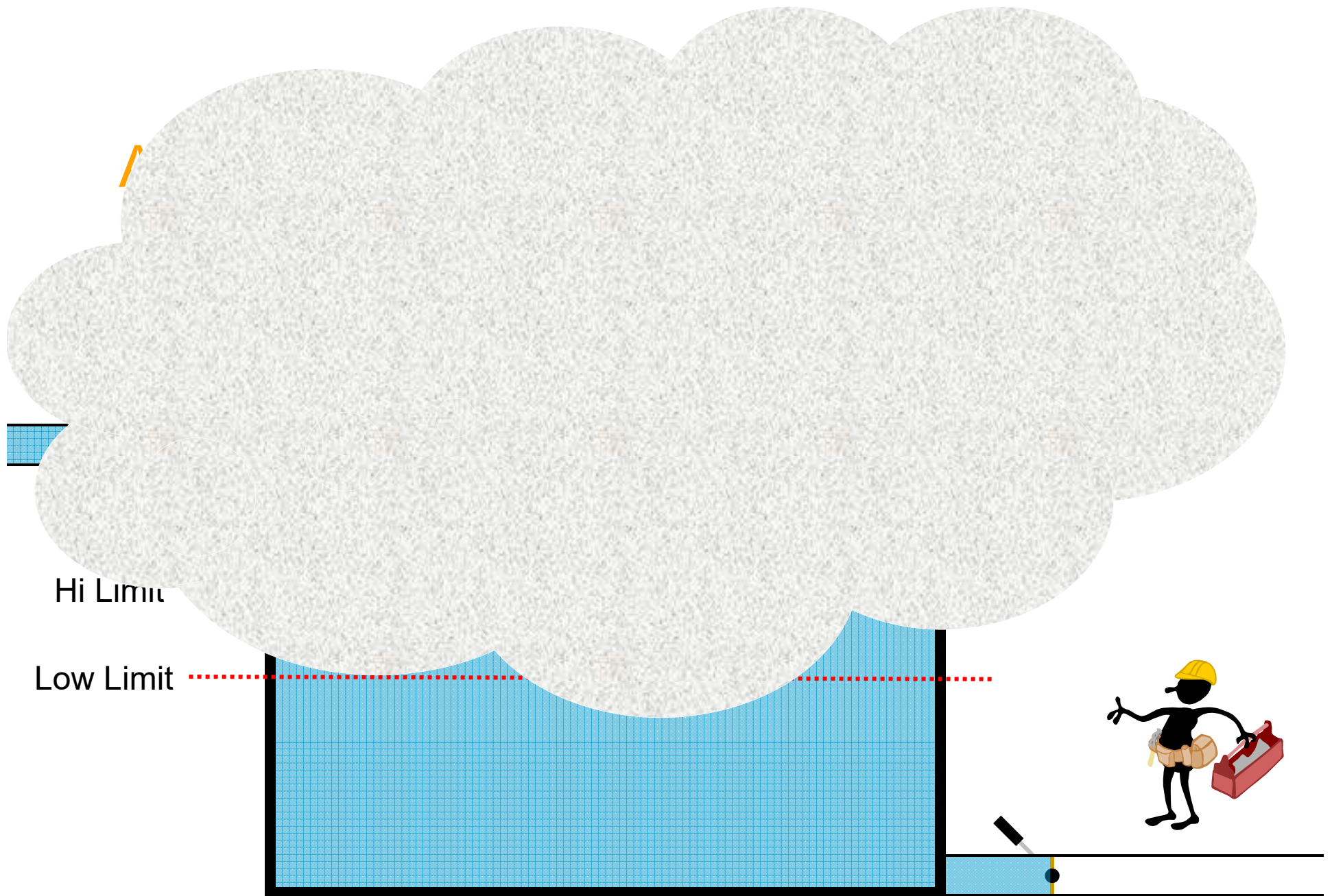
A Simple Control System

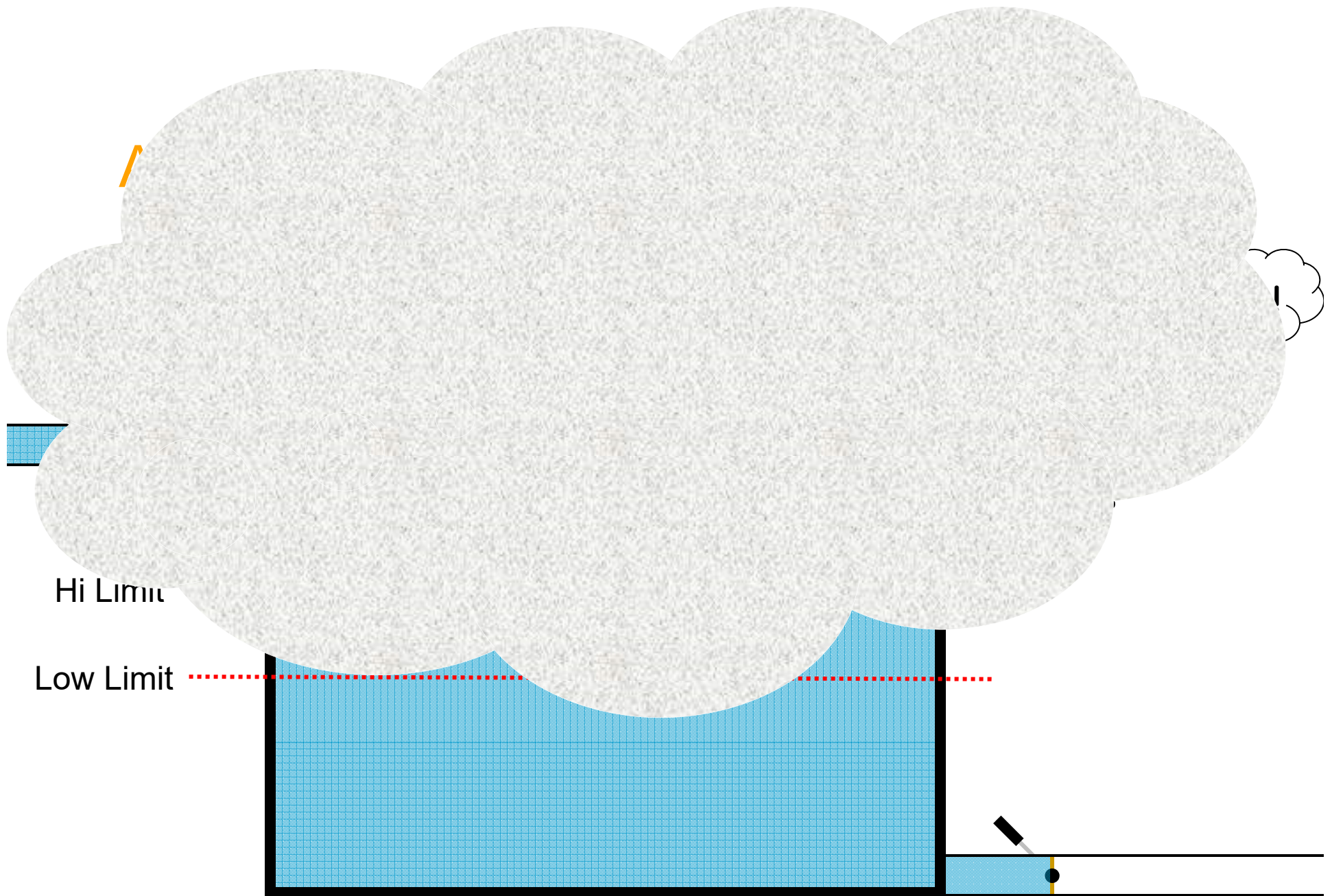


A Simple Control System

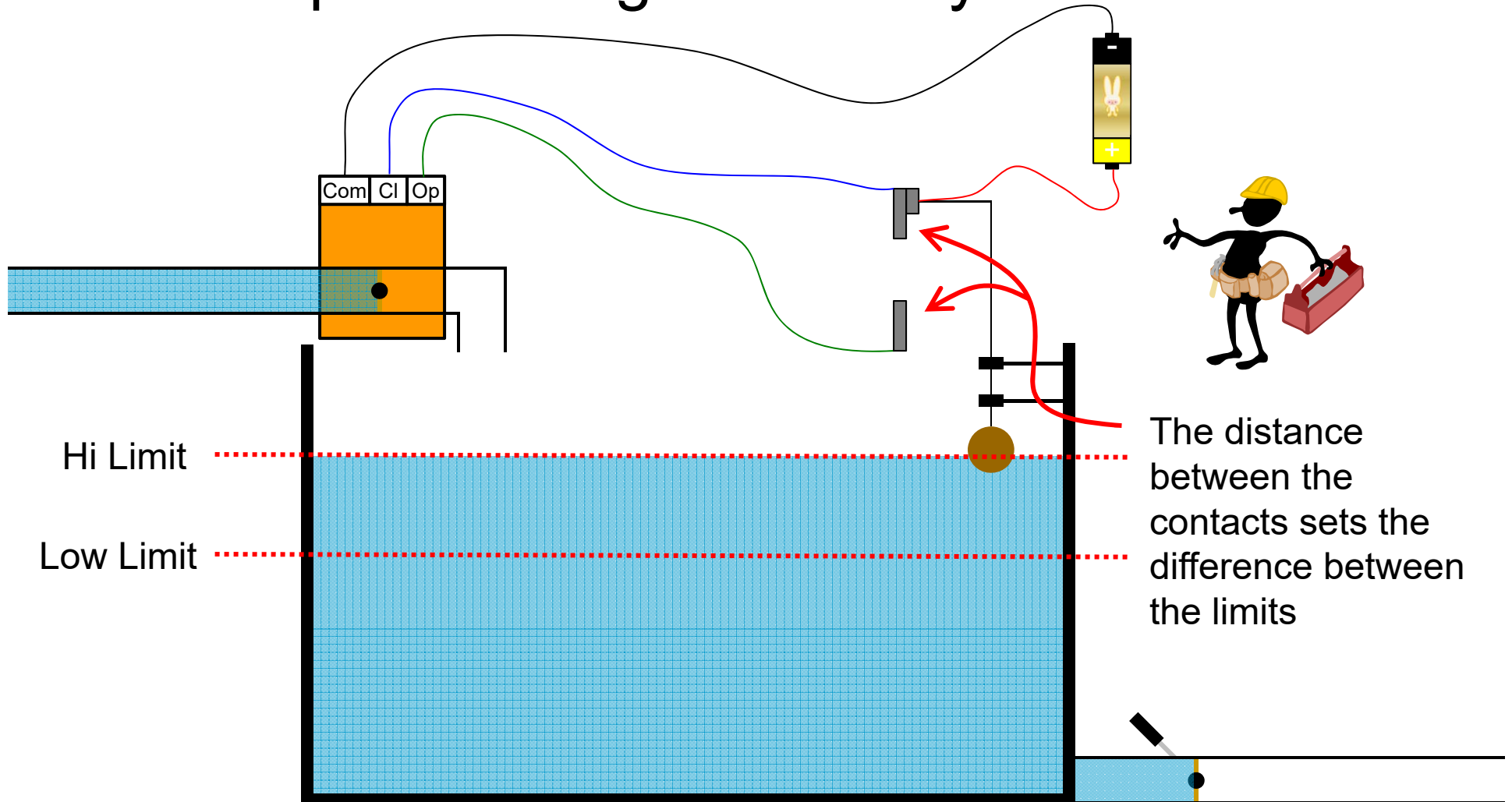
It may be possible to achieve satisfactory control by simply keeping the tank level between two limits



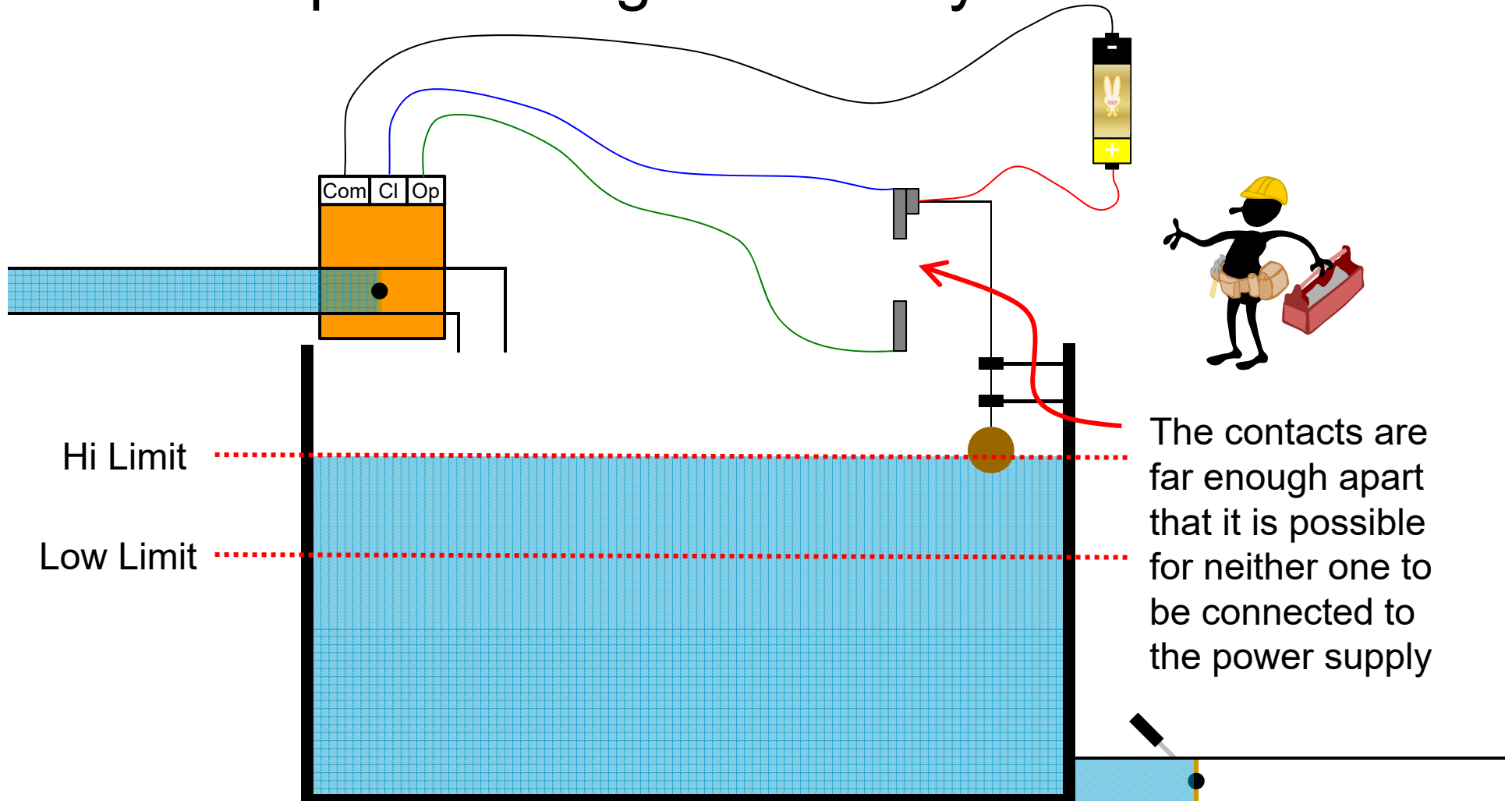




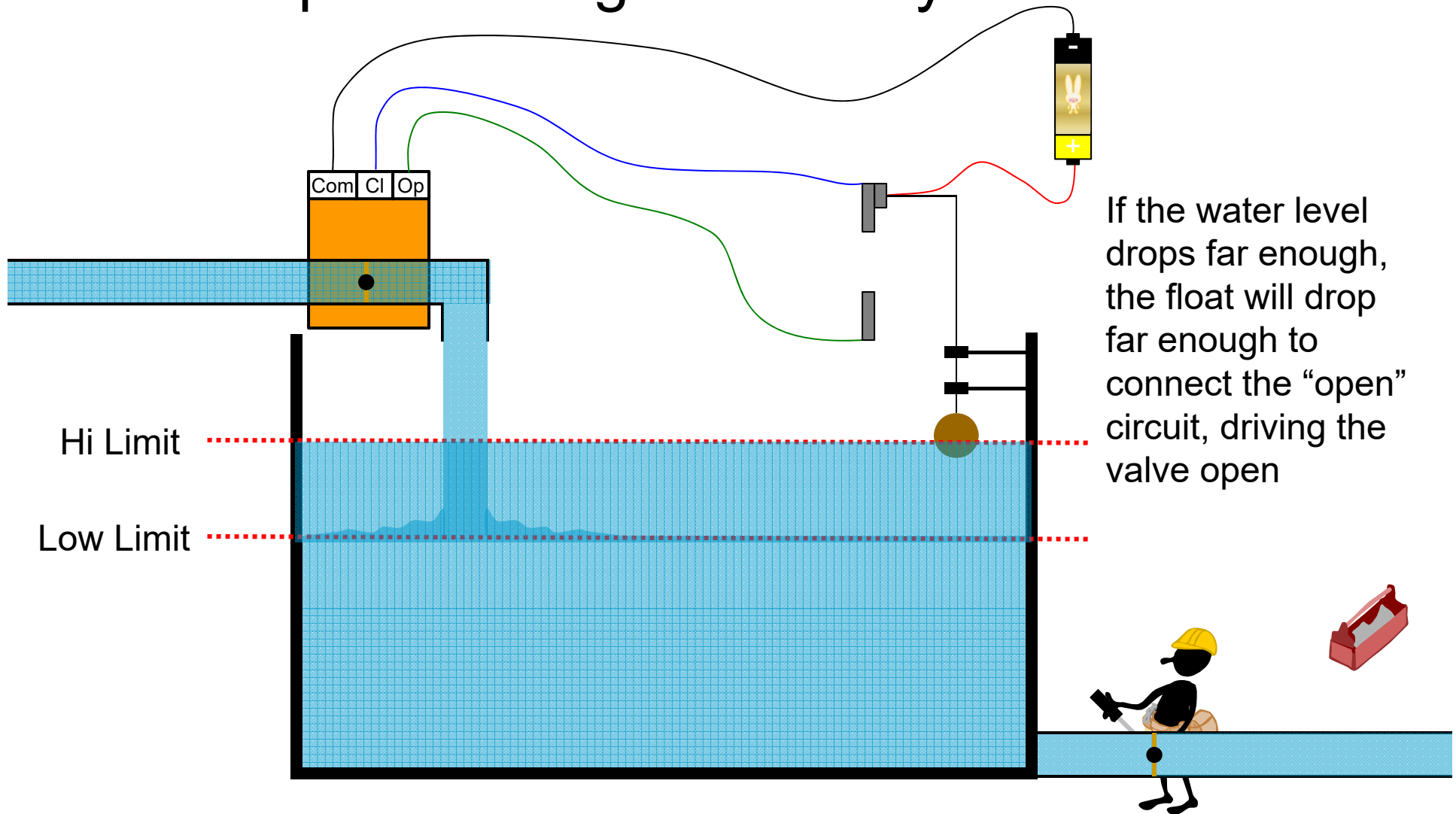
A Simple Floating Control System



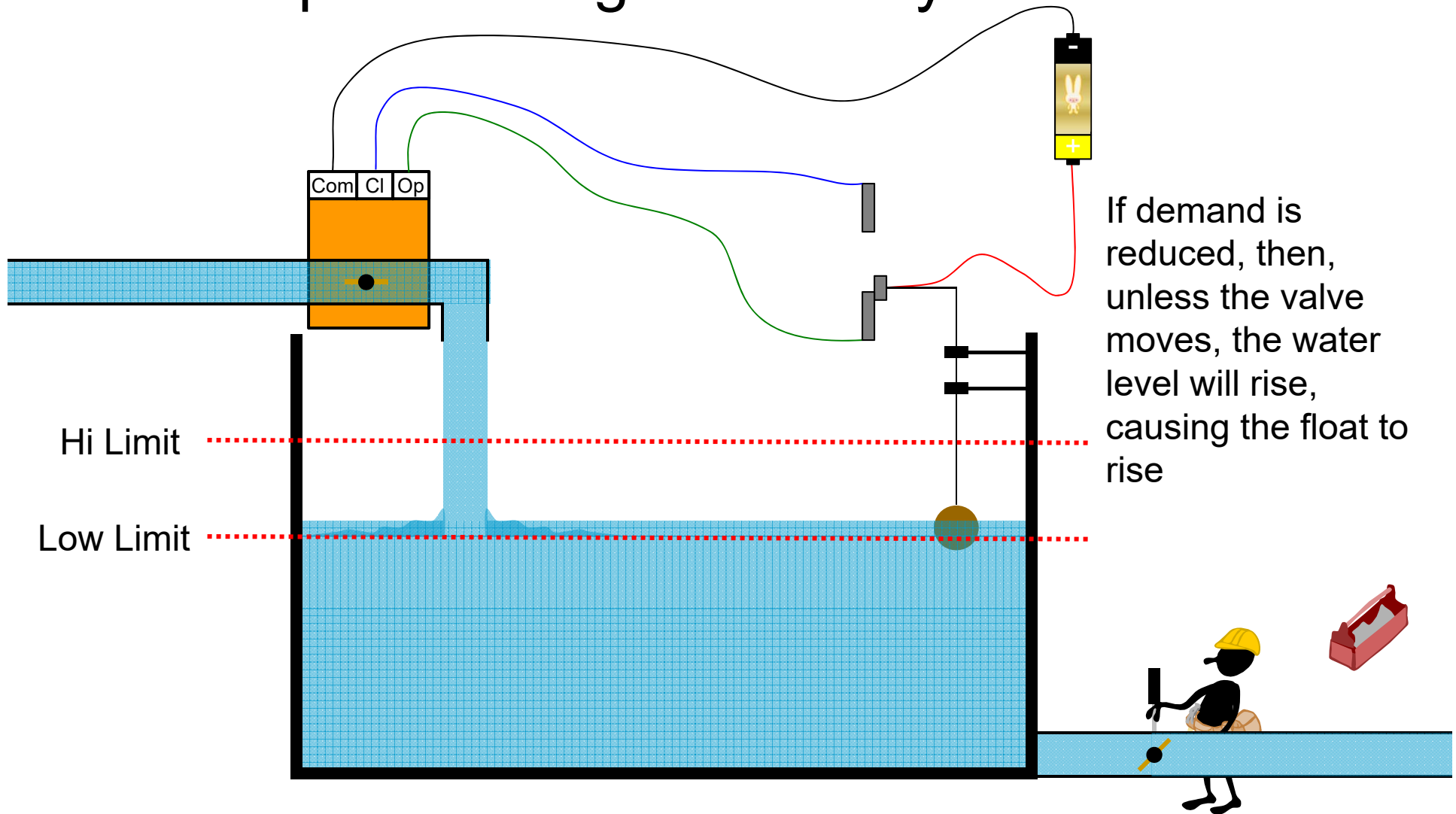
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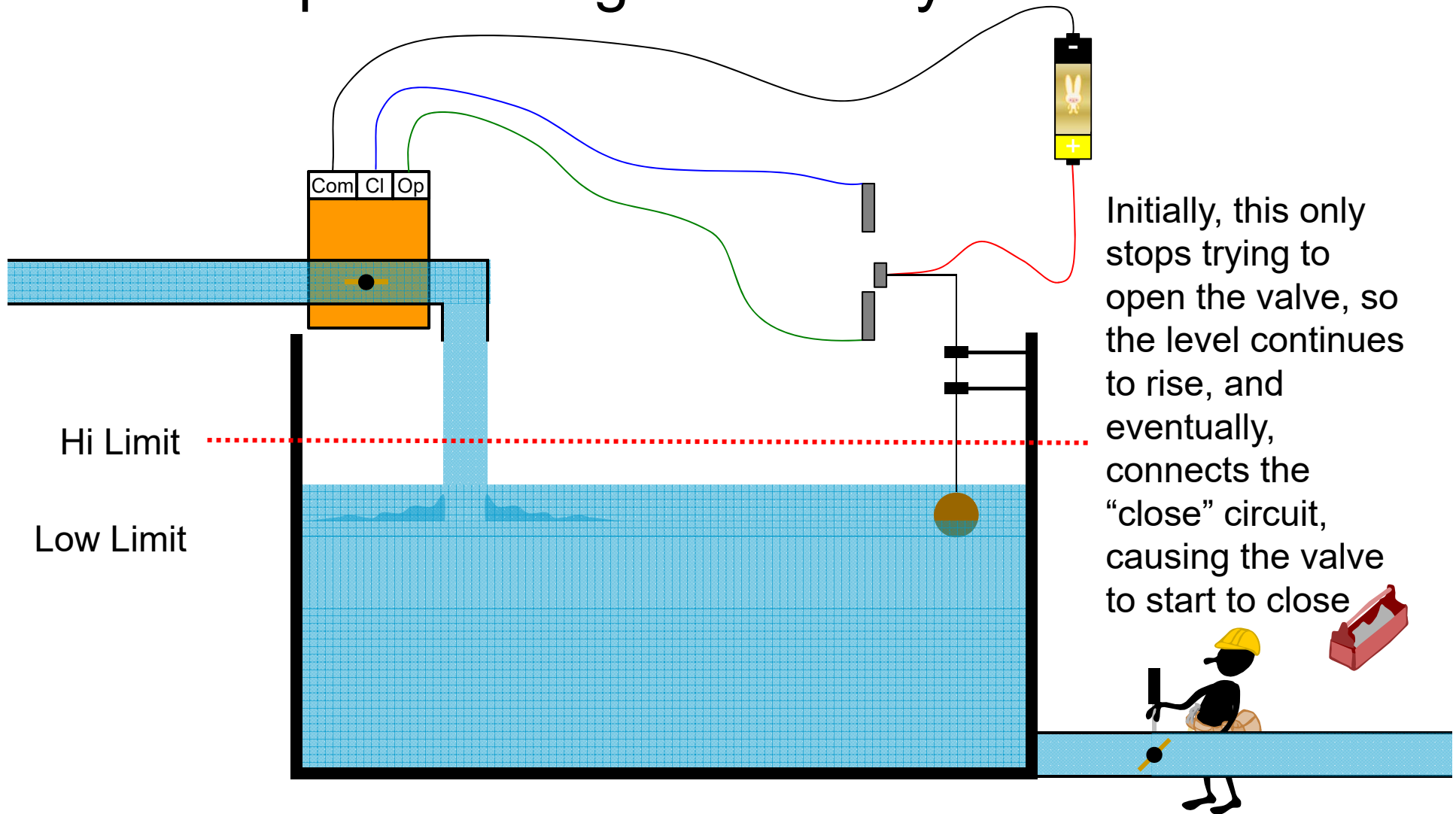
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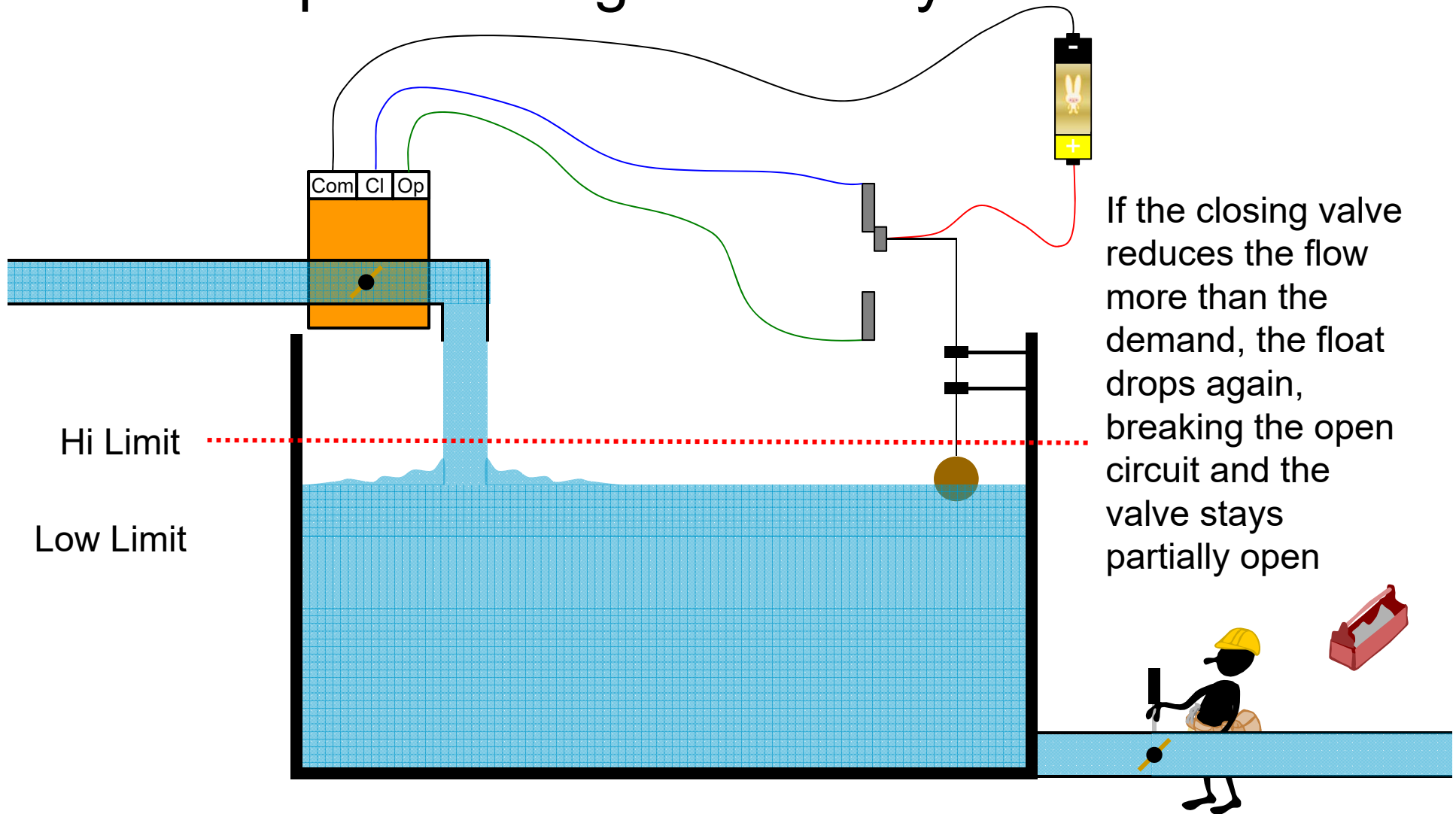
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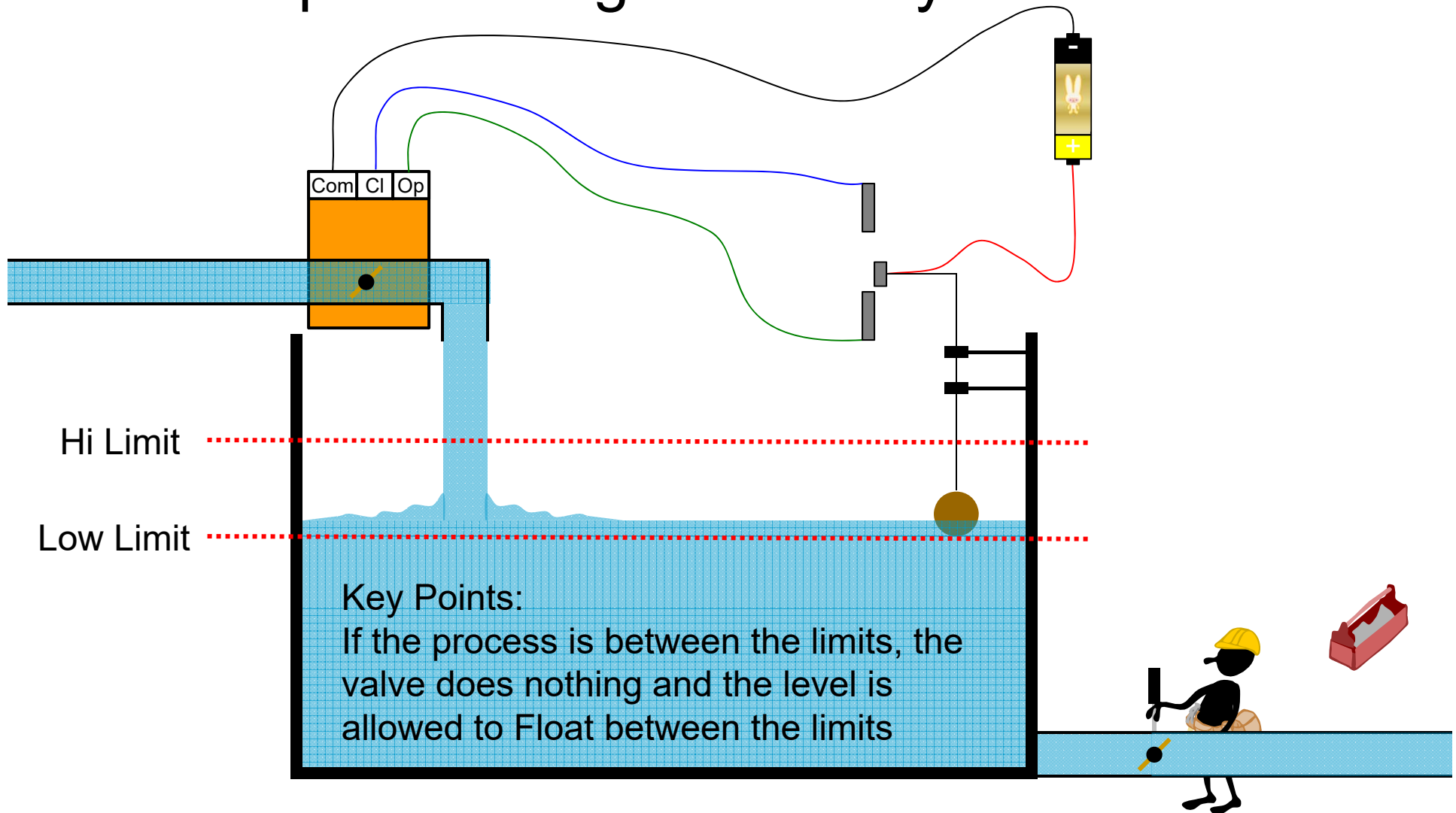
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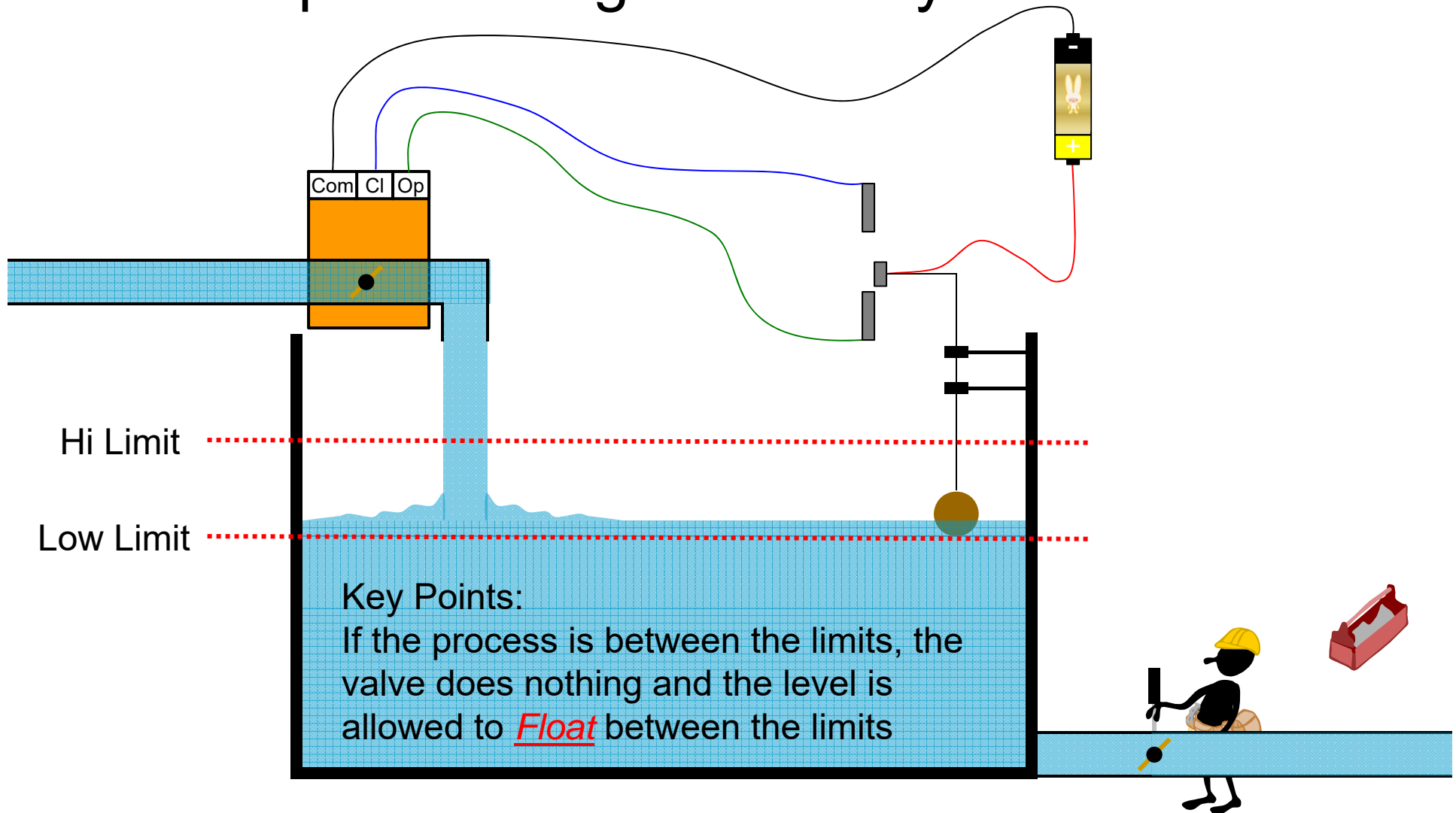
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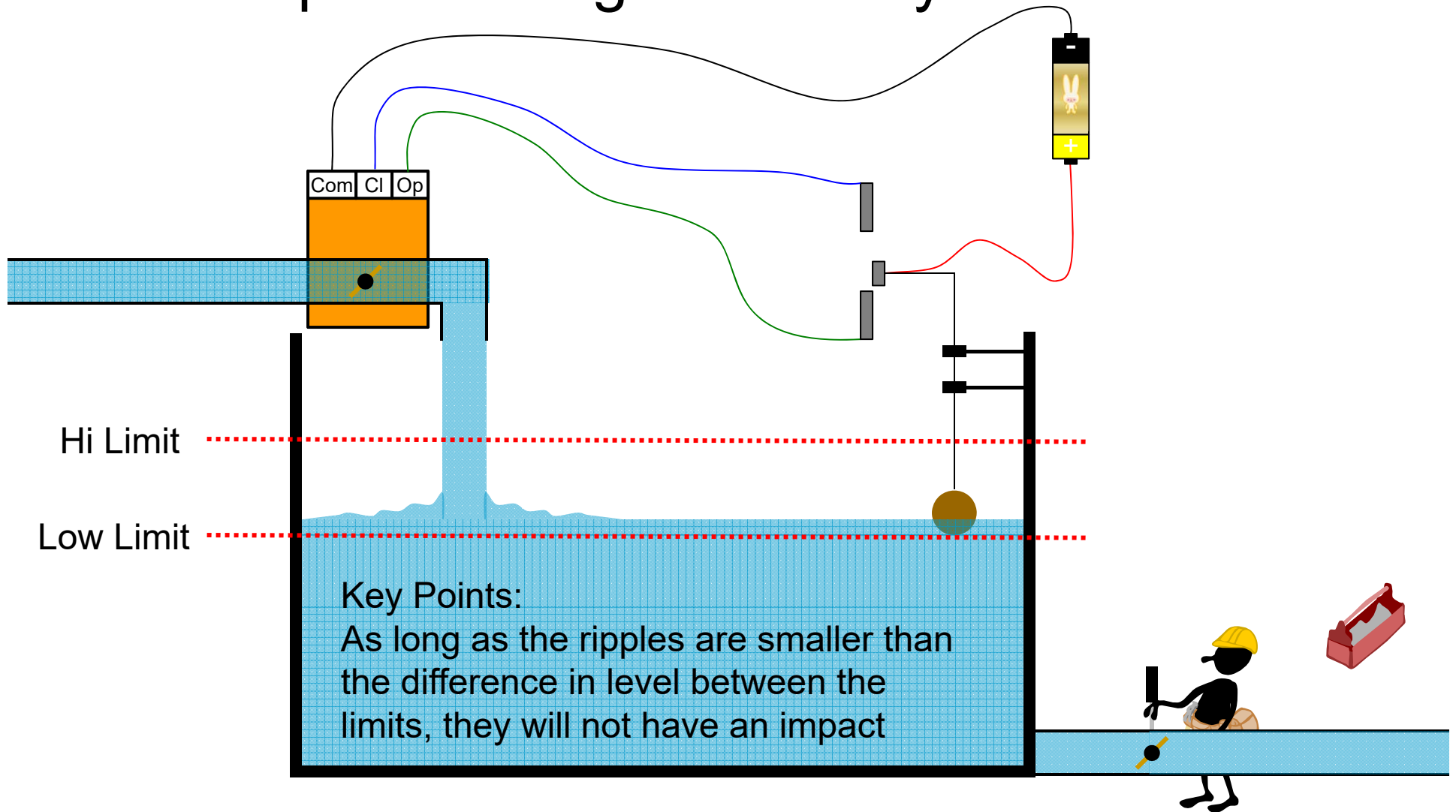
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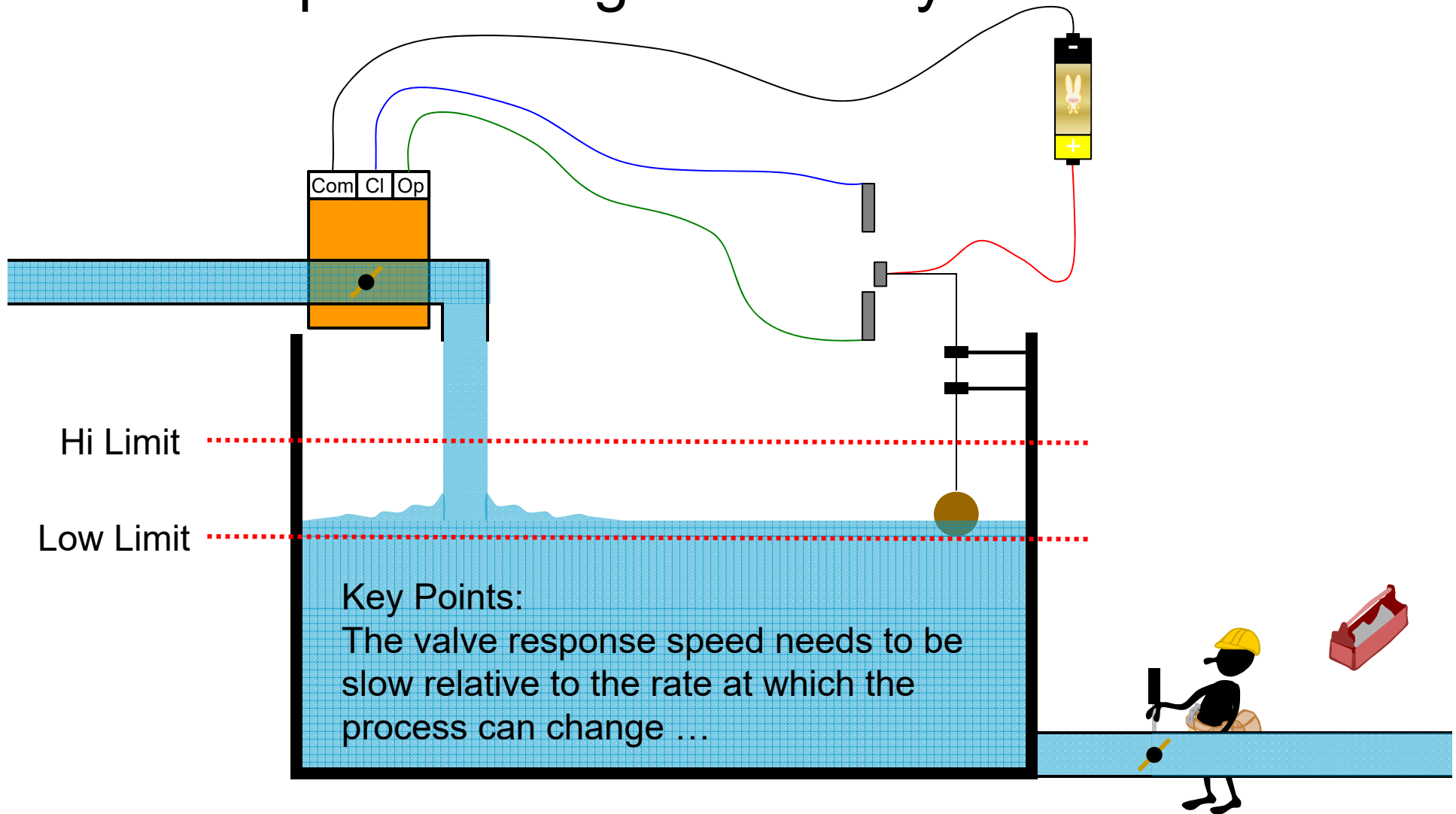
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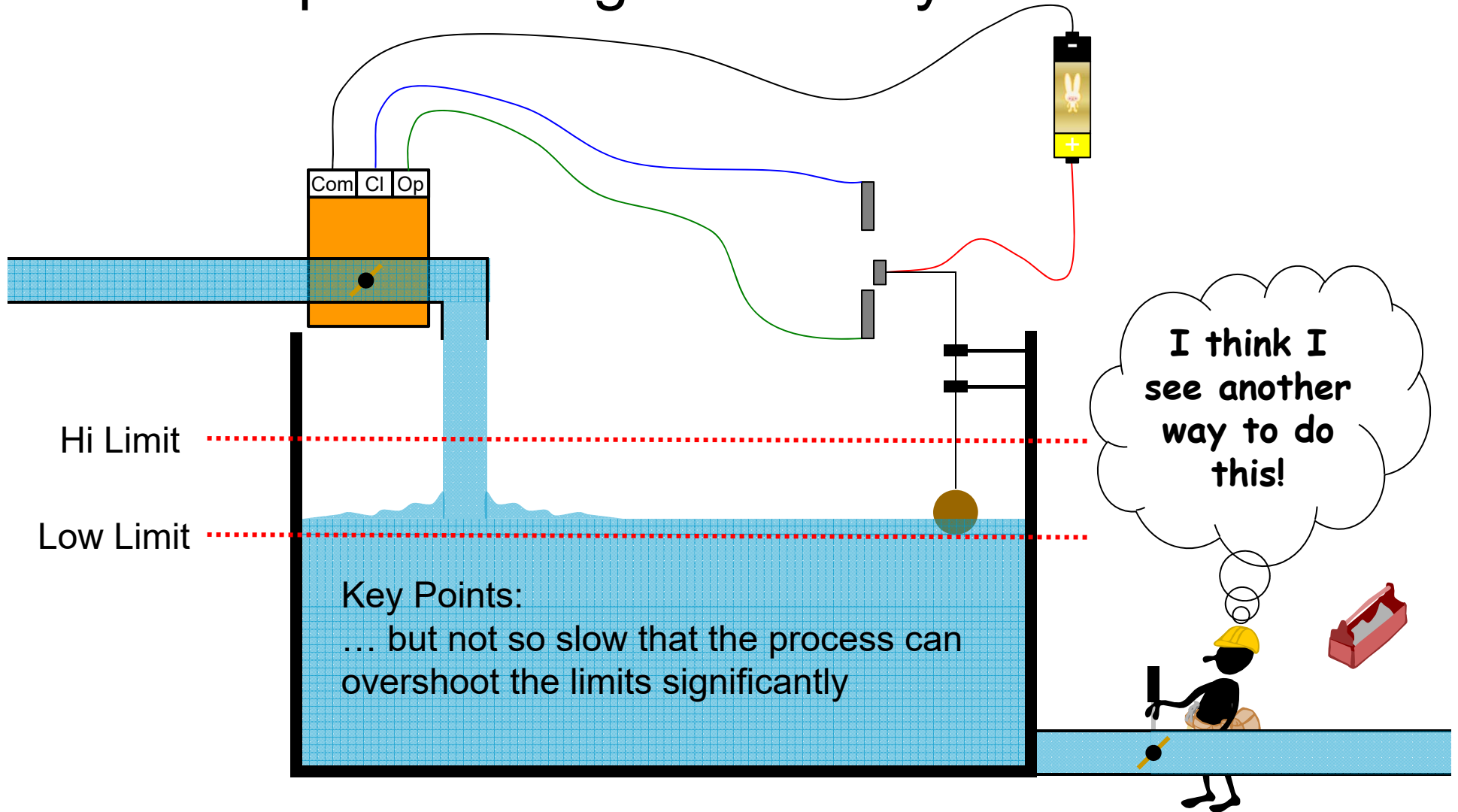
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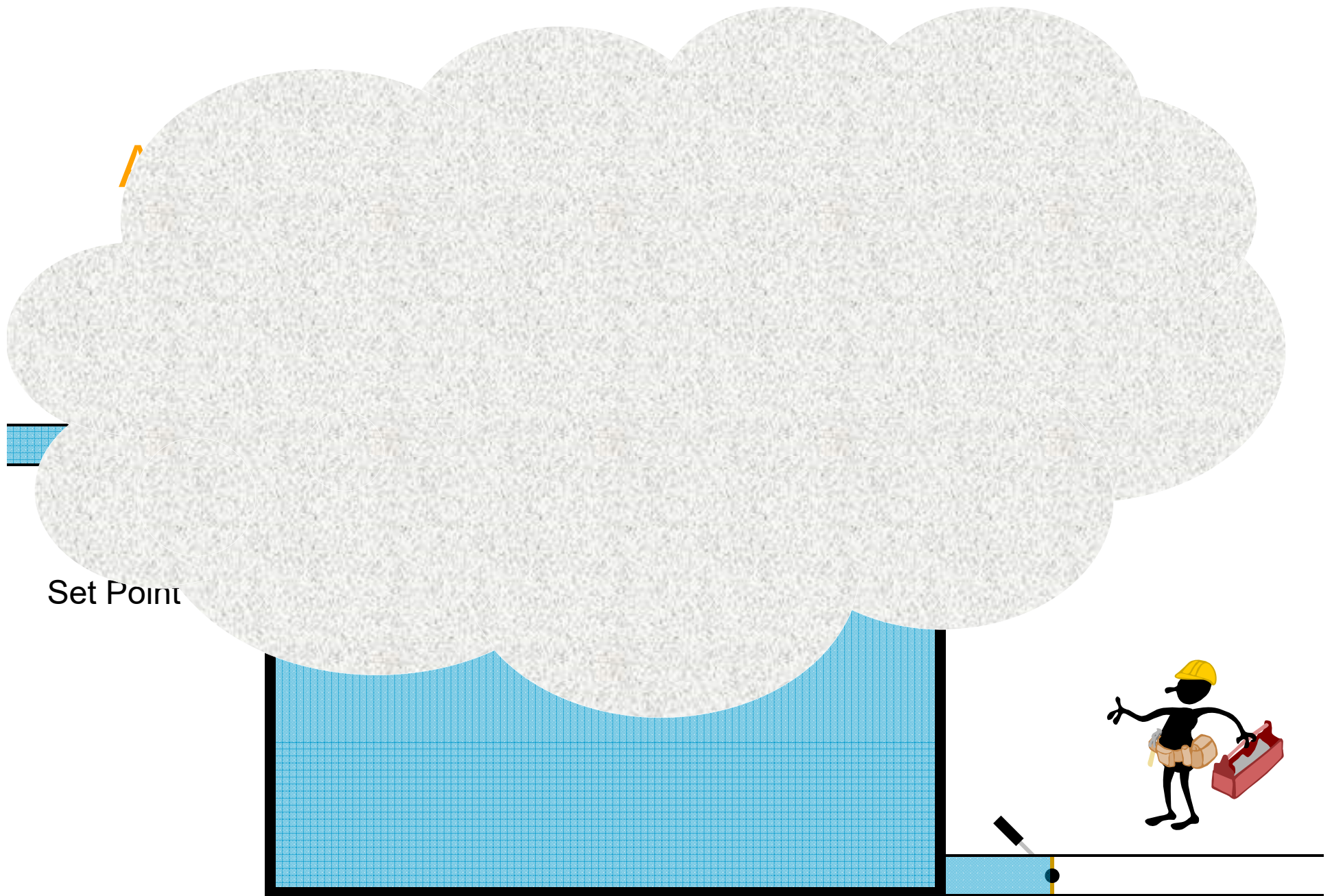


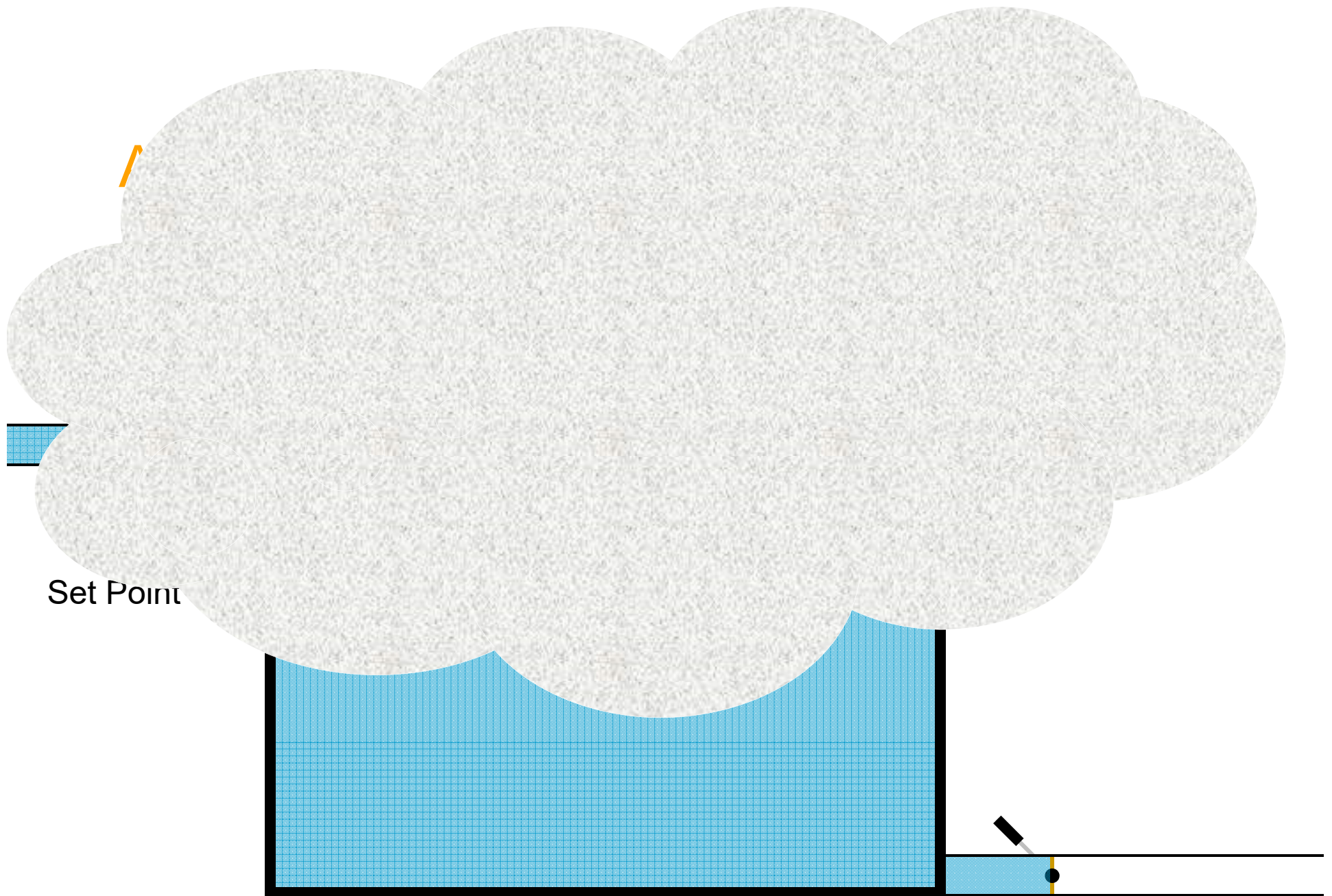
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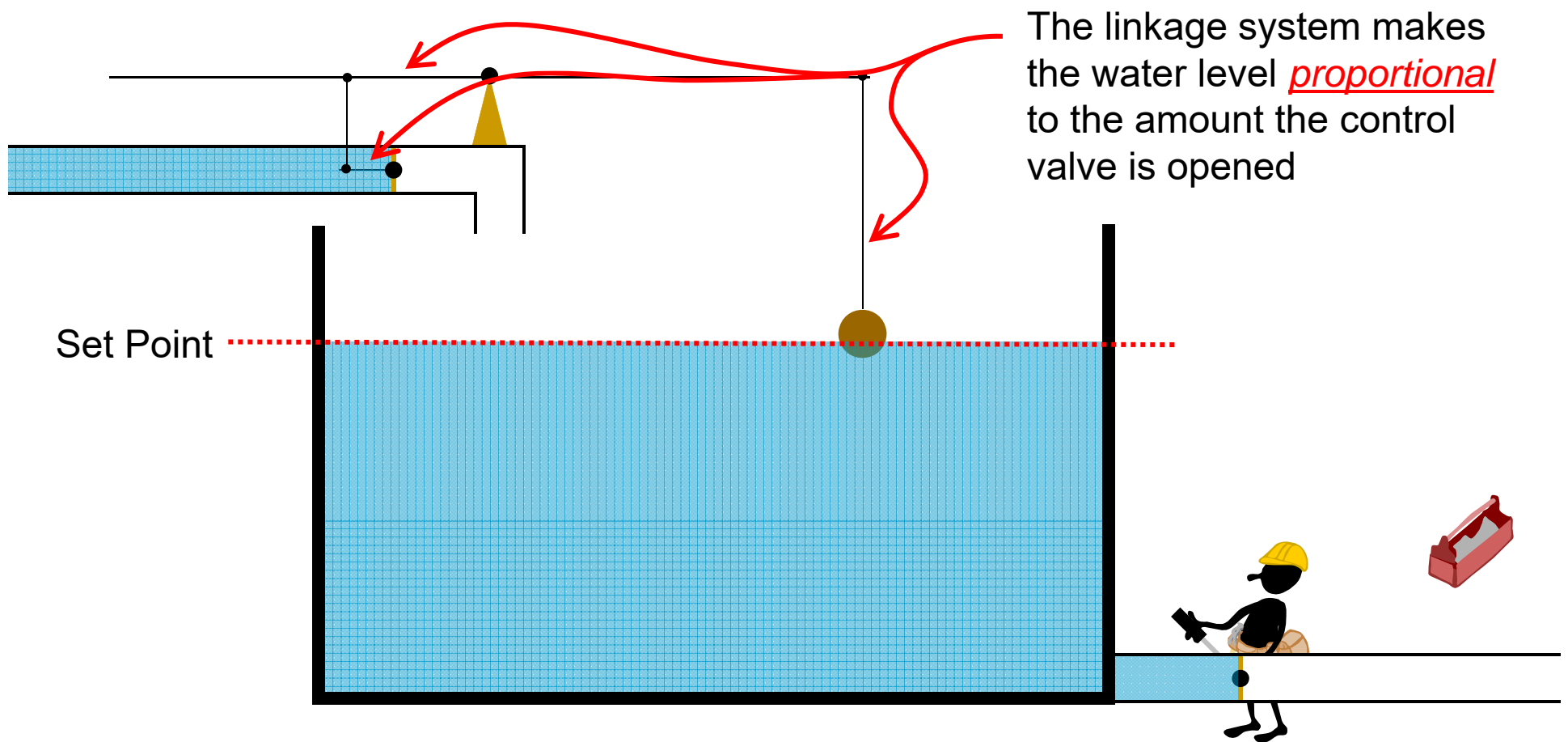




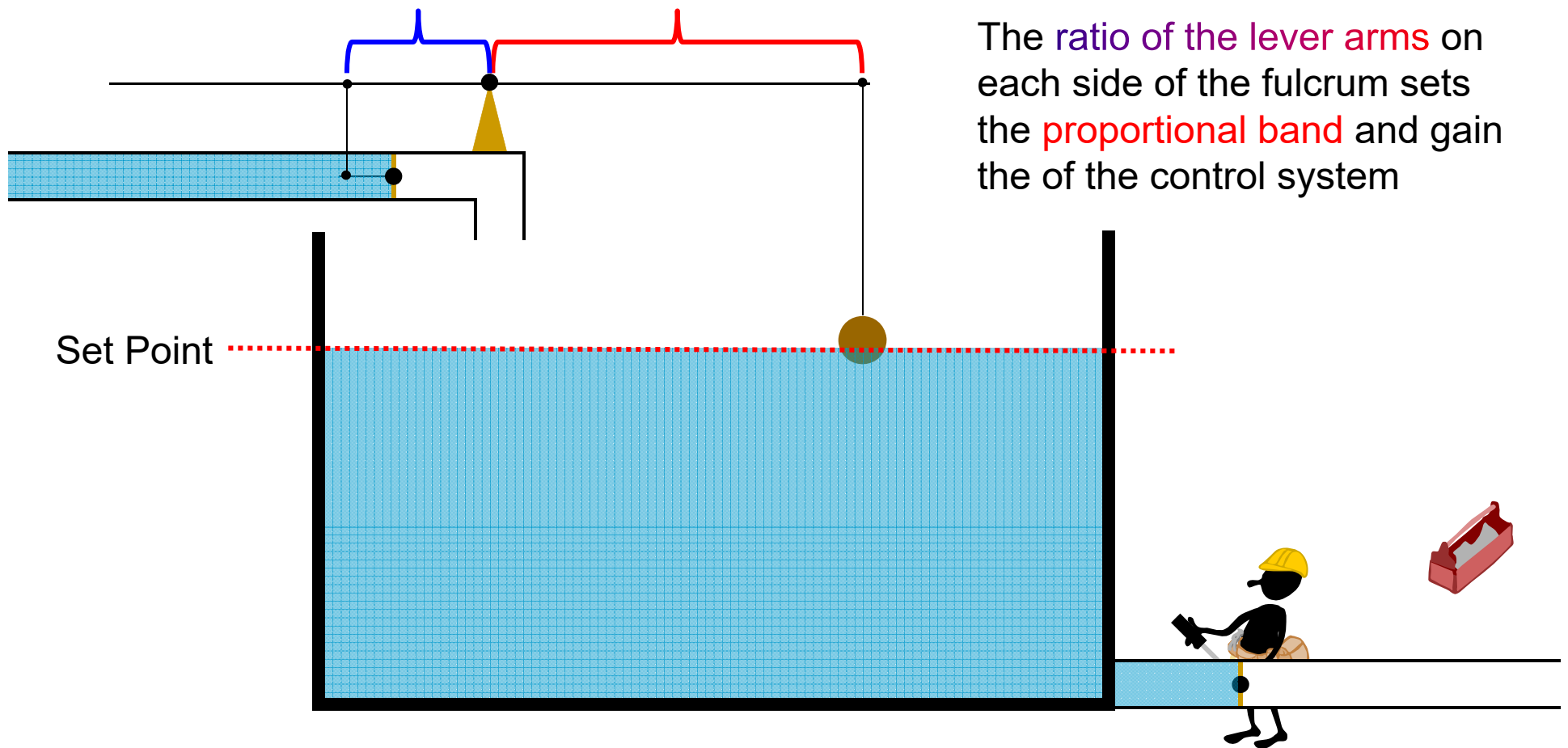


Set Point

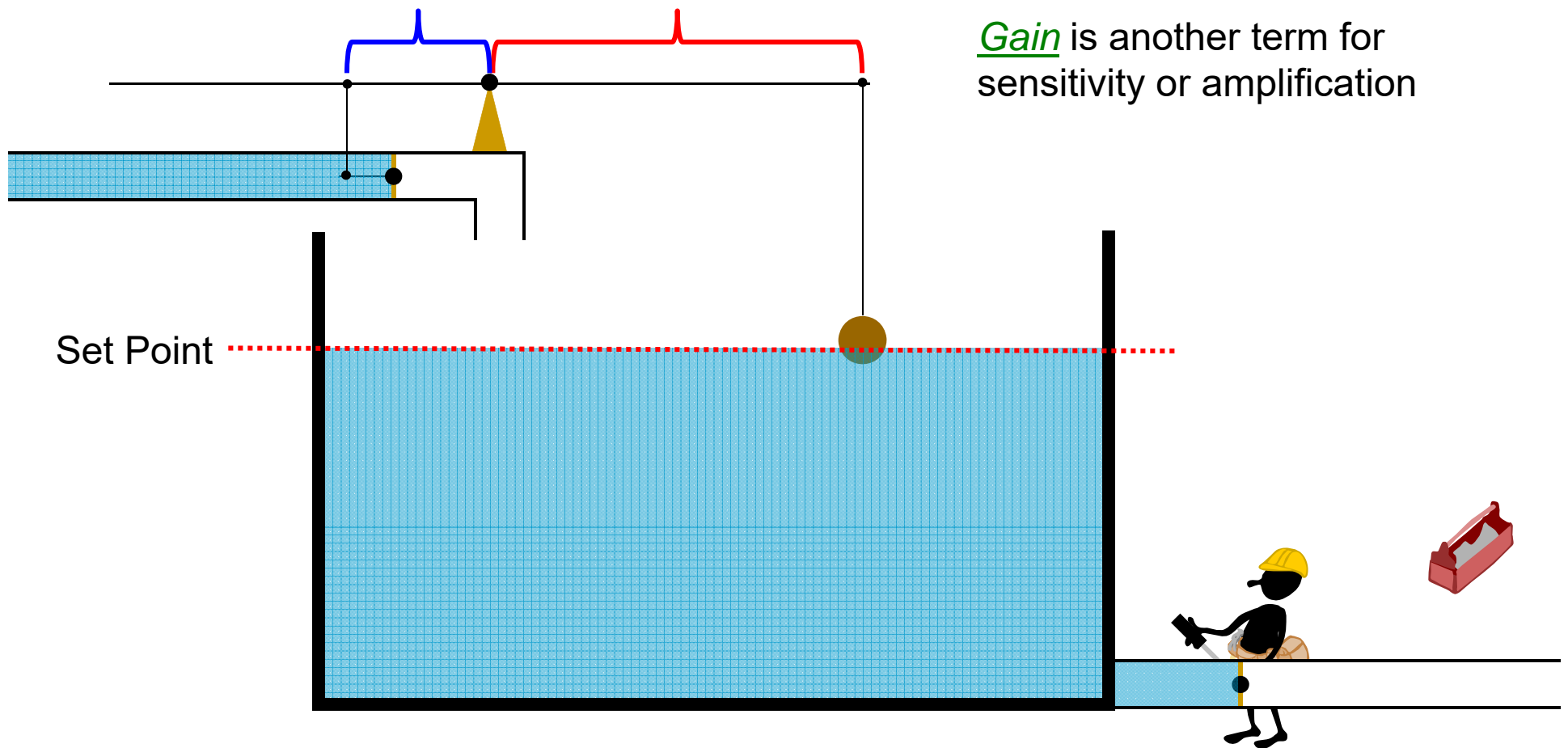
A Simple Proportional Control System



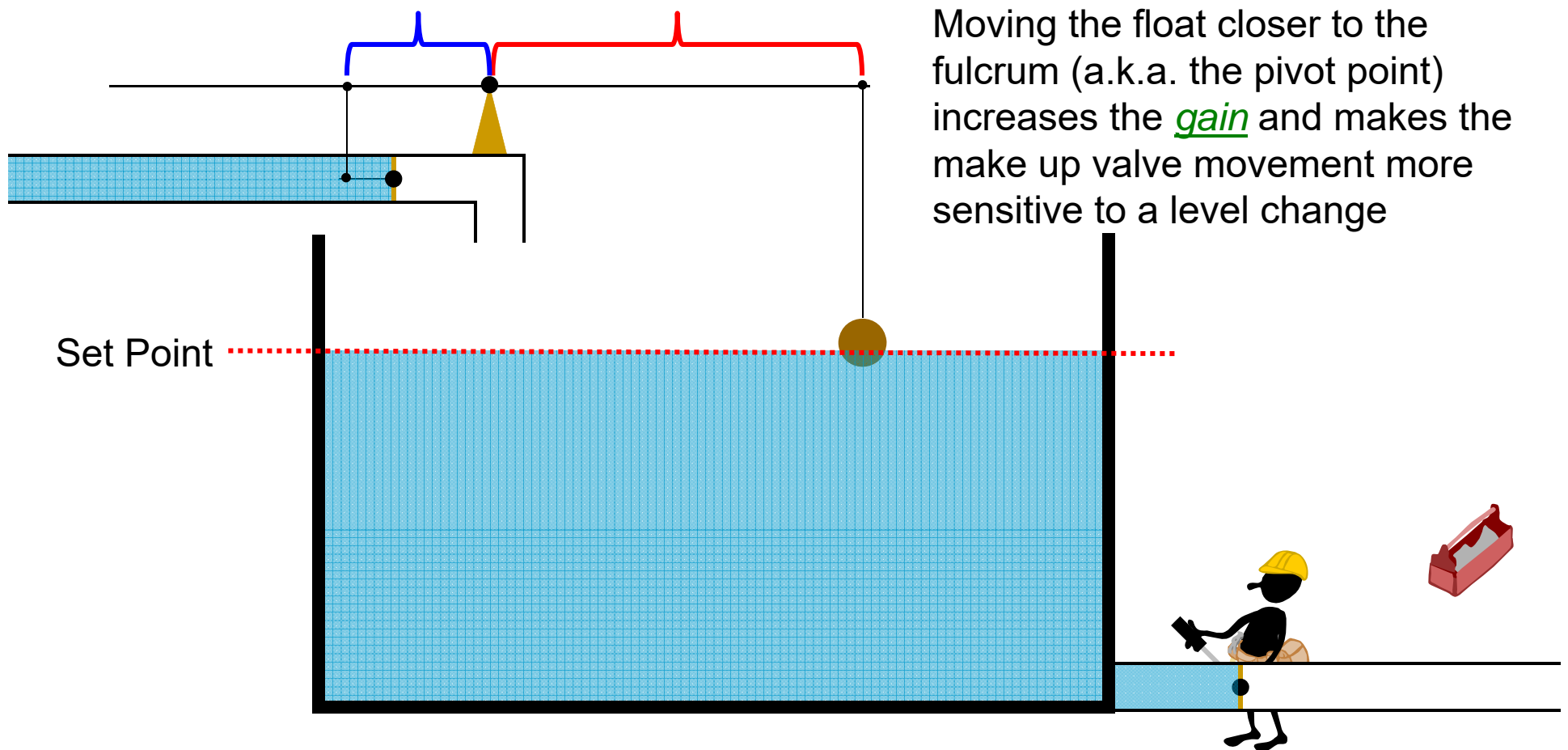
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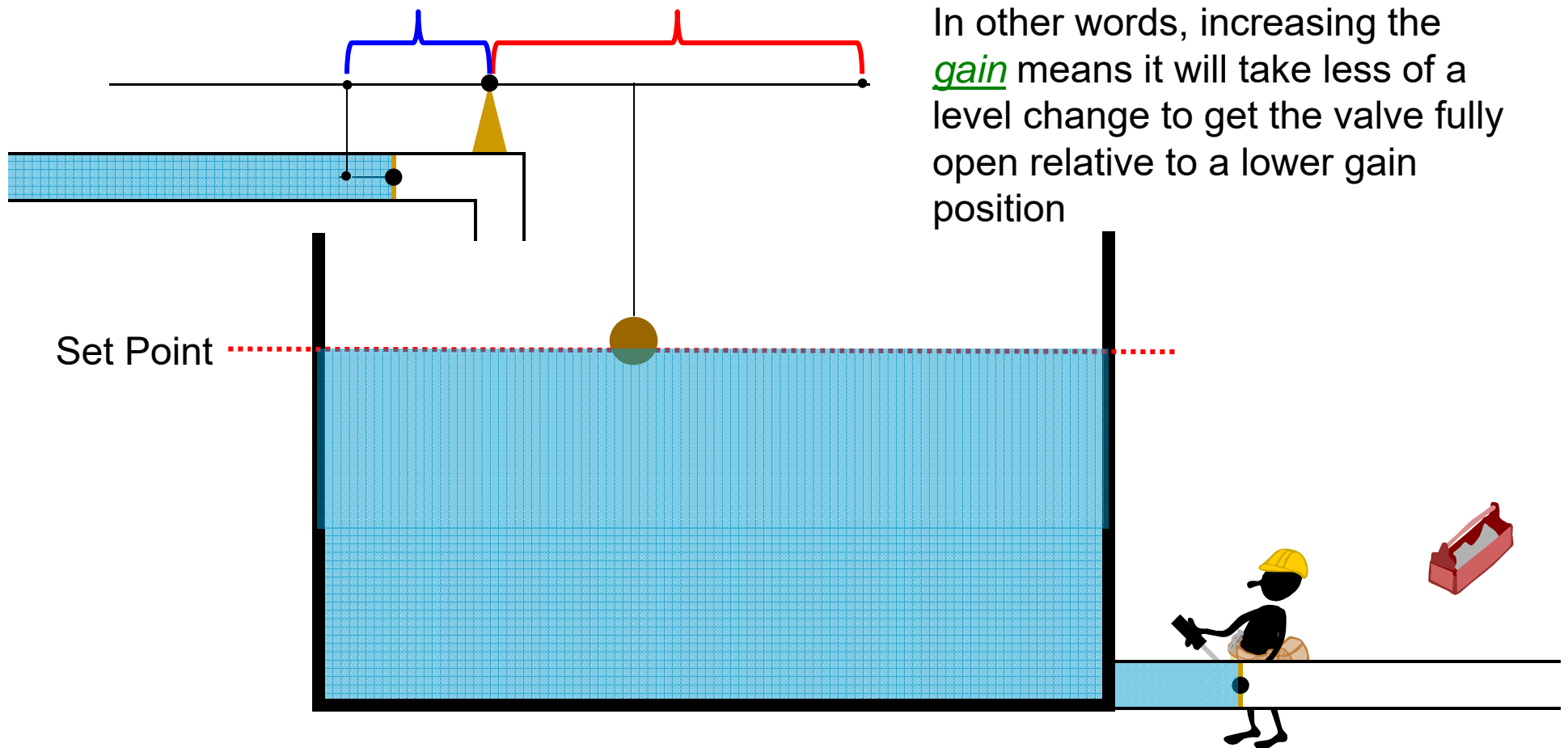
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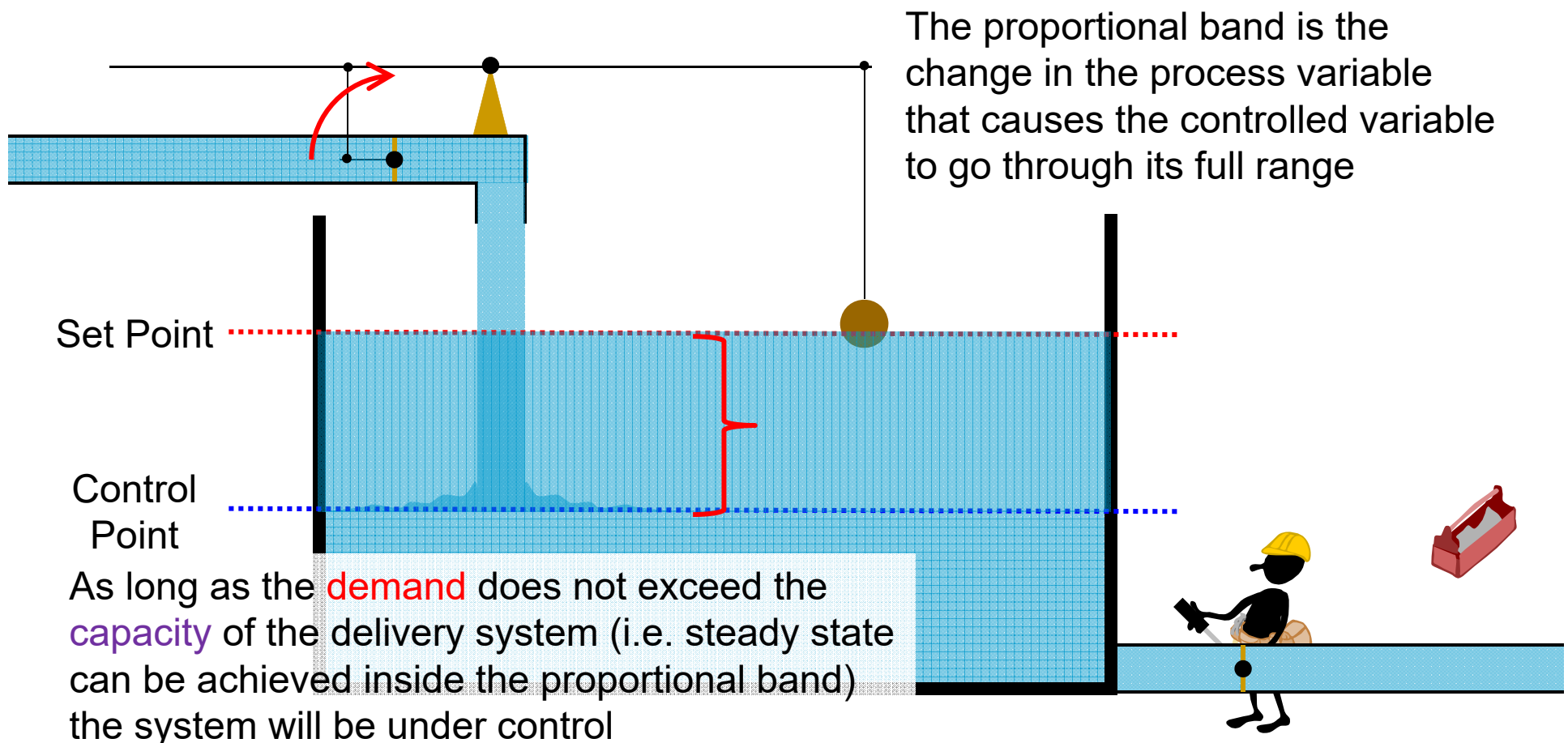
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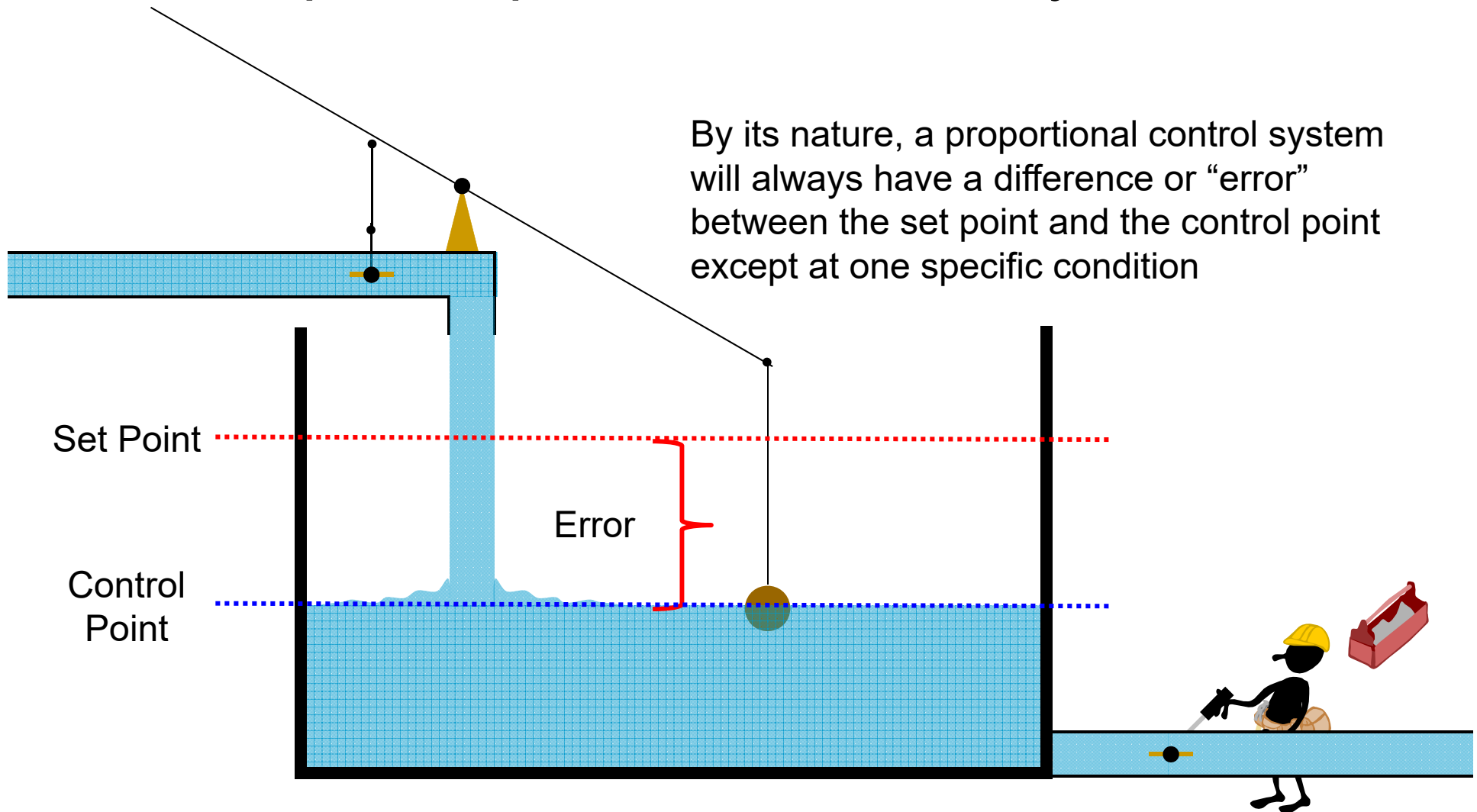


A Simple Proportional Control System

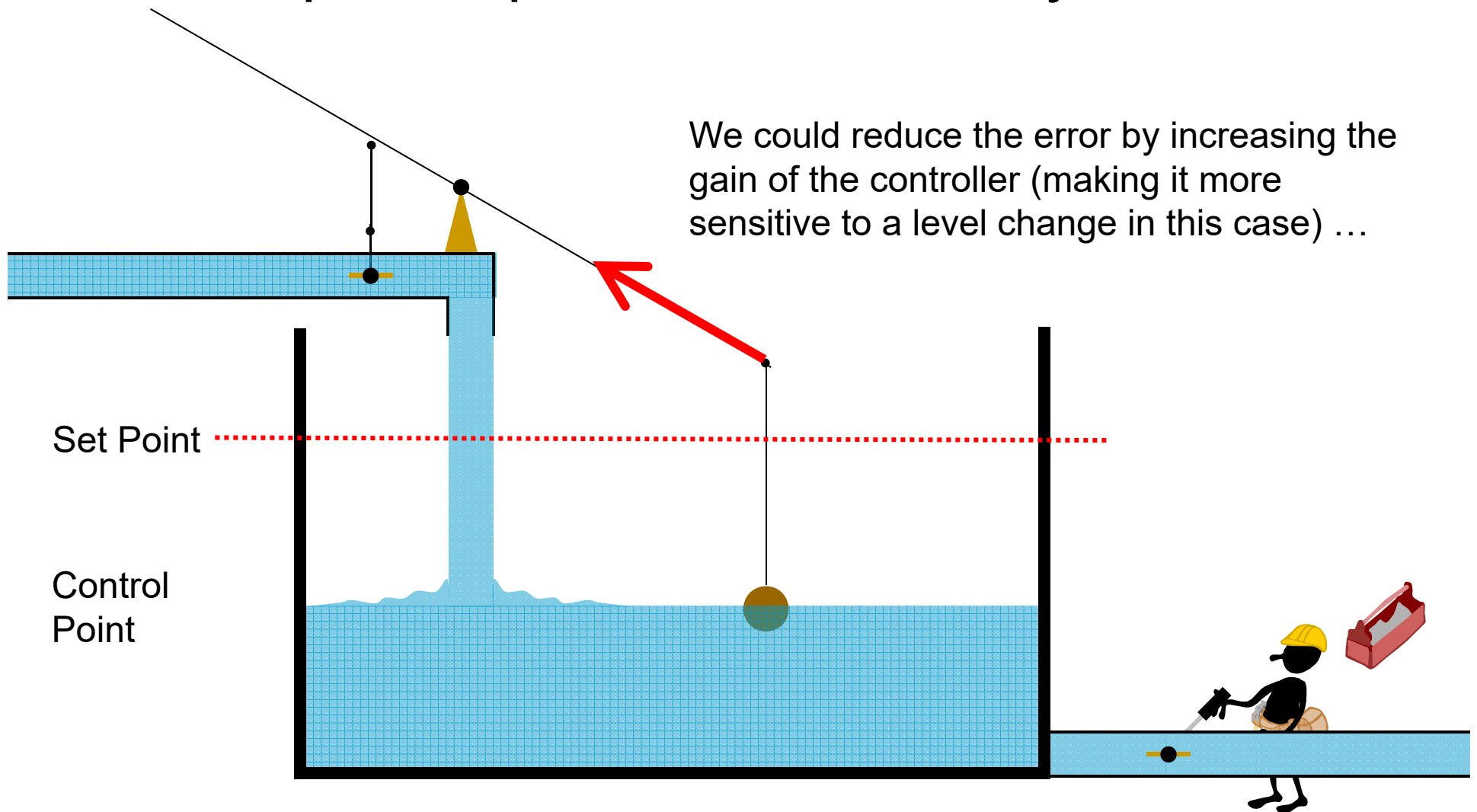


A Simple Proportional Control System

By its nature, a proportional control system will always have a difference or “error” between the set point and the control point except at one specific condition

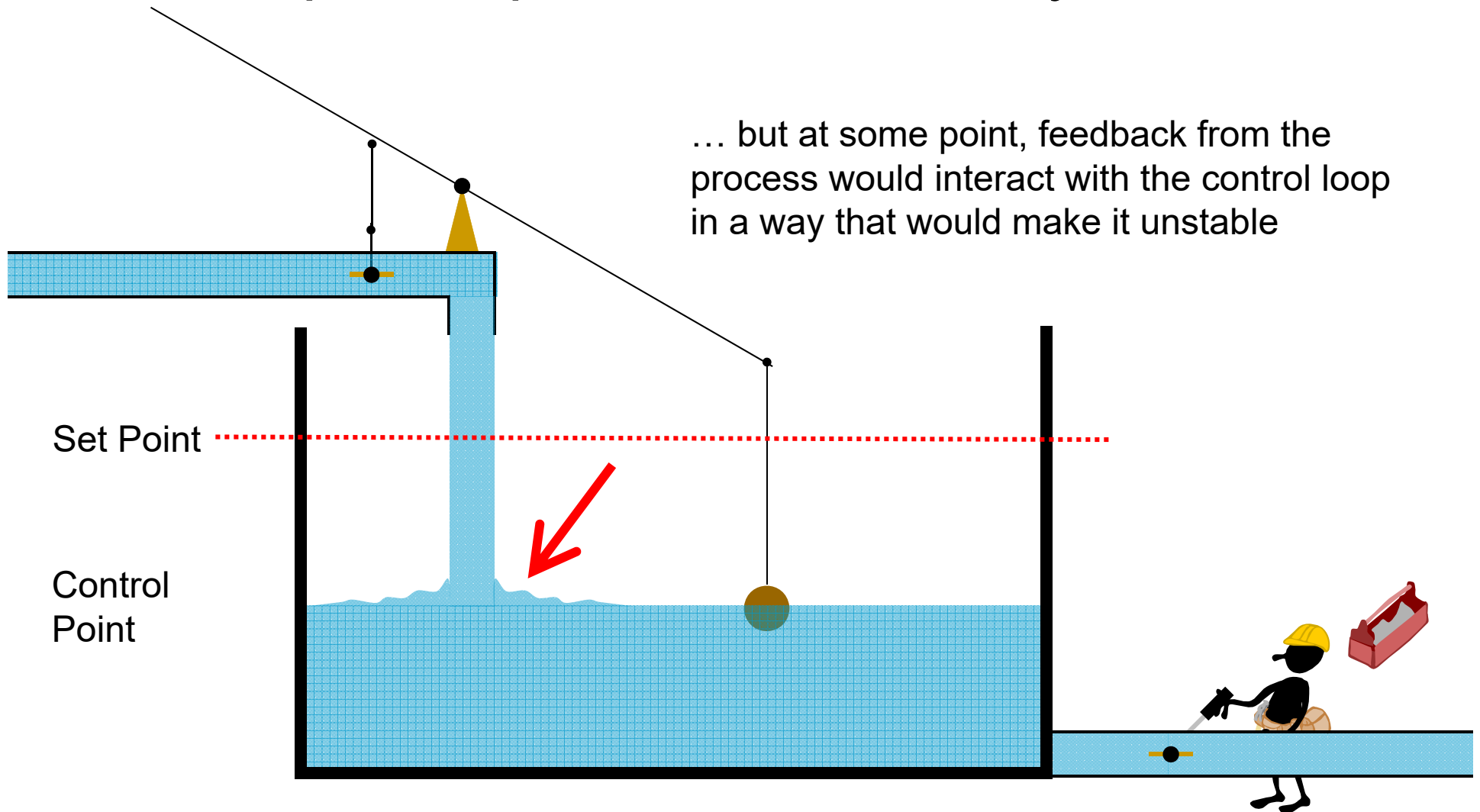


A Simple Proportional Control System

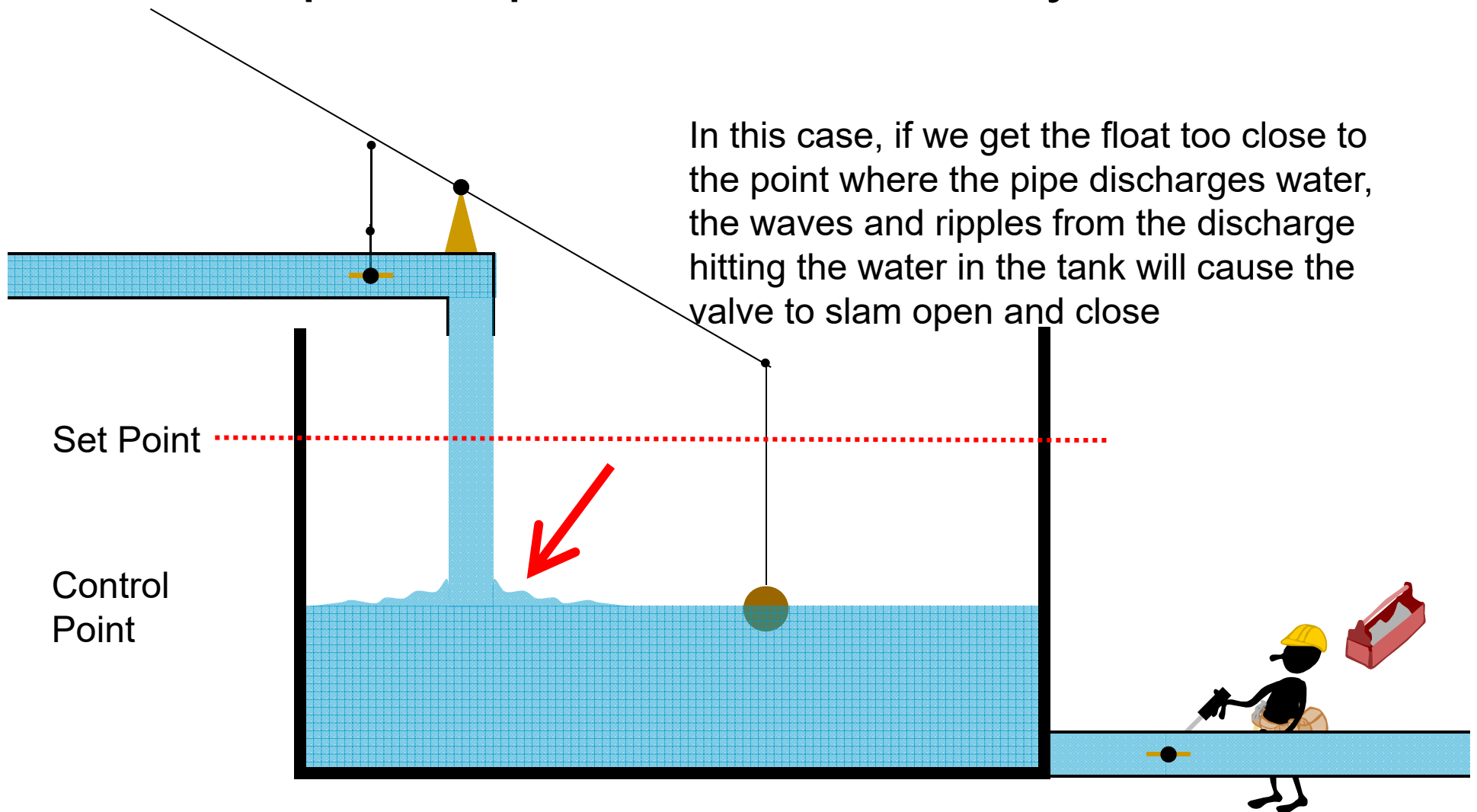


A Simple Proportional Control System

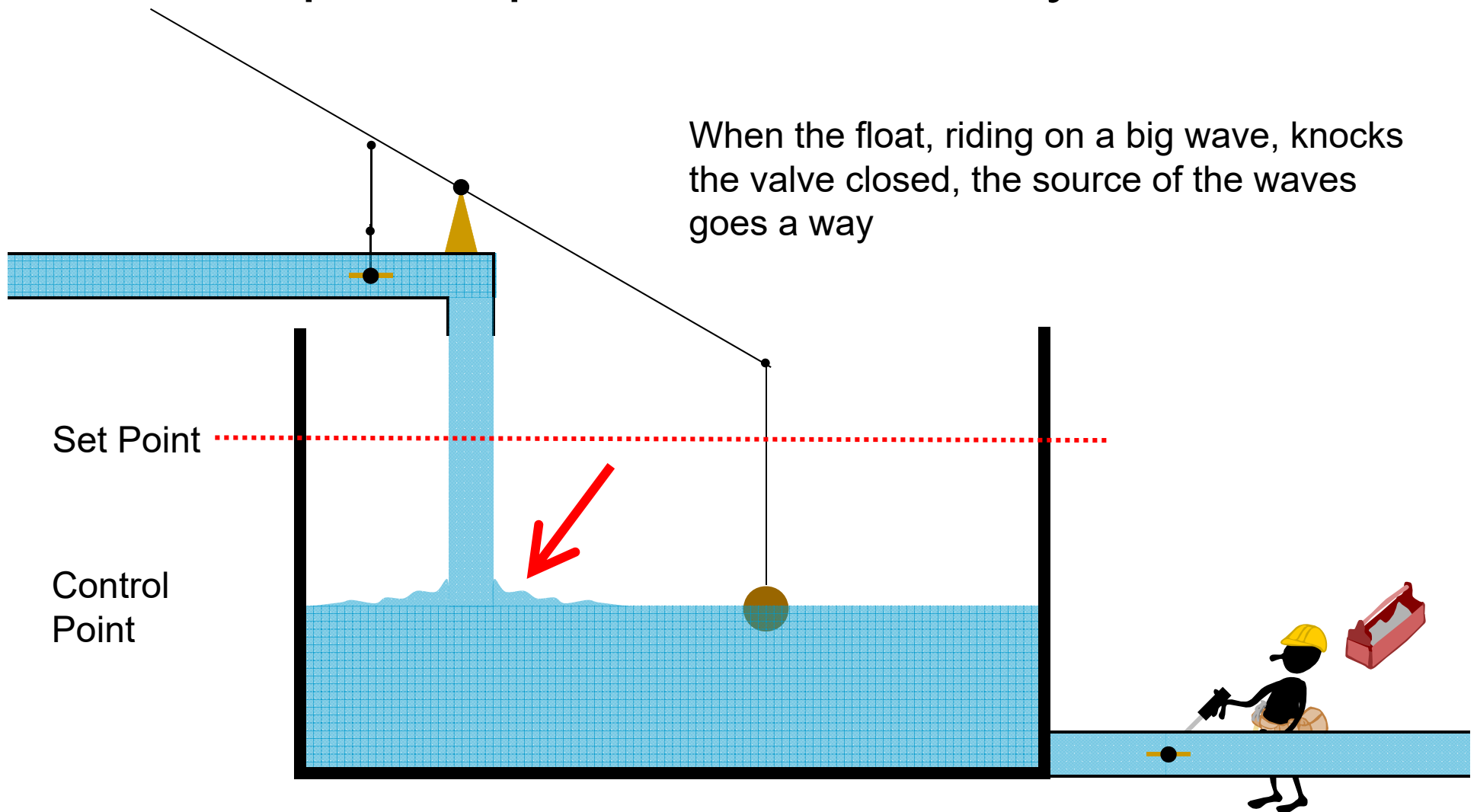
... but at some point, feedback from the process would interact with the control loop in a way that would make it unstable



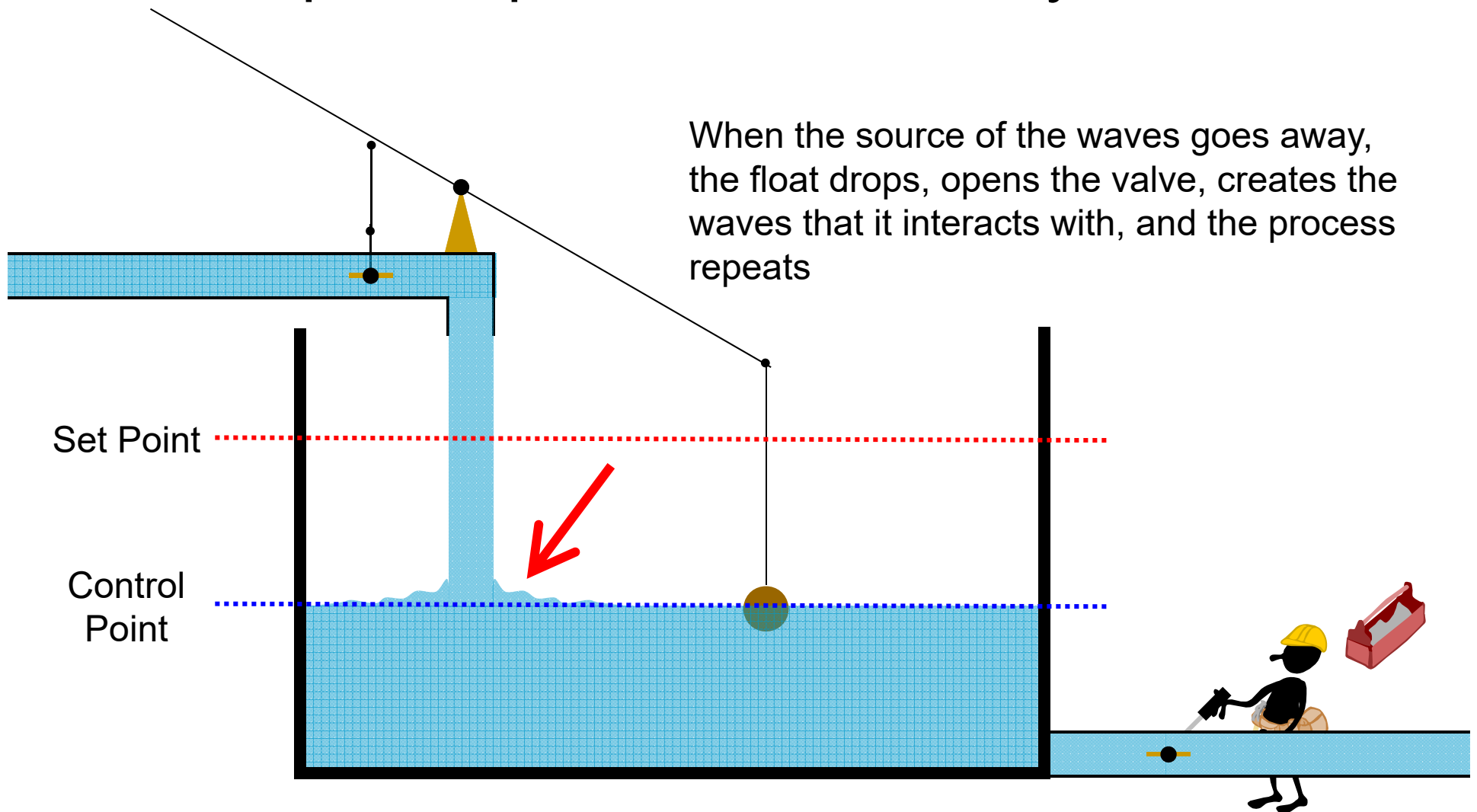
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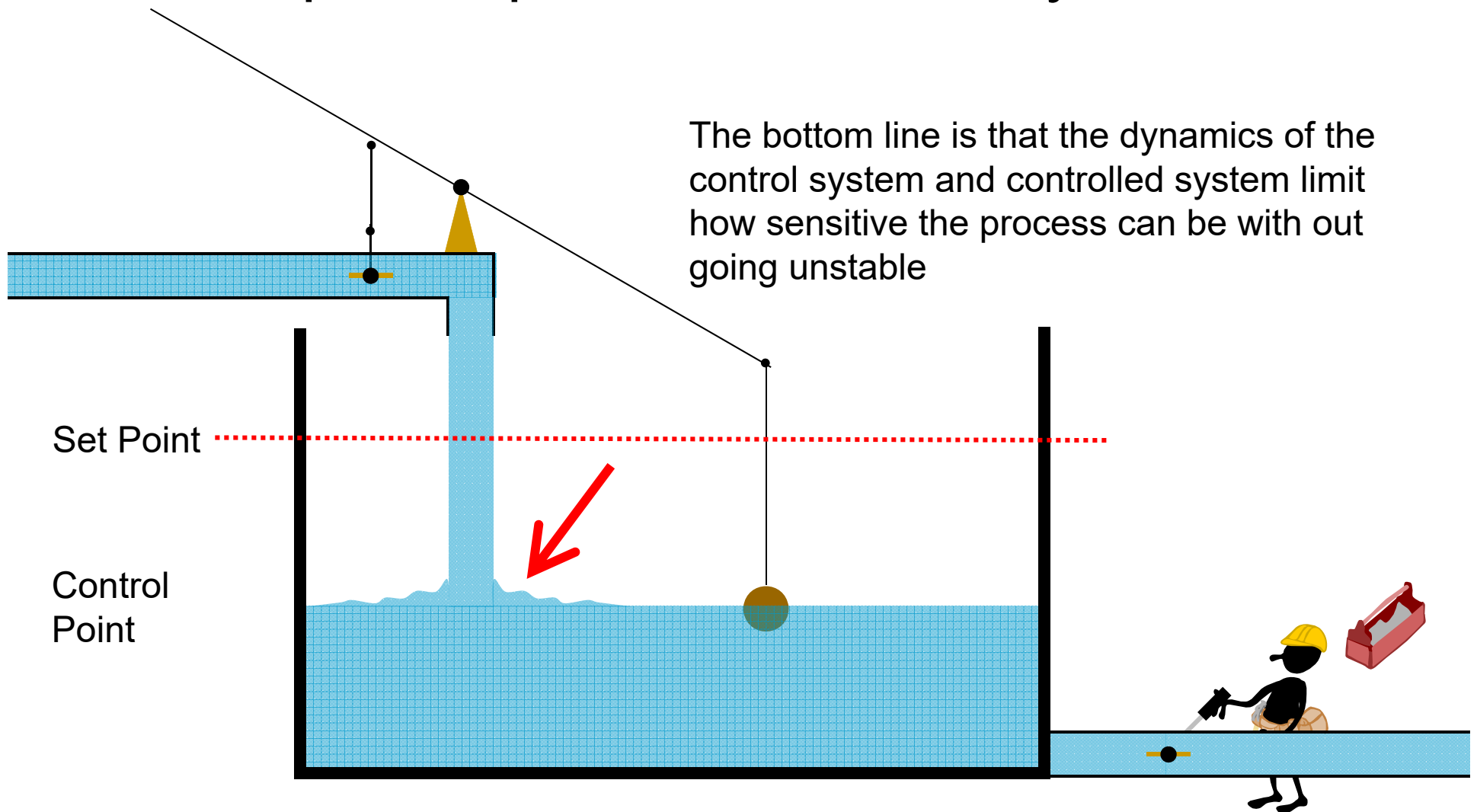
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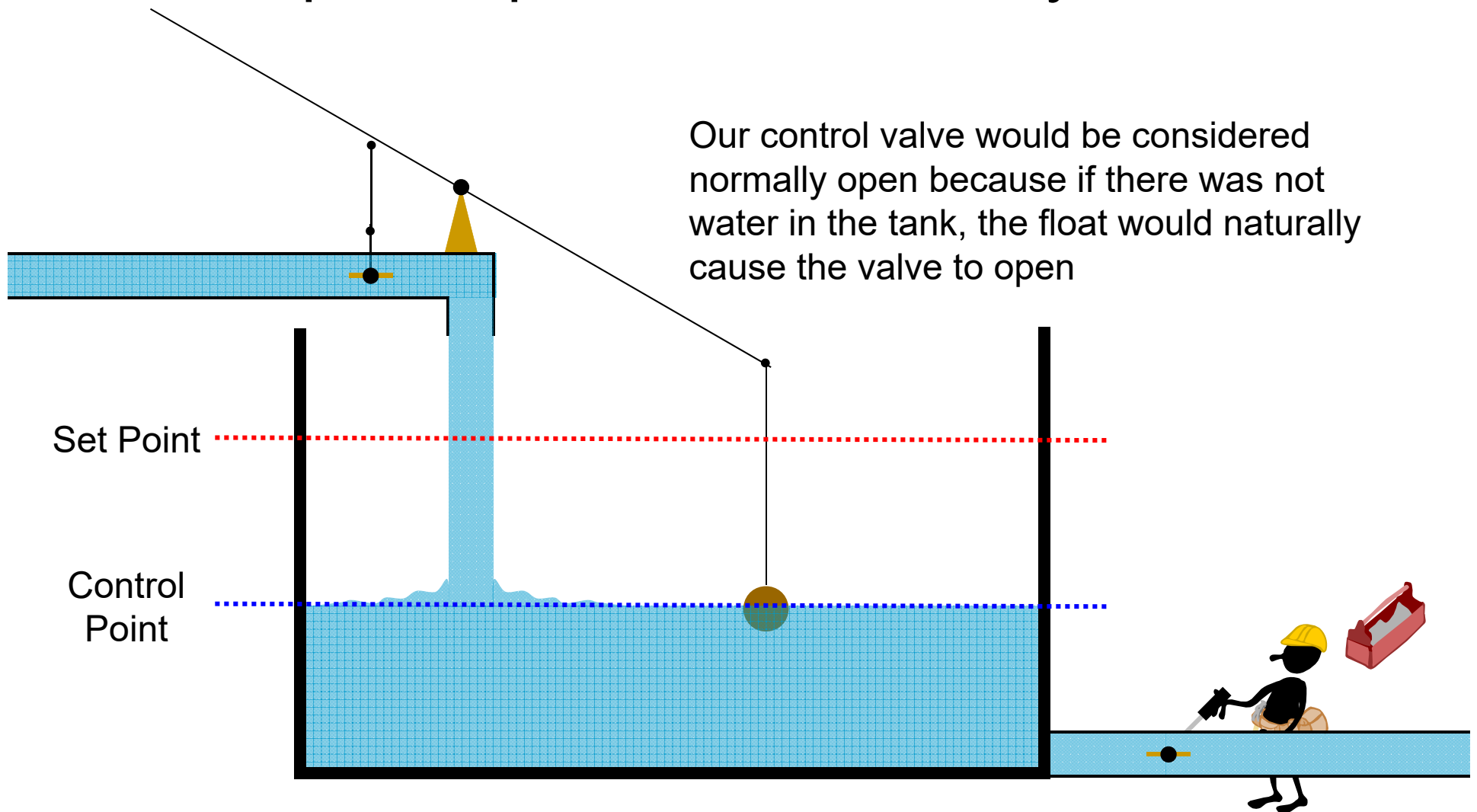
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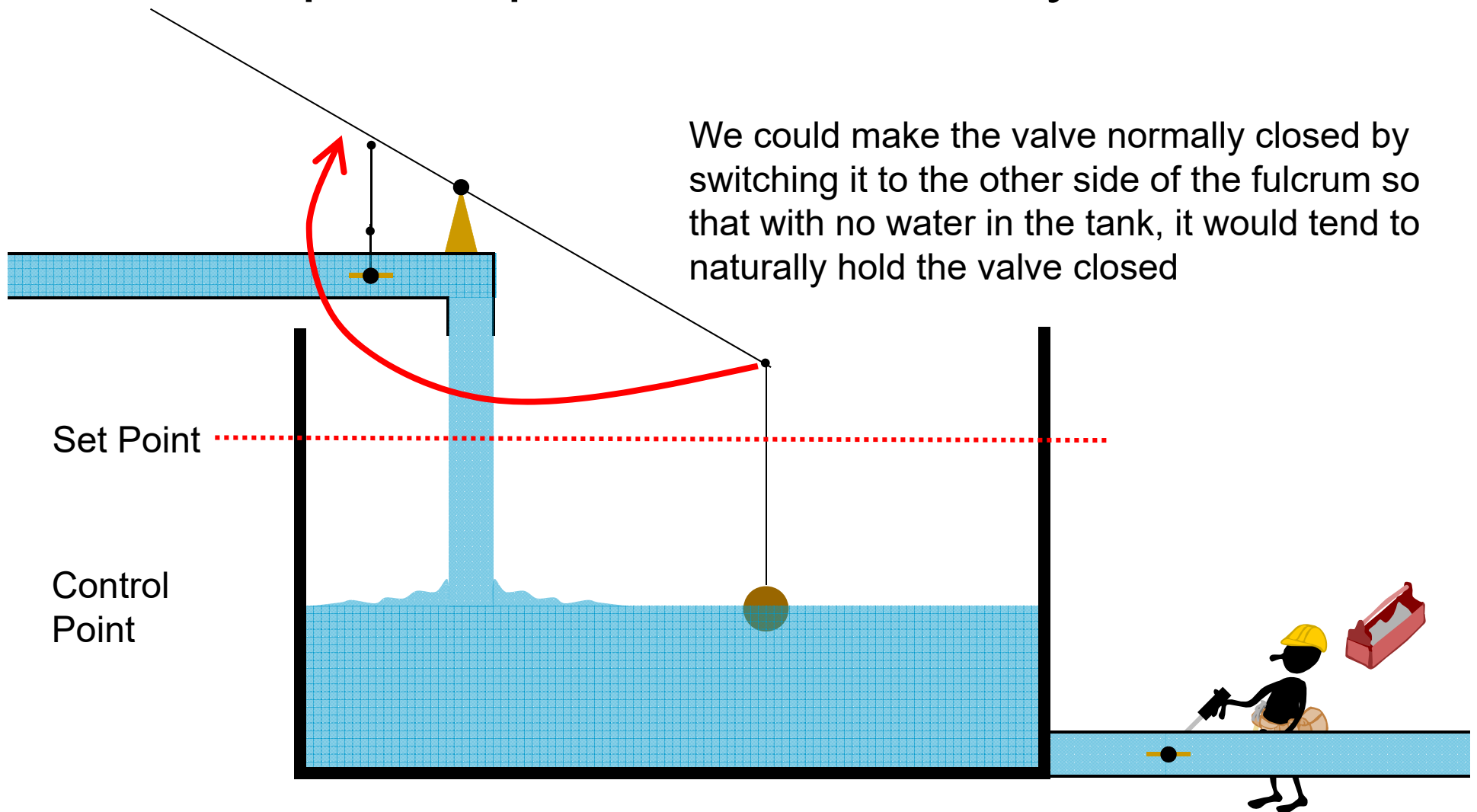
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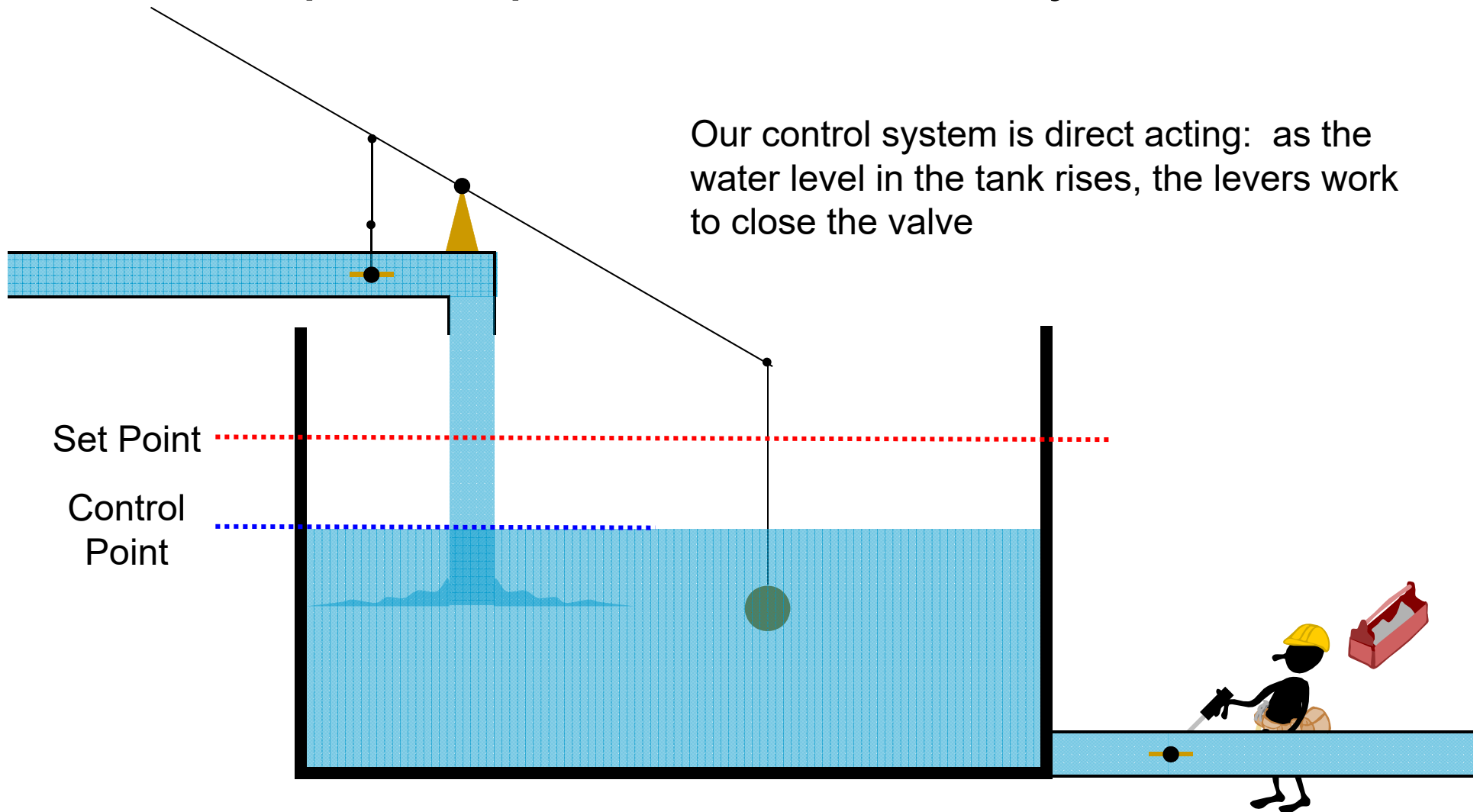


A Simple Proportional Control System



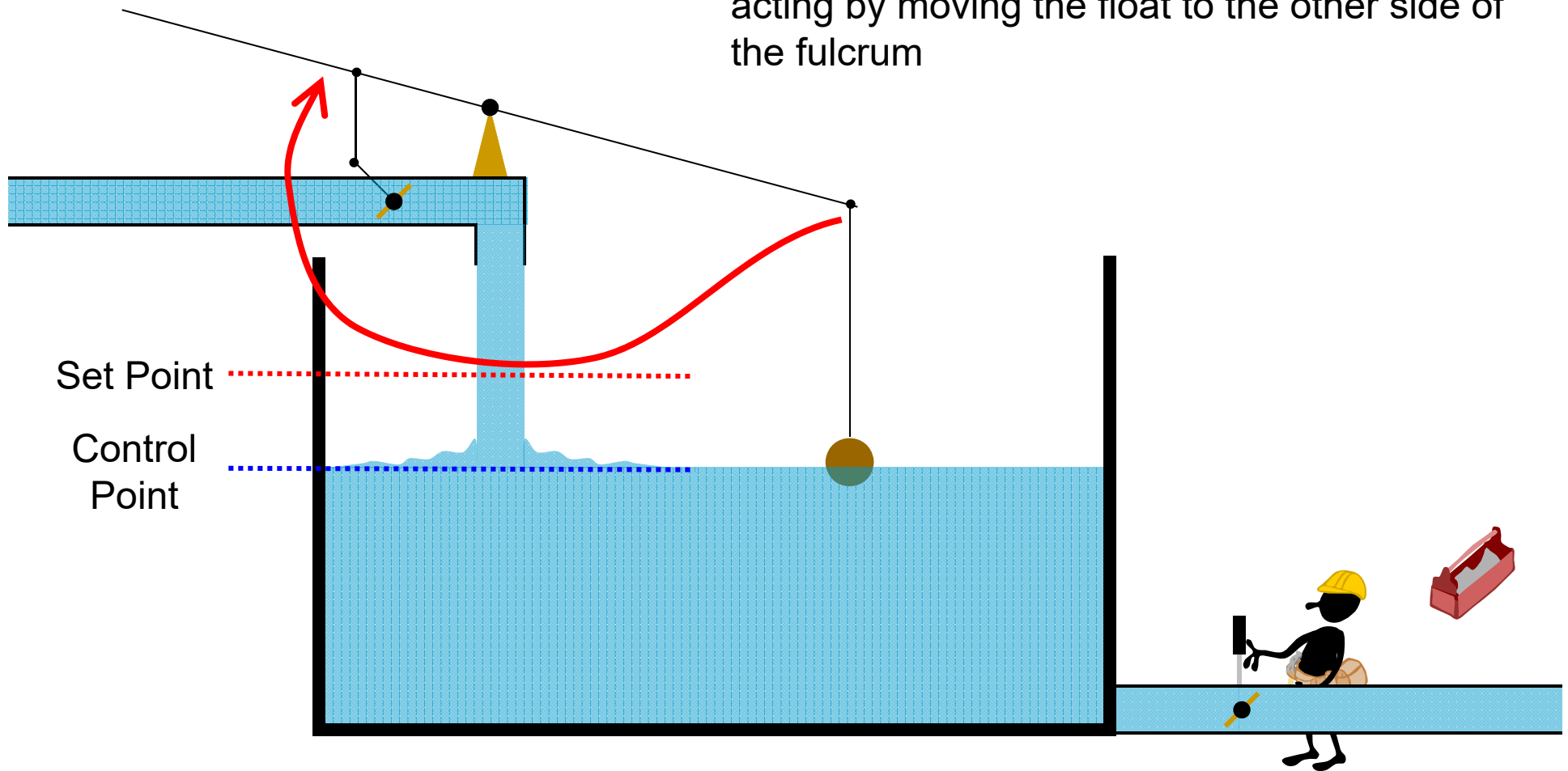
A Simple Proportional Control System

Our control system is direct acting: as the water level in the tank rises, the levers work to close the valve



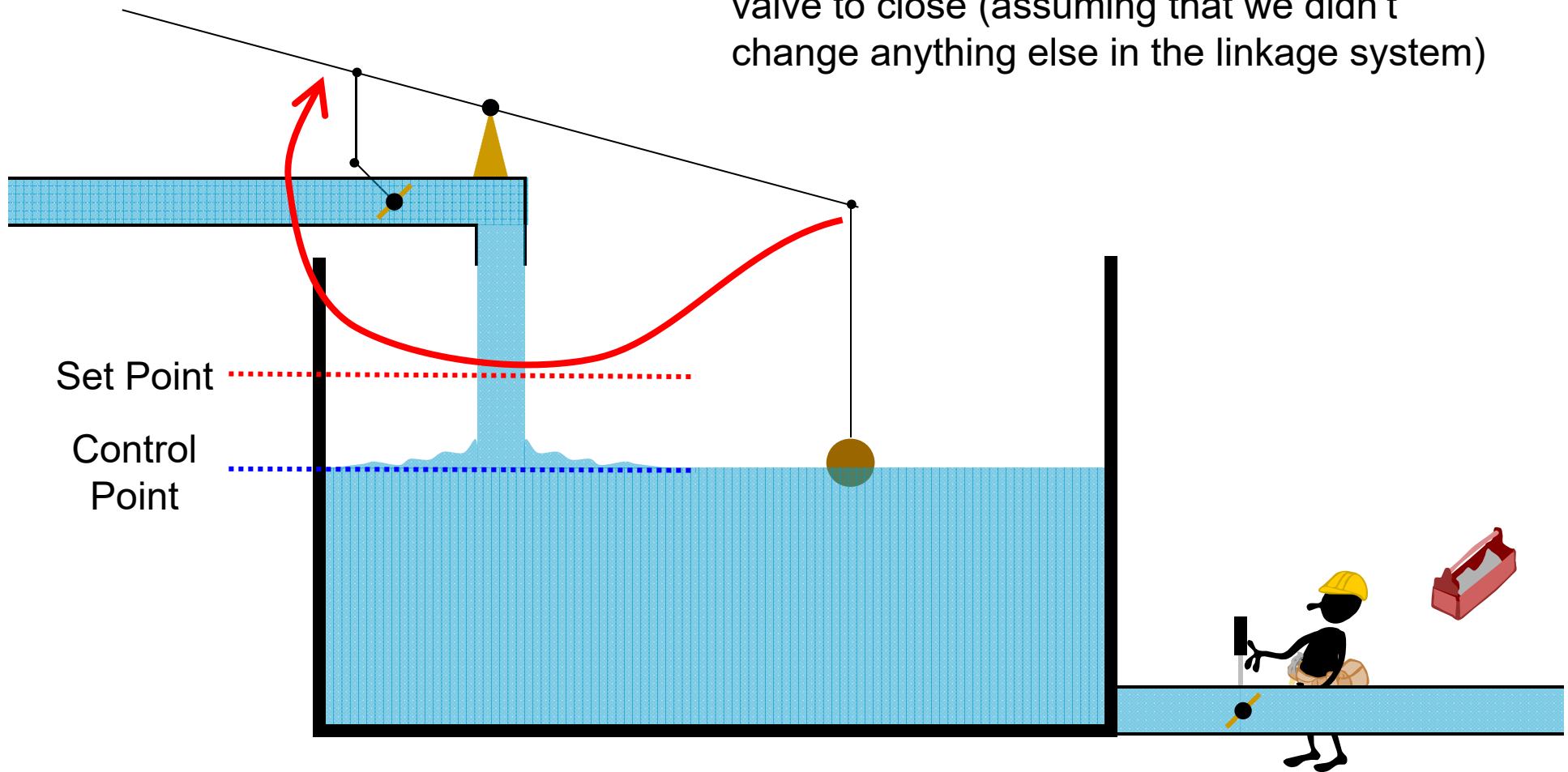
A Simple Proportional Control System

We could make the control system reverse acting by moving the float to the other side of the fulcrum



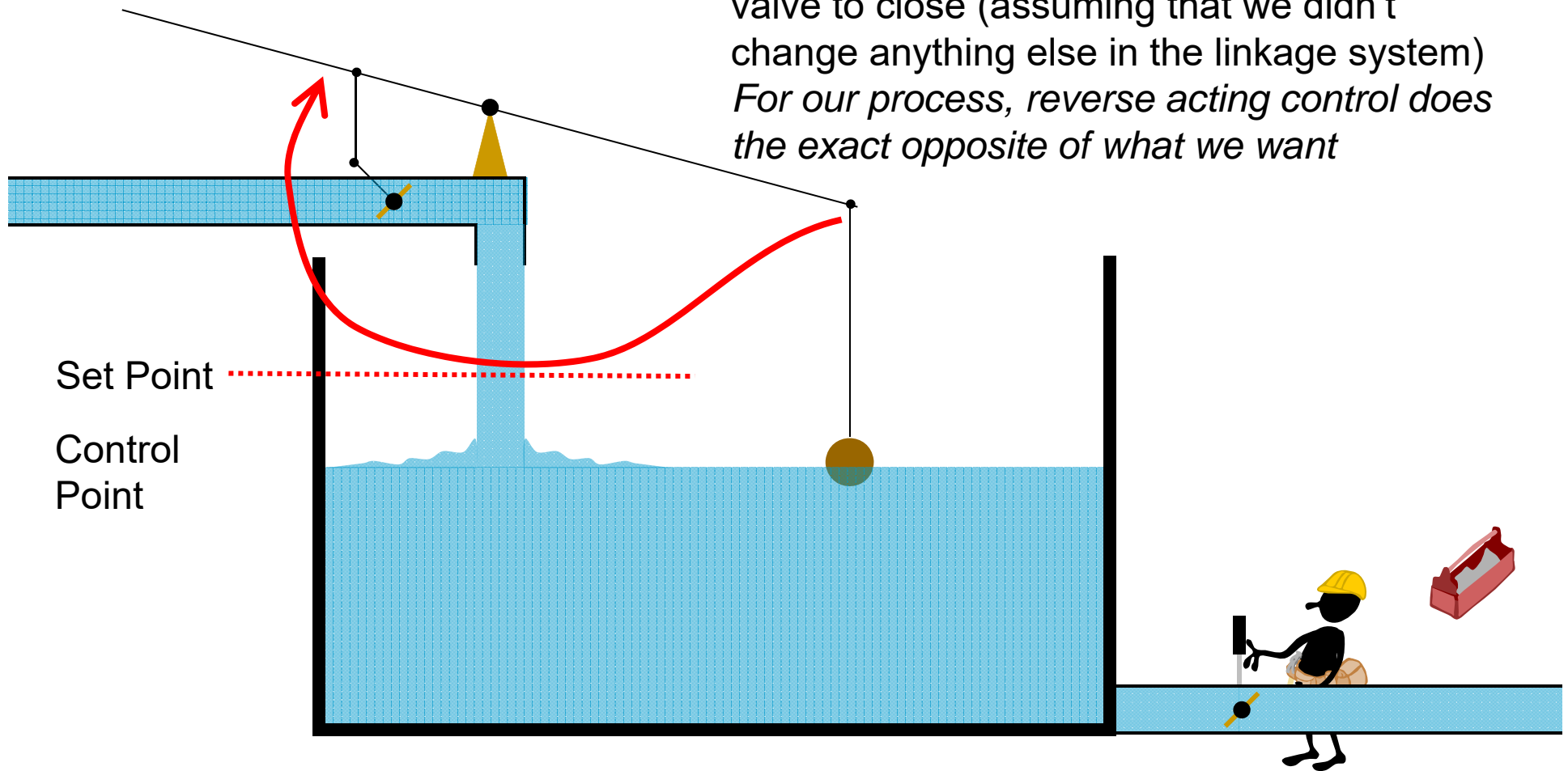
A Simple Proportional Control System

Then a drop in water level would cause the valve to close (assuming that we didn't change anything else in the linkage system)



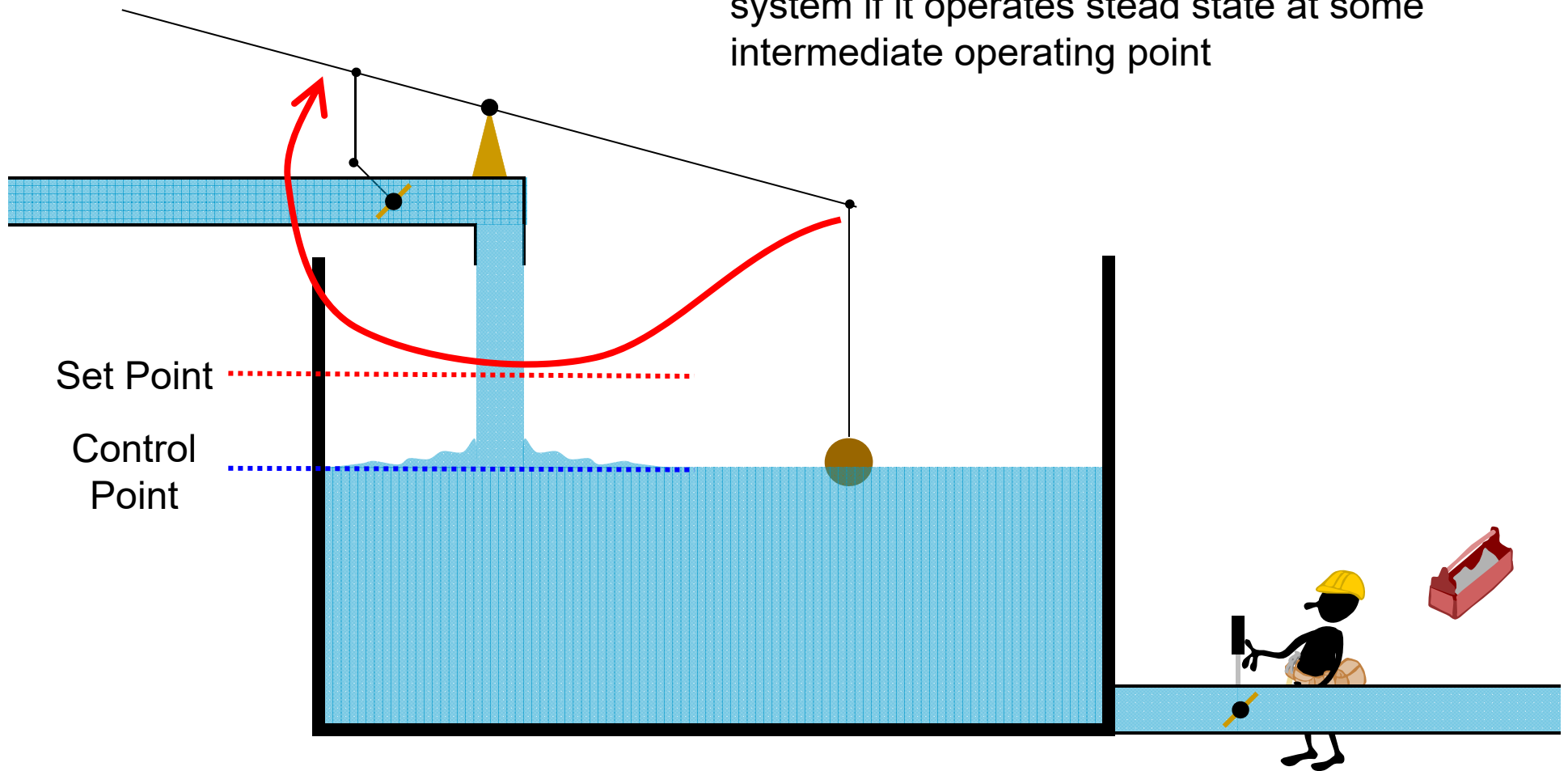
A Simple Proportional Control System

Then a drop in water level would cause the valve to close (assuming that we didn't change anything else in the linkage system)
For our process, reverse acting control does the exact opposite of what we want

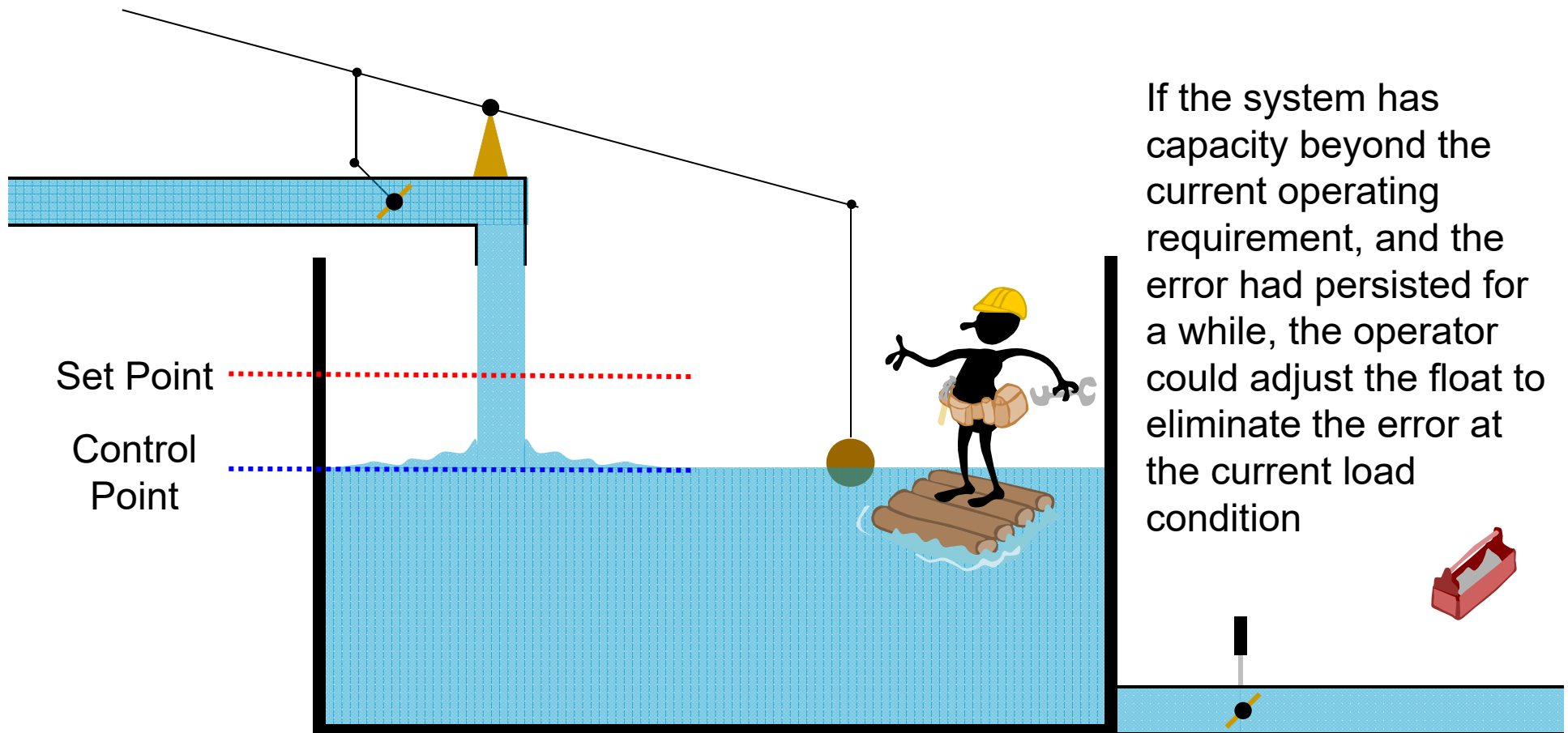


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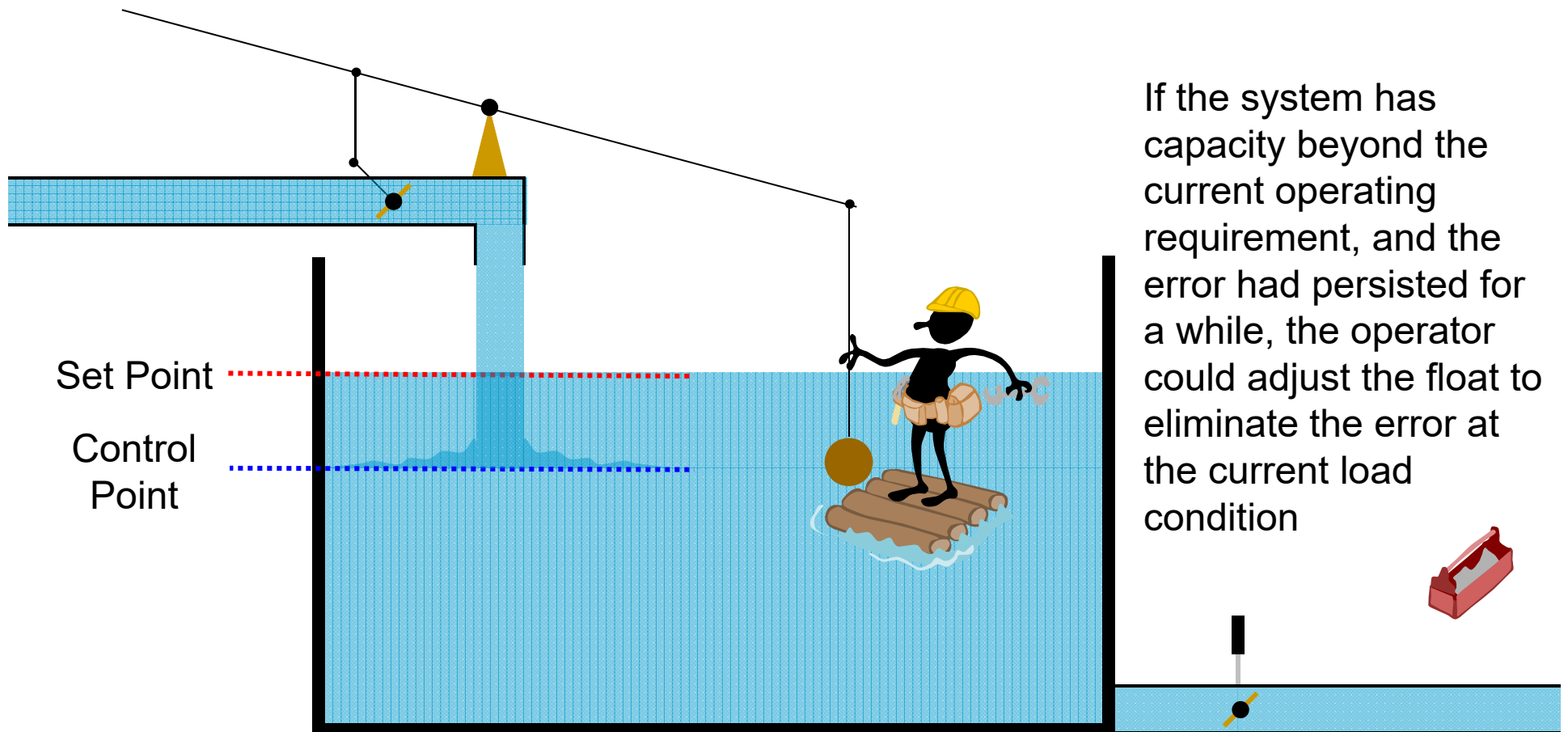
Now lets consider what happens with this system if it operates steady state at some intermediate operating point



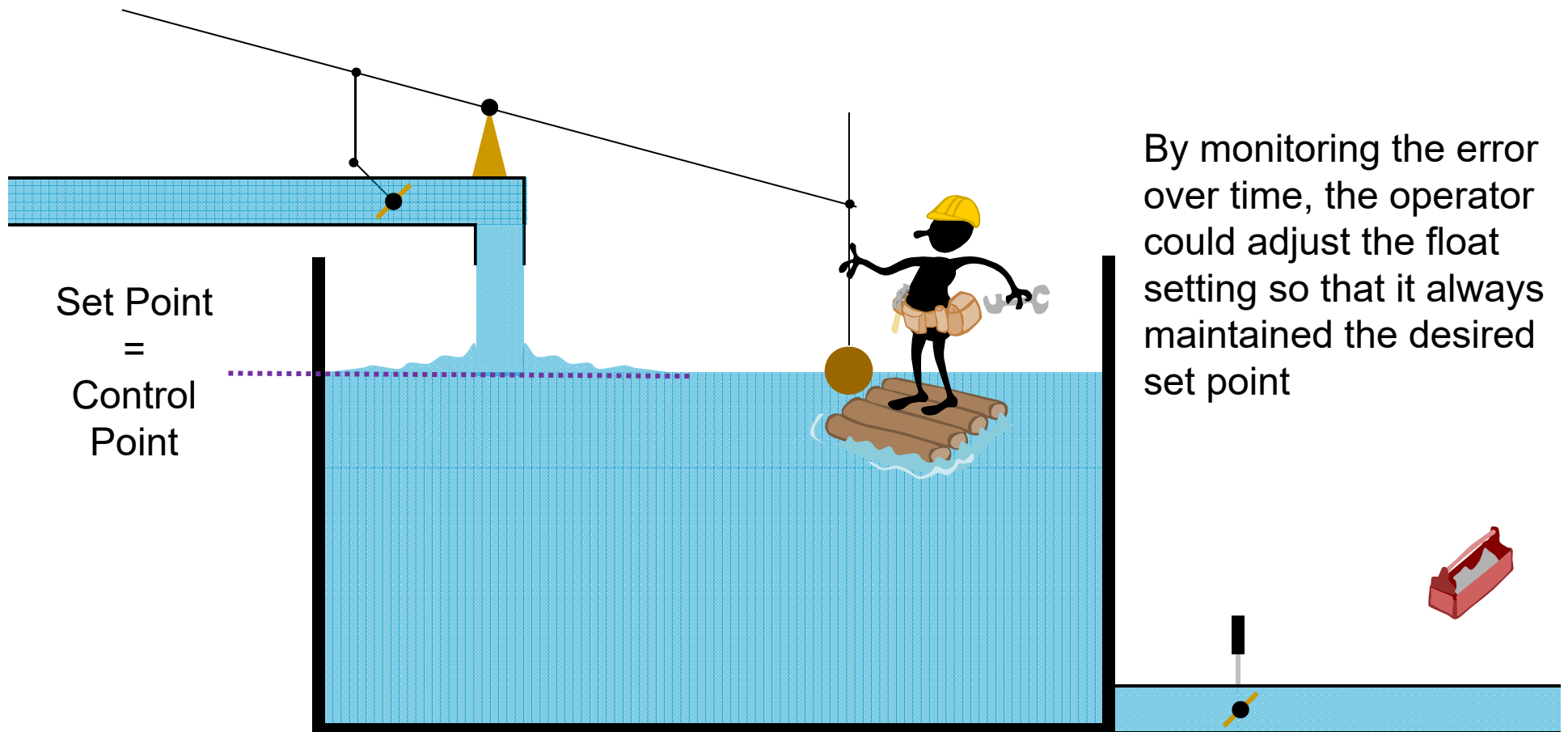
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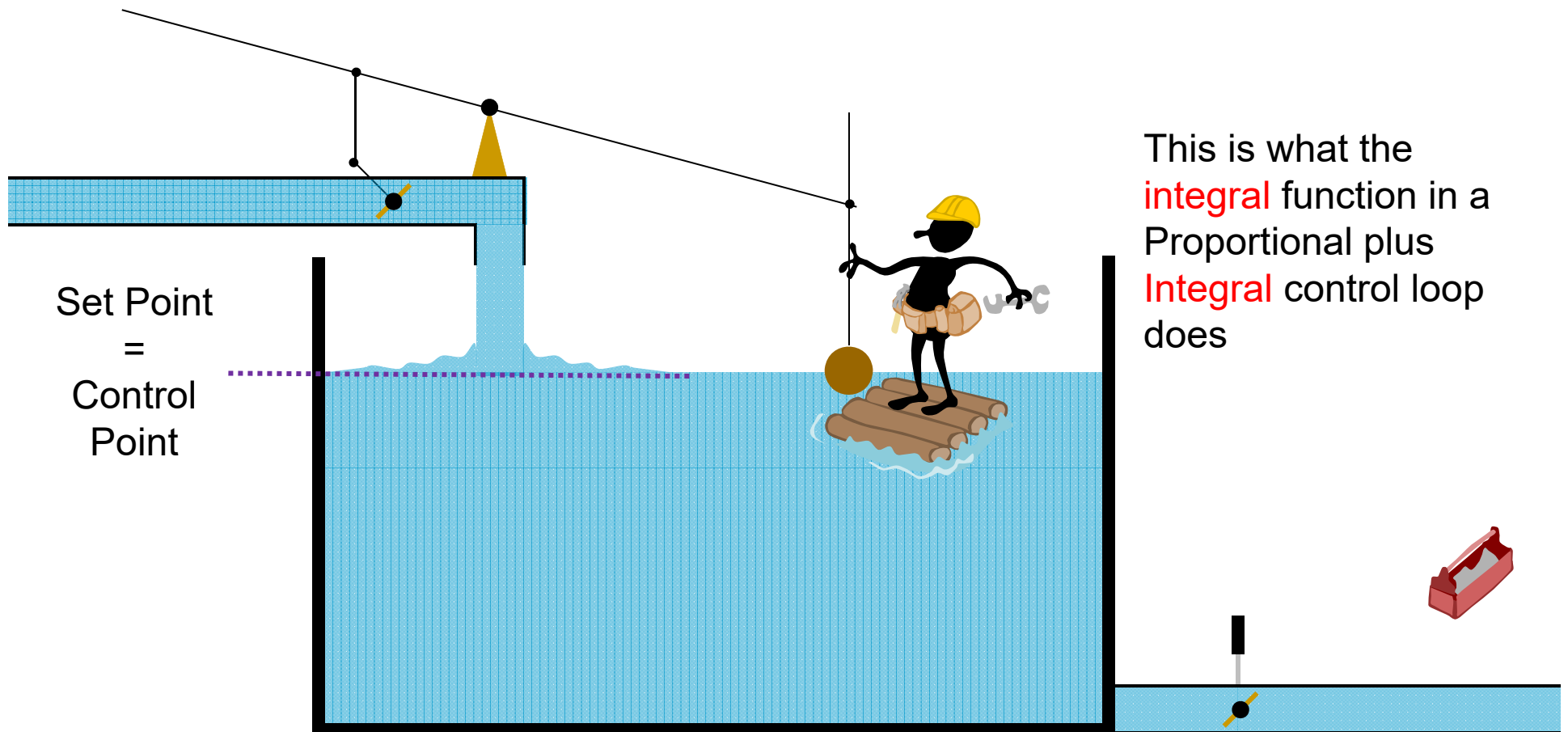
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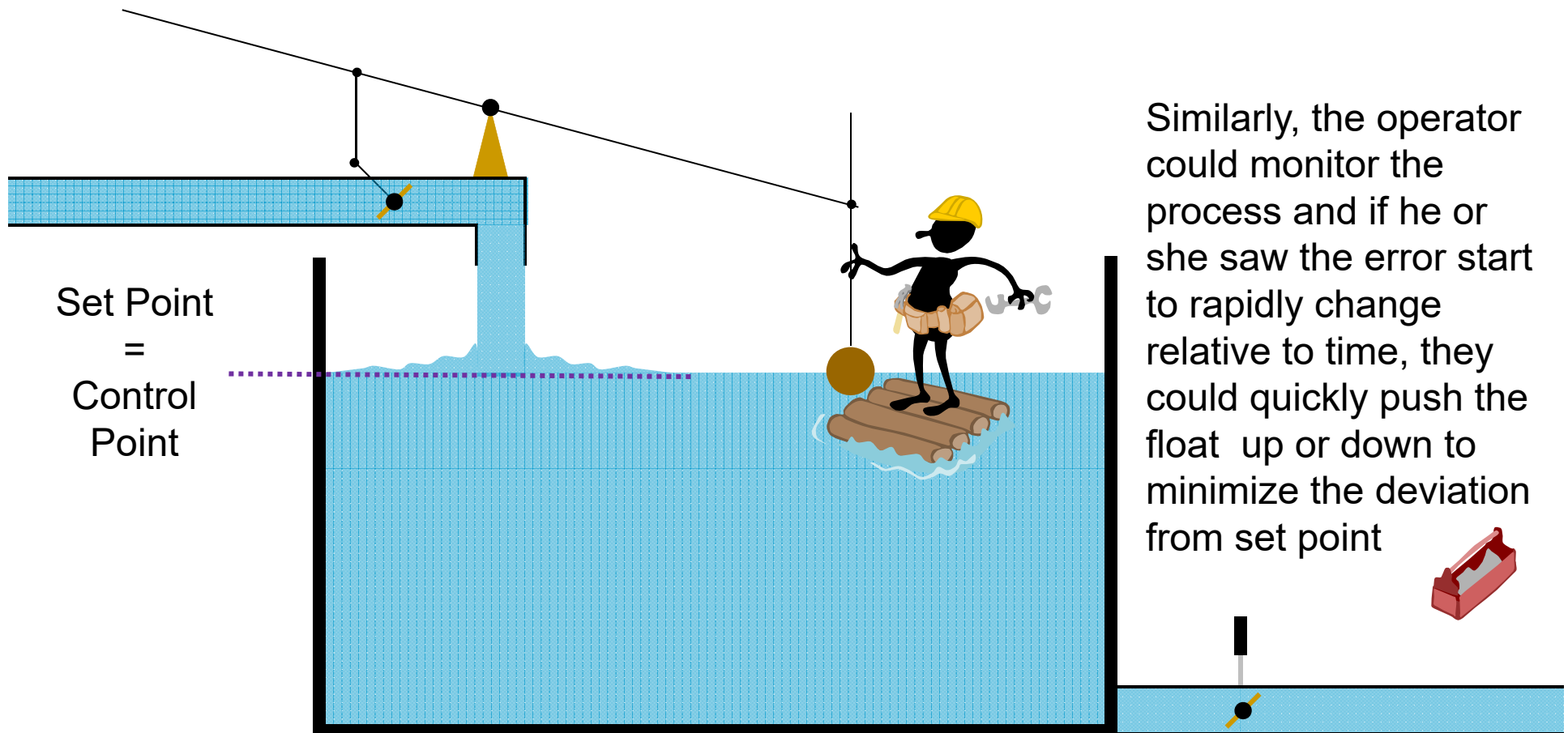
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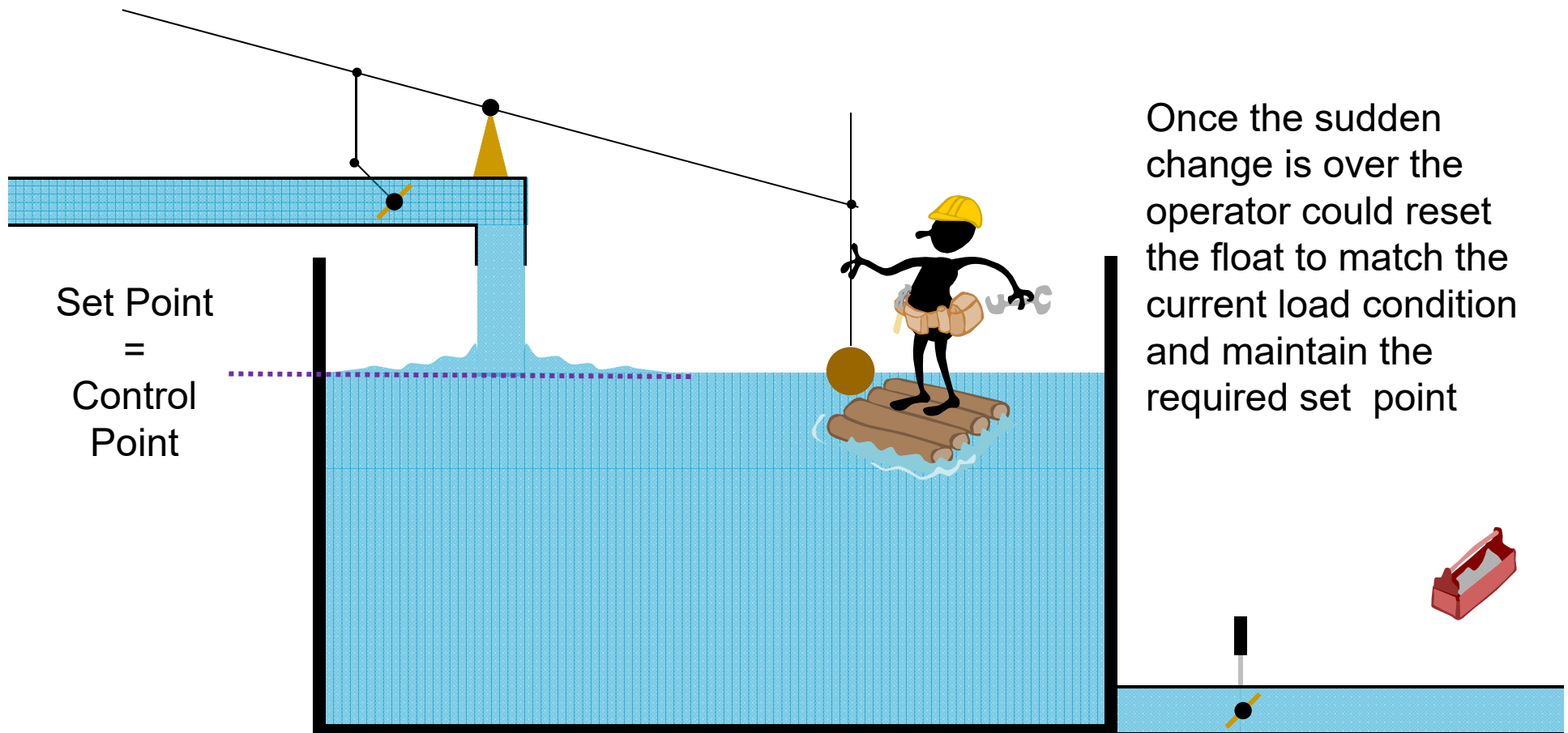
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