

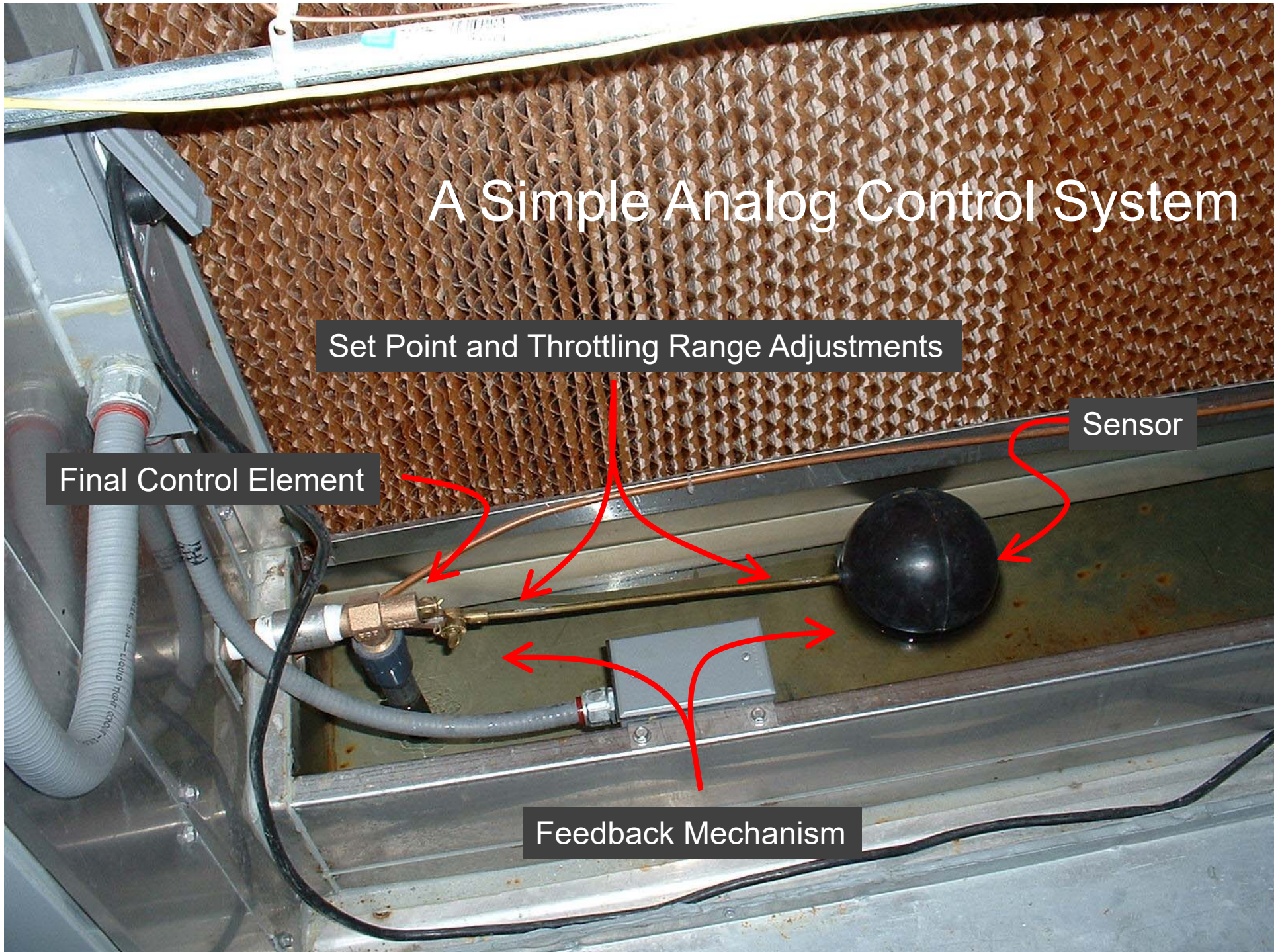
A Simple Analog Control System

Set Point and Throttling Range Adjustments

Final Control Element

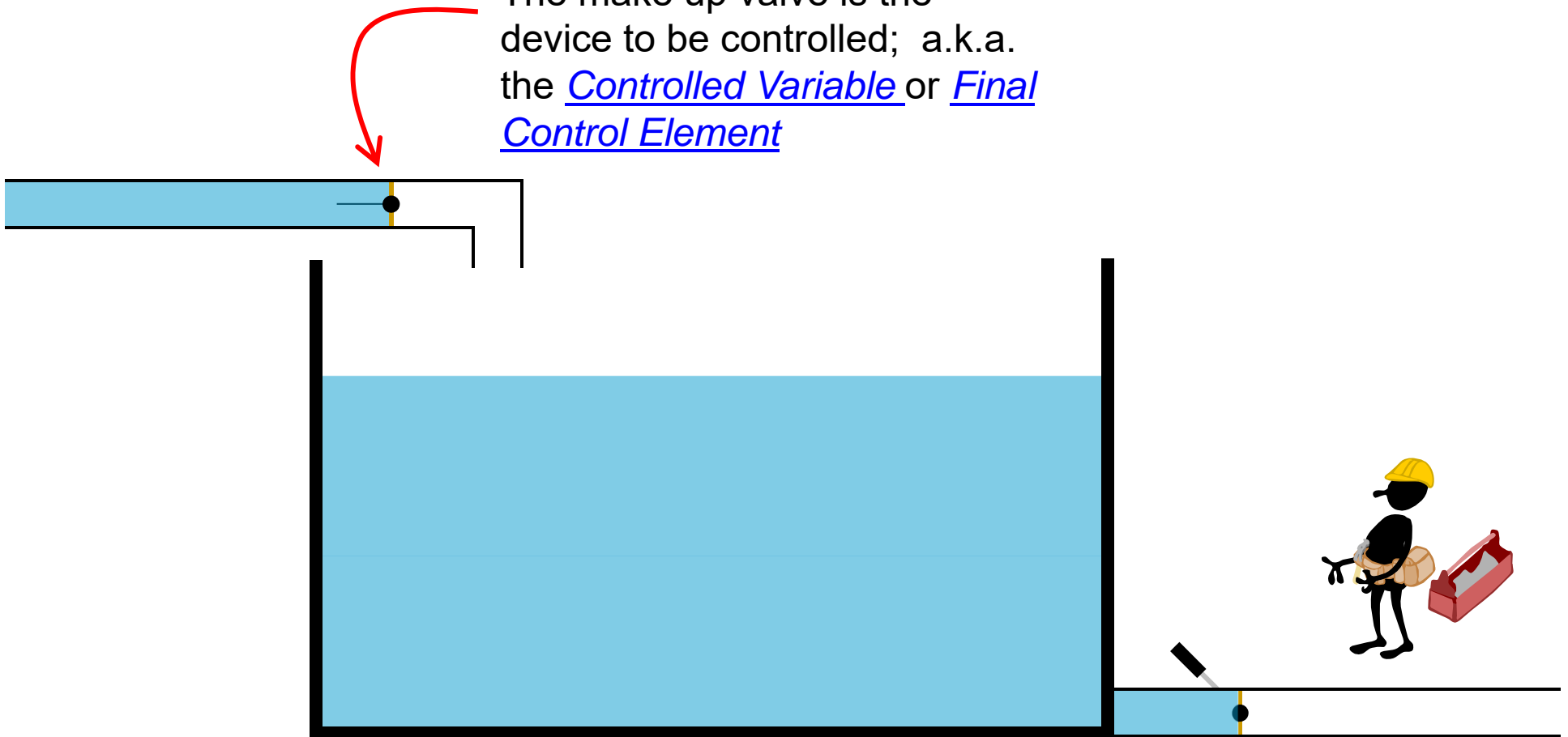
Sensor

Feedback Mechanism

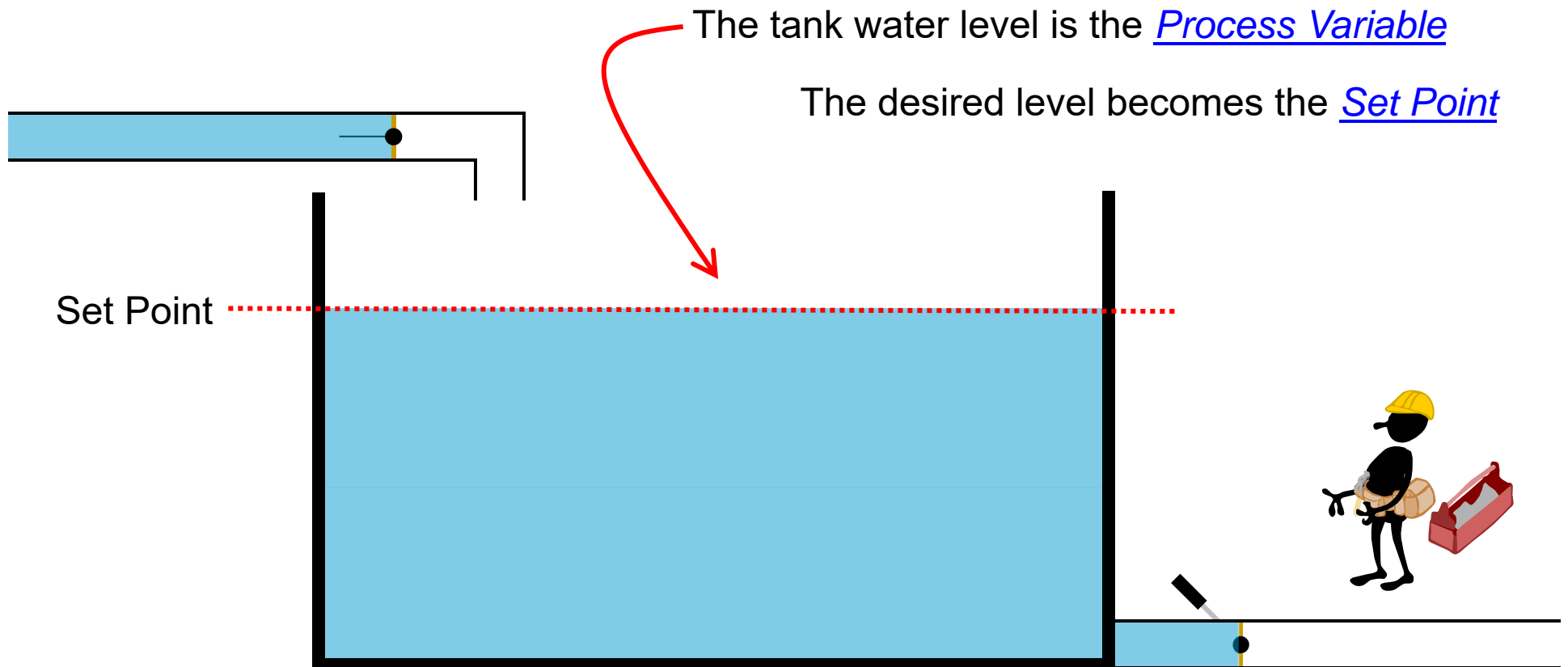


A Simple Control Requirement

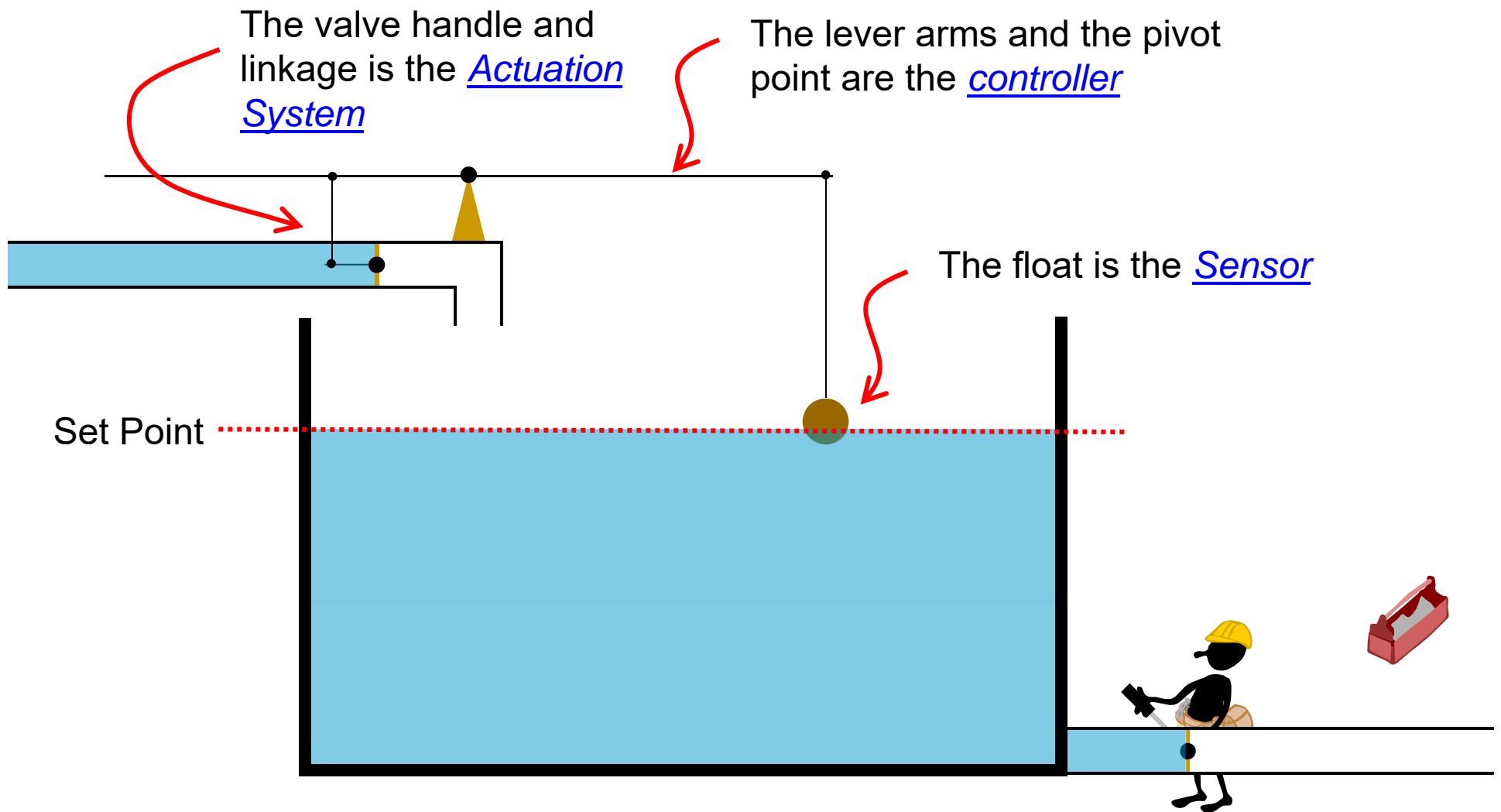
The make up valve is the device to be controlled; a.k.a. the Controlled Variable or Final Control Element



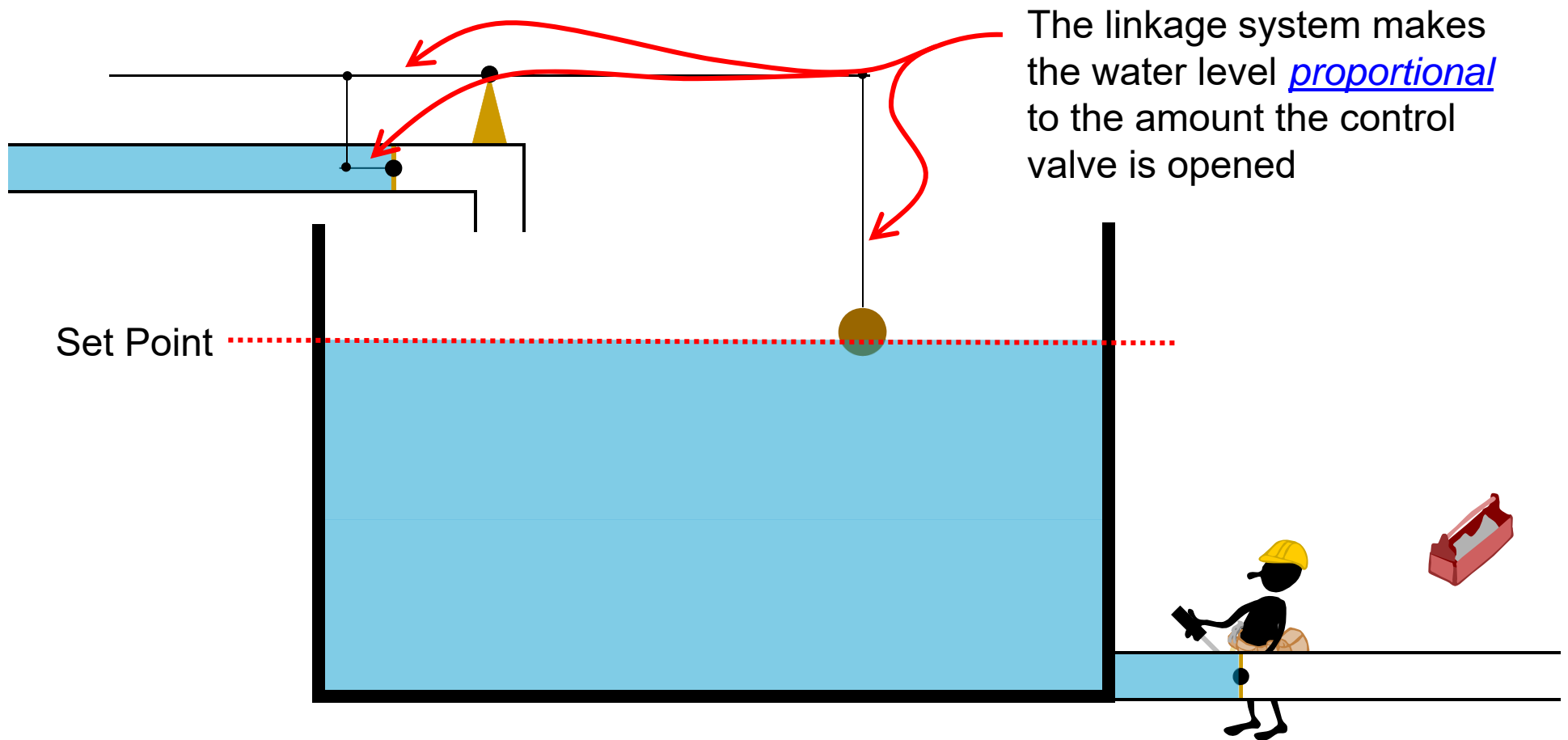
A Simple Control Requirement



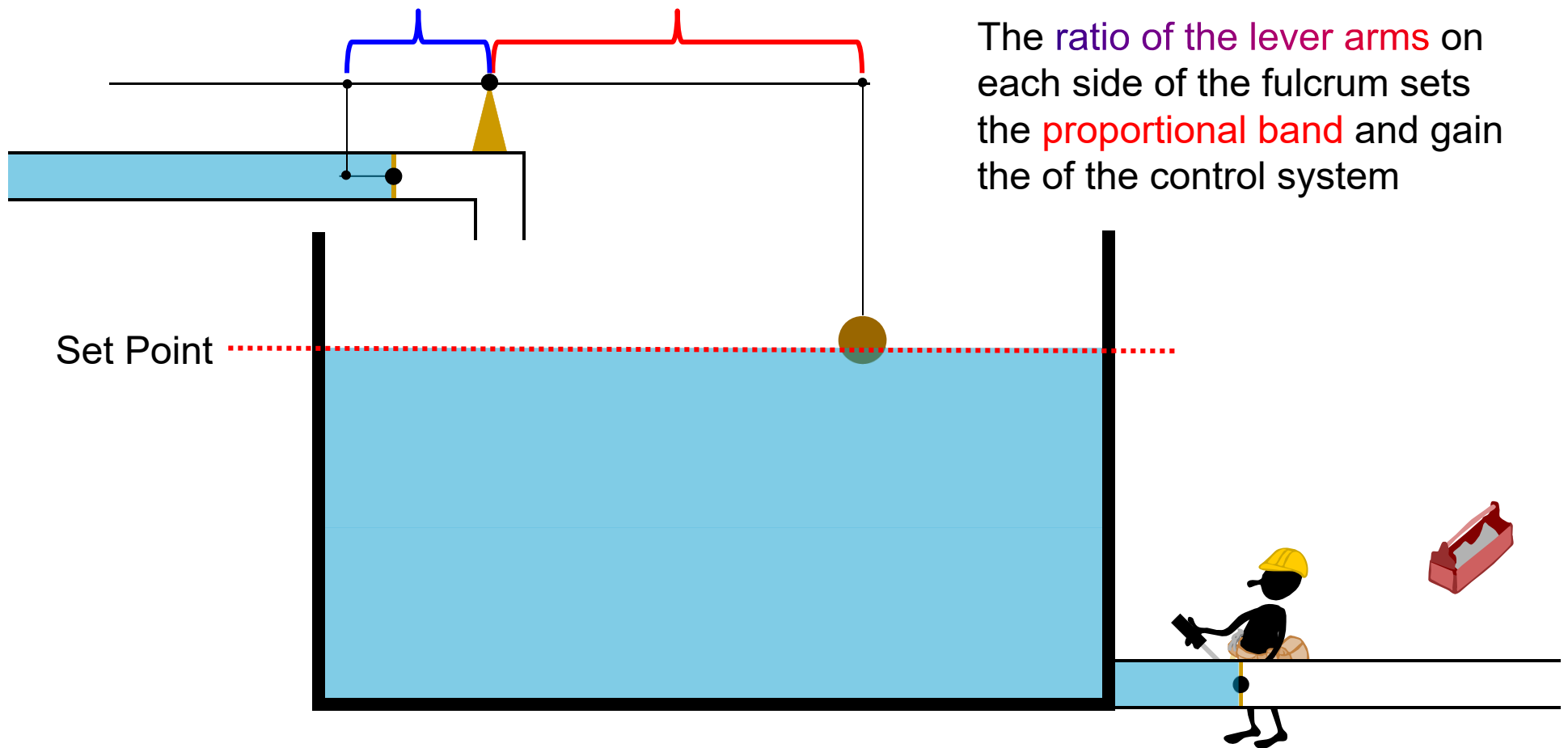
A Simple Proportional Control System



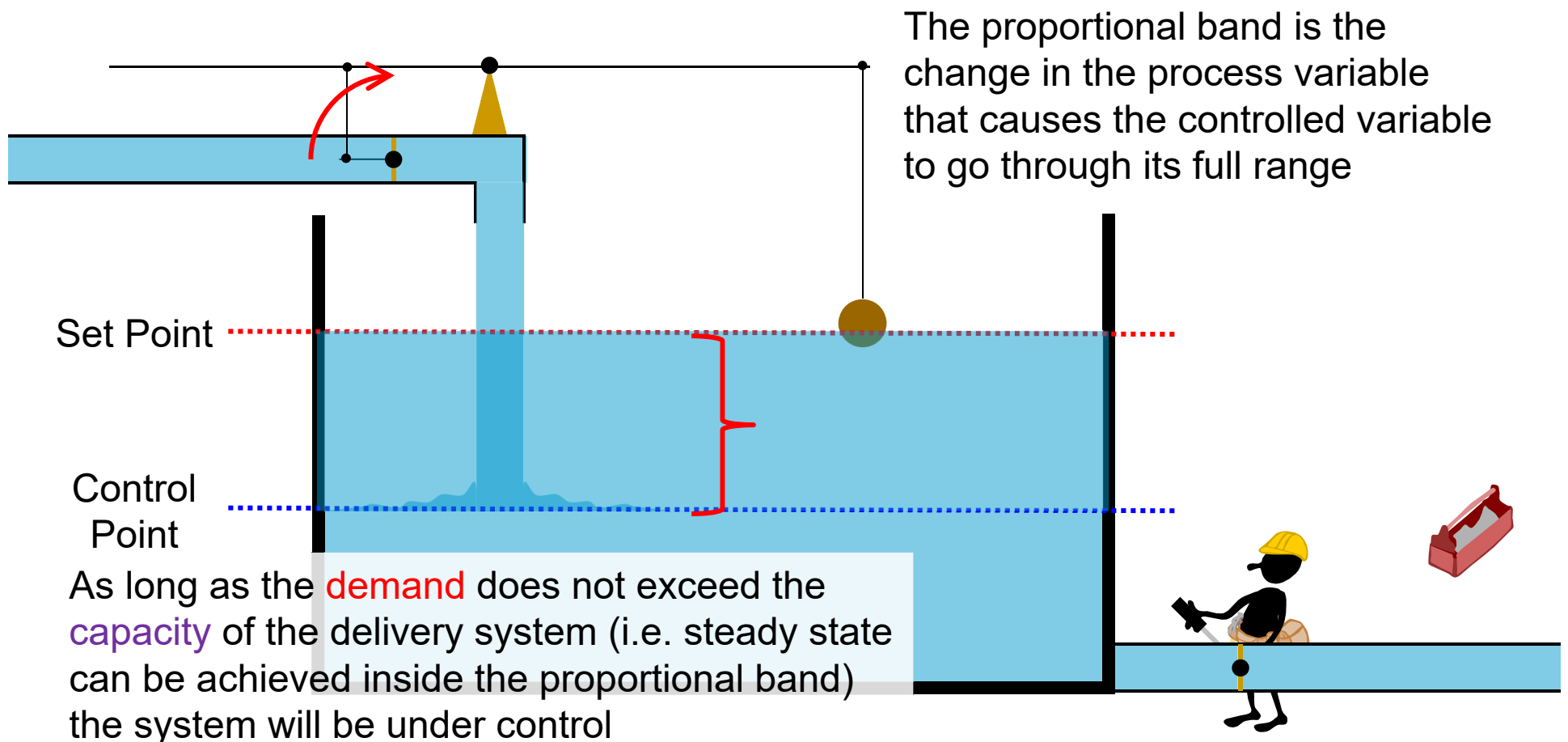
A Simple Proportional Control System



A Simple Proportional Control System

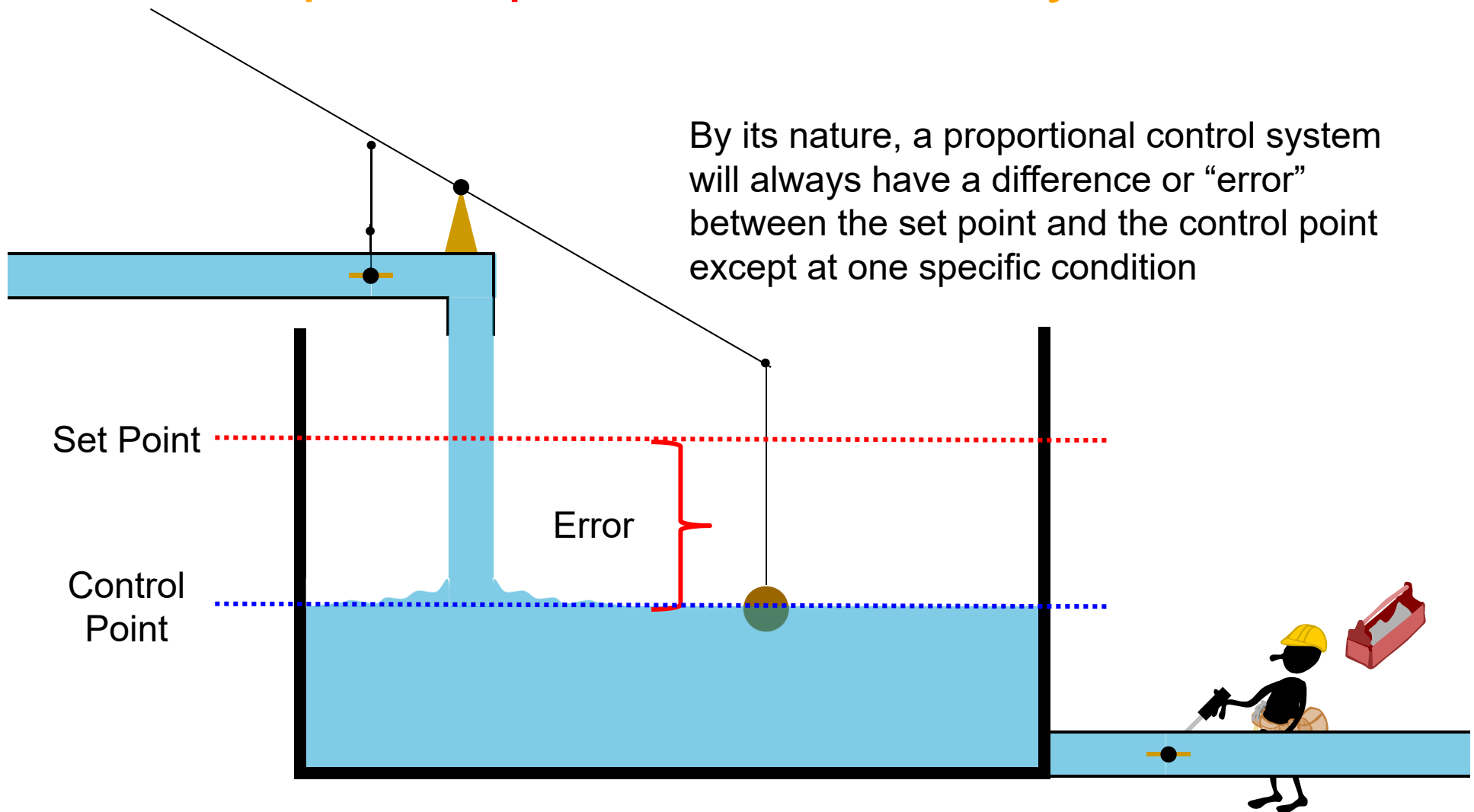


A Simple Proportional Control System

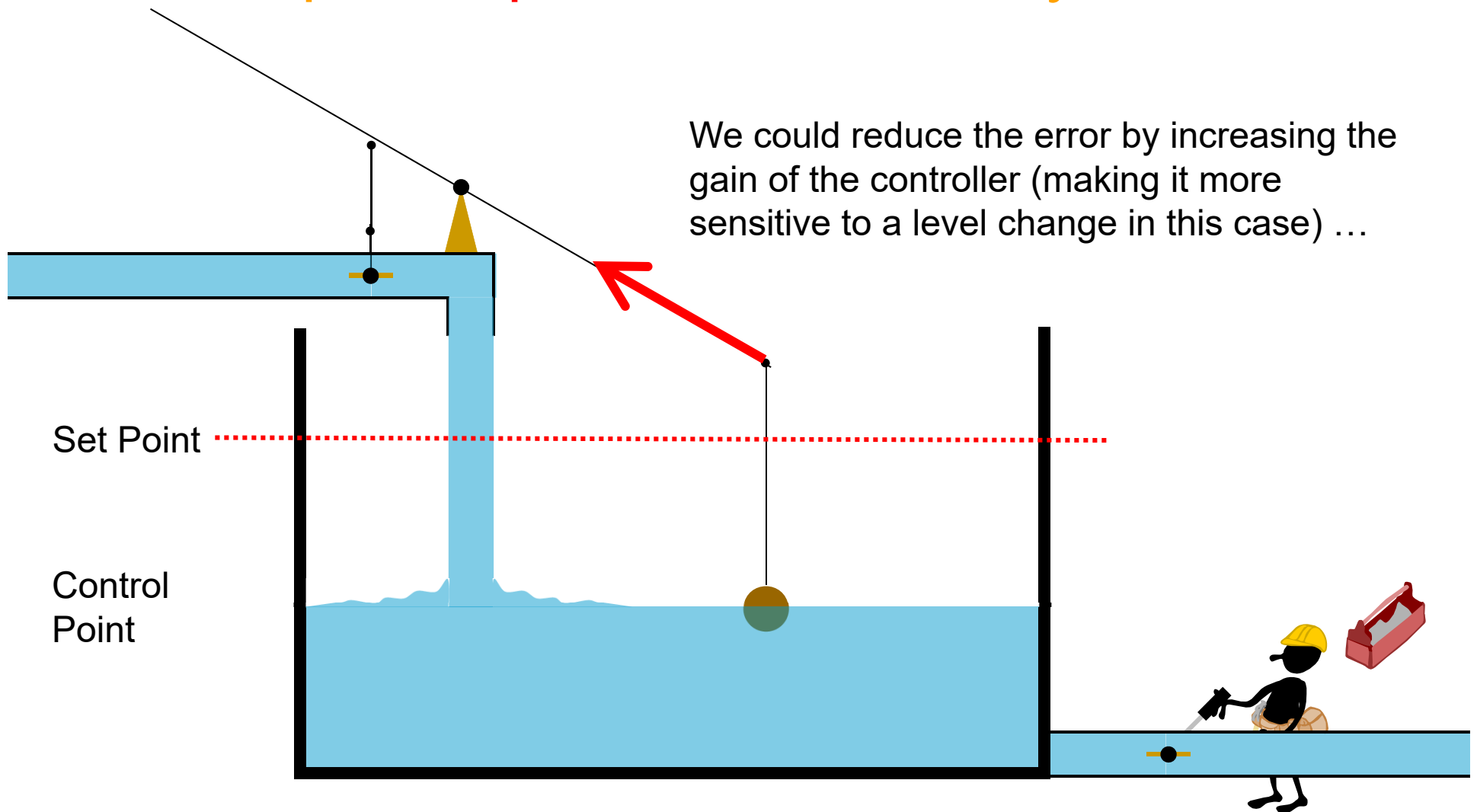


A Simple Proportional Control System

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

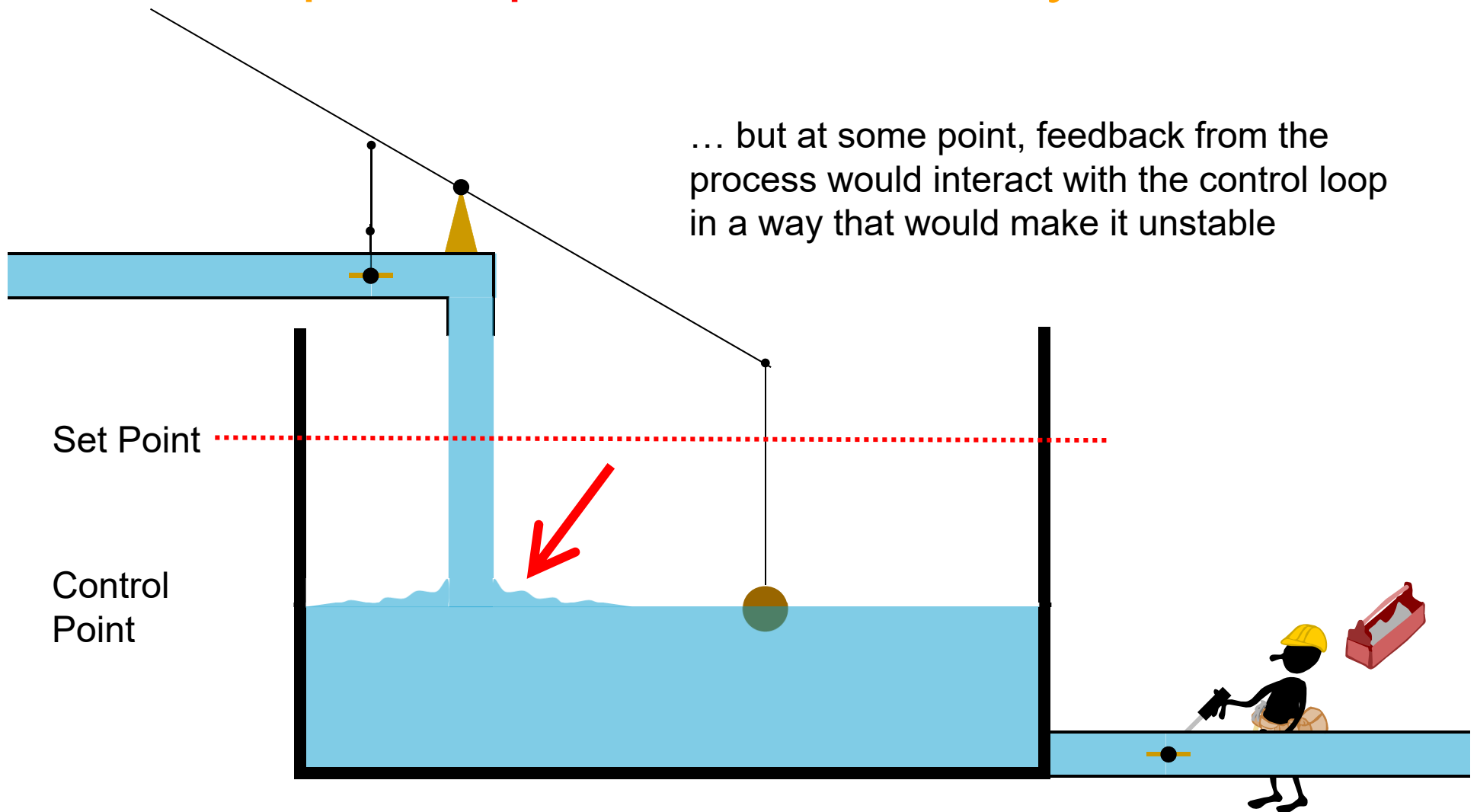


A Simple Proportional Control System



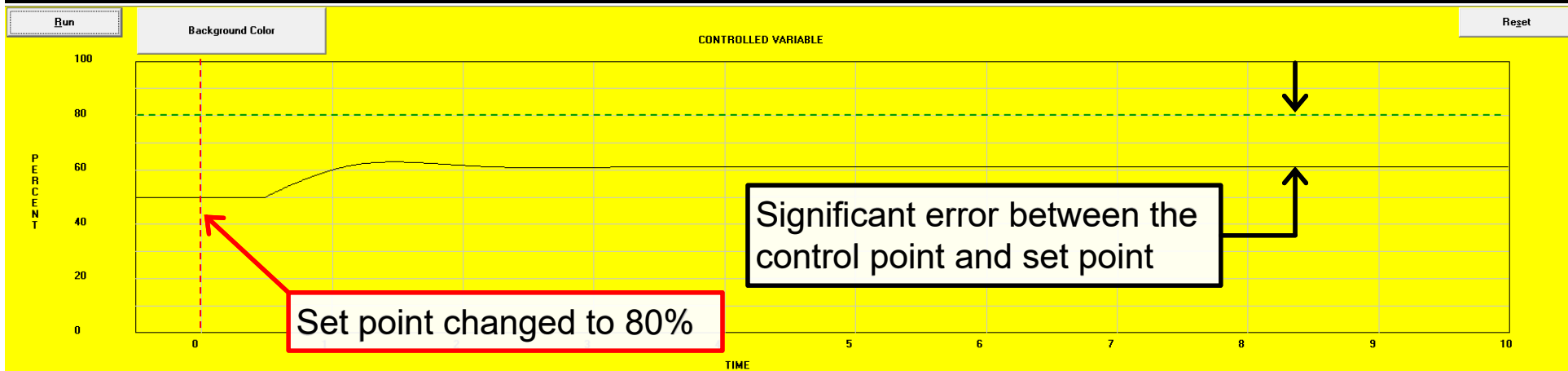
A Simple Proportional Control System

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



The Impact of Narrowing Throttling Range

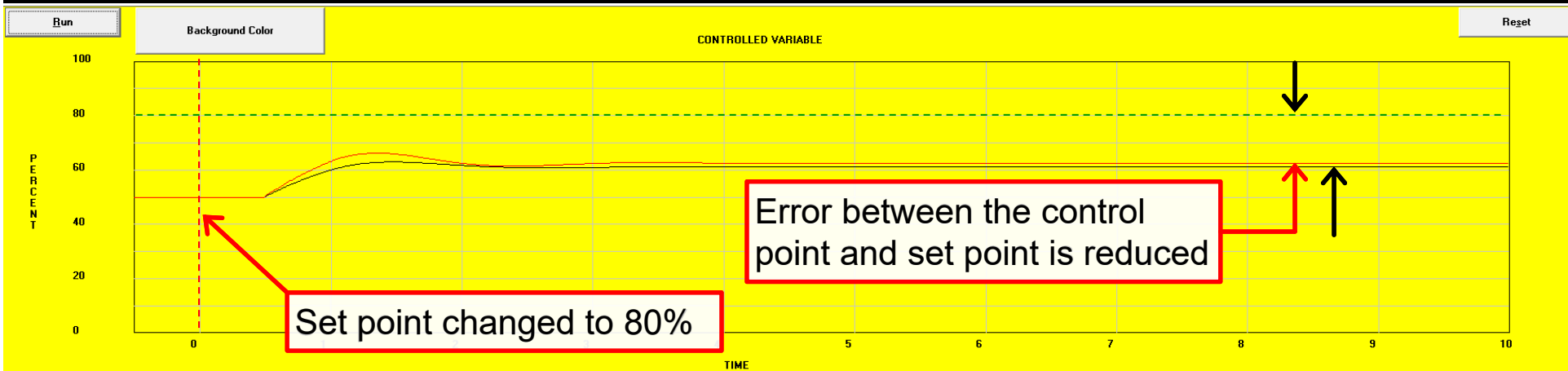
Proportional band = 400% and set point changed to 80%
(black line)



The Impact of Narrowing Throttling Range

Proportional band = 400% (black line)

Proportional band = 300% and set point changed to 80% (red line)

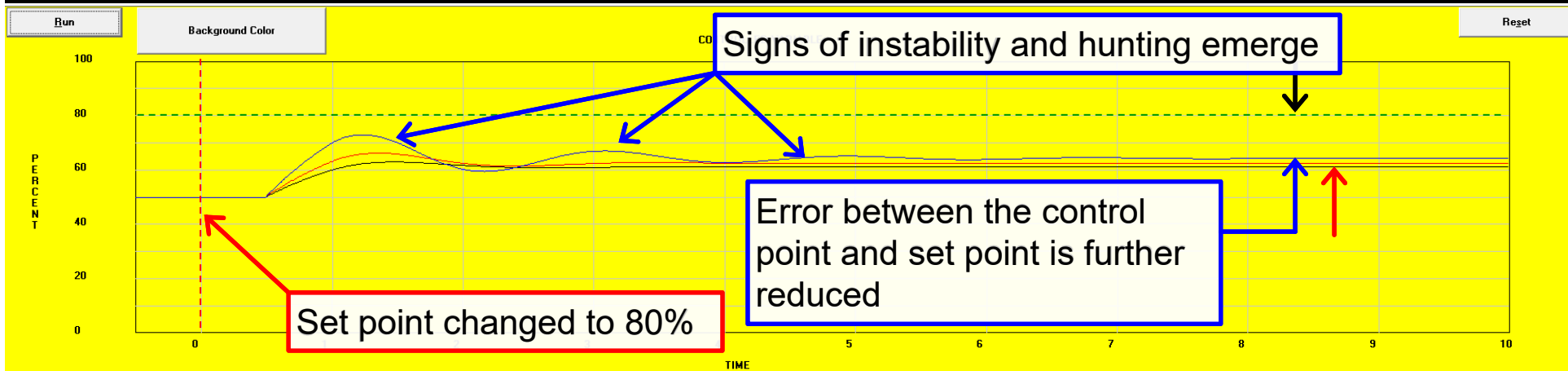


The Impact of Narrowing Throttling Range

Proportional band = 400% (black line)

Proportional band = 300% (red line)

Proportional band = 200% and set point changed to 80% (blue line)



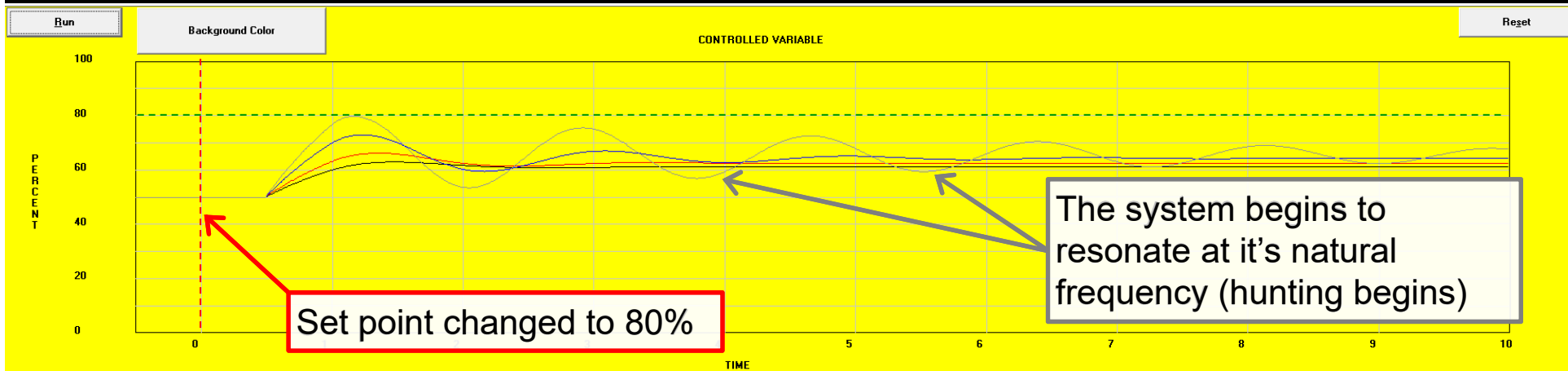
The Impact of Narrowing Throttling Range

Proportional band = 400% (black line)

Proportional band = 300% (red line)

Proportional band = 200% (blue line)

Proportional band = 150% and set point changed to 80% (gray line)



The Impact of Narrowing Throttling Range

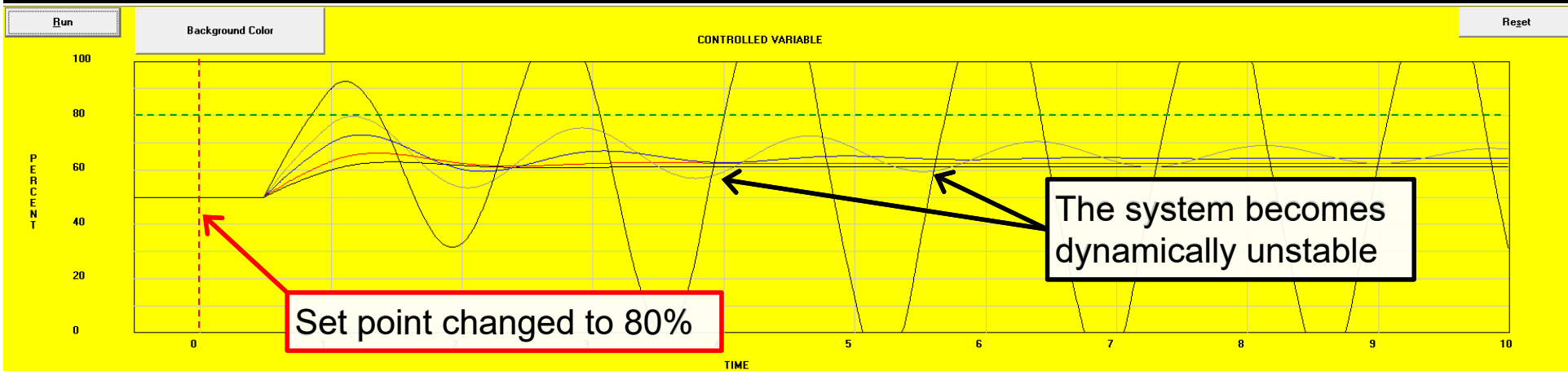
Proportional band = 400% (black line)

Proportional band = 300% (red line)

Proportional band = 200% (blue line)

Proportional band = 150% (gray line)

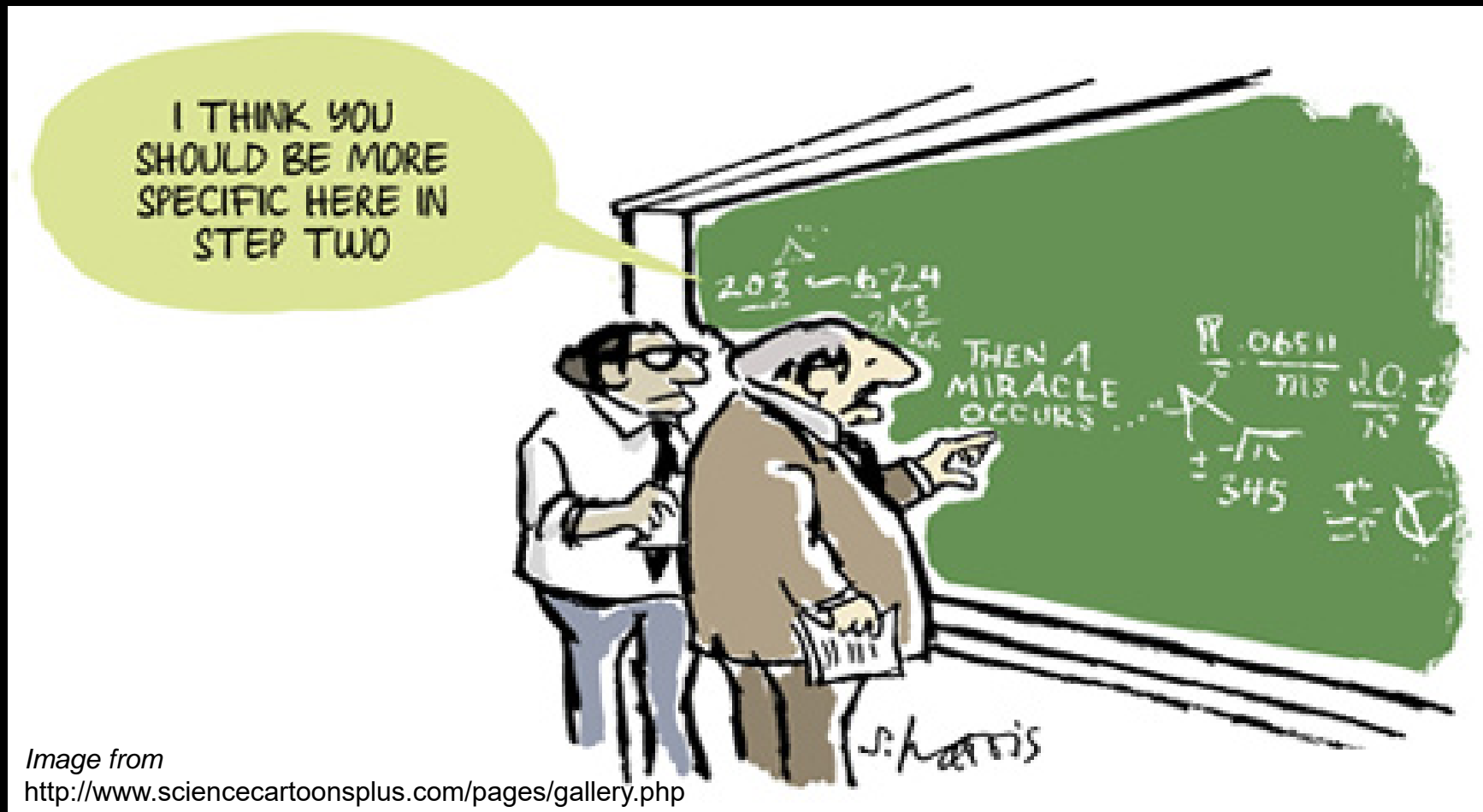
Proportional band = 100% and set point changed to 80%
(second black line)



Bottom Lines On Proportional Control

1. All proportional control processes will show a difference between set point and control point (a.k.a. error) under all operating conditions other than one very specific condition
2. The error can be reduced by narrowing down the throttling range
3. There is a limit to how much you can narrow the throttling range without hunting
4. The limit is a function of the physics of the control system; things like lags, play in the linkage system, the nature of the process, etc.

Then a Miracle Occurs



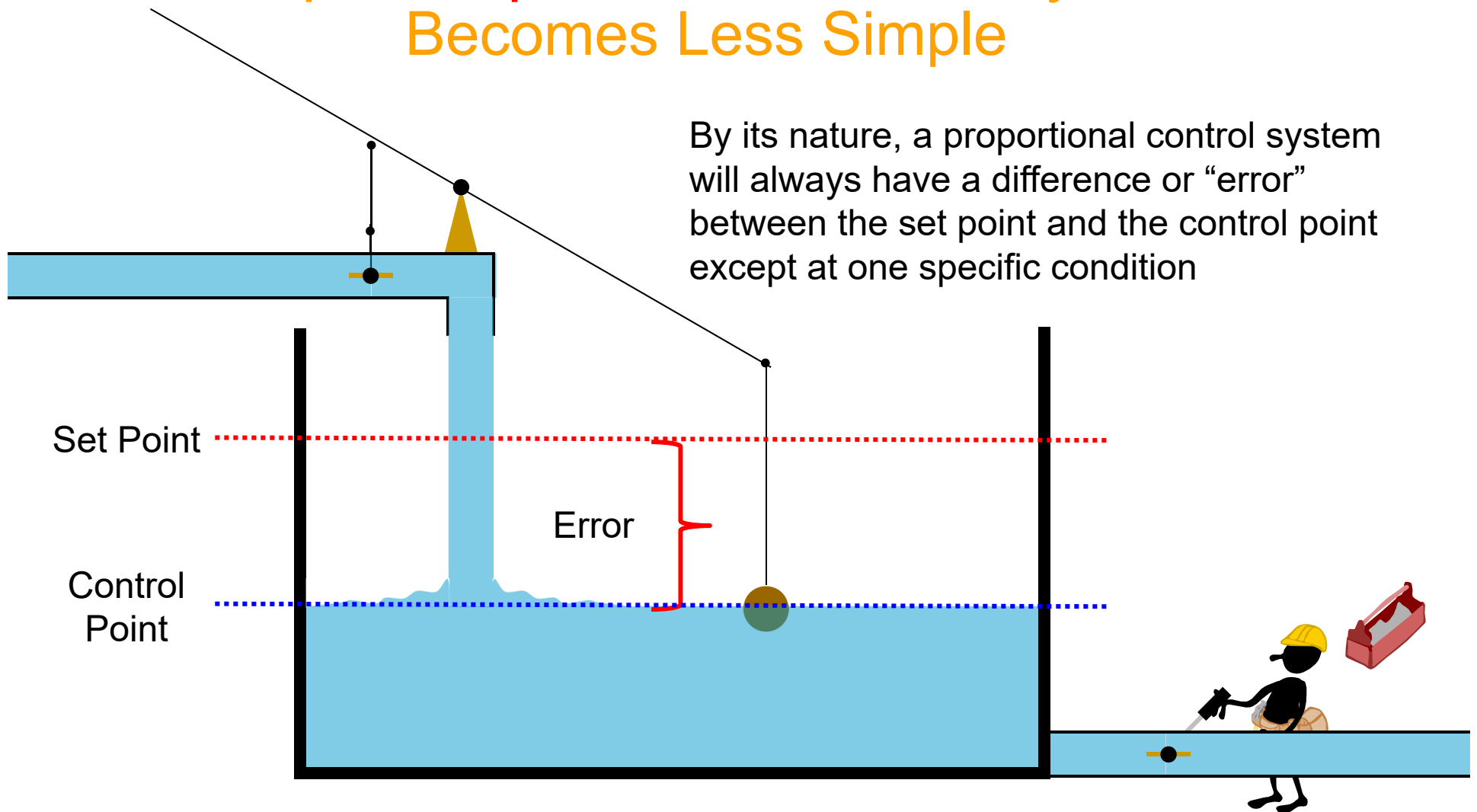
Proportional plus Integral plus Derivative Control (PID)

PID is the Miracle that can:

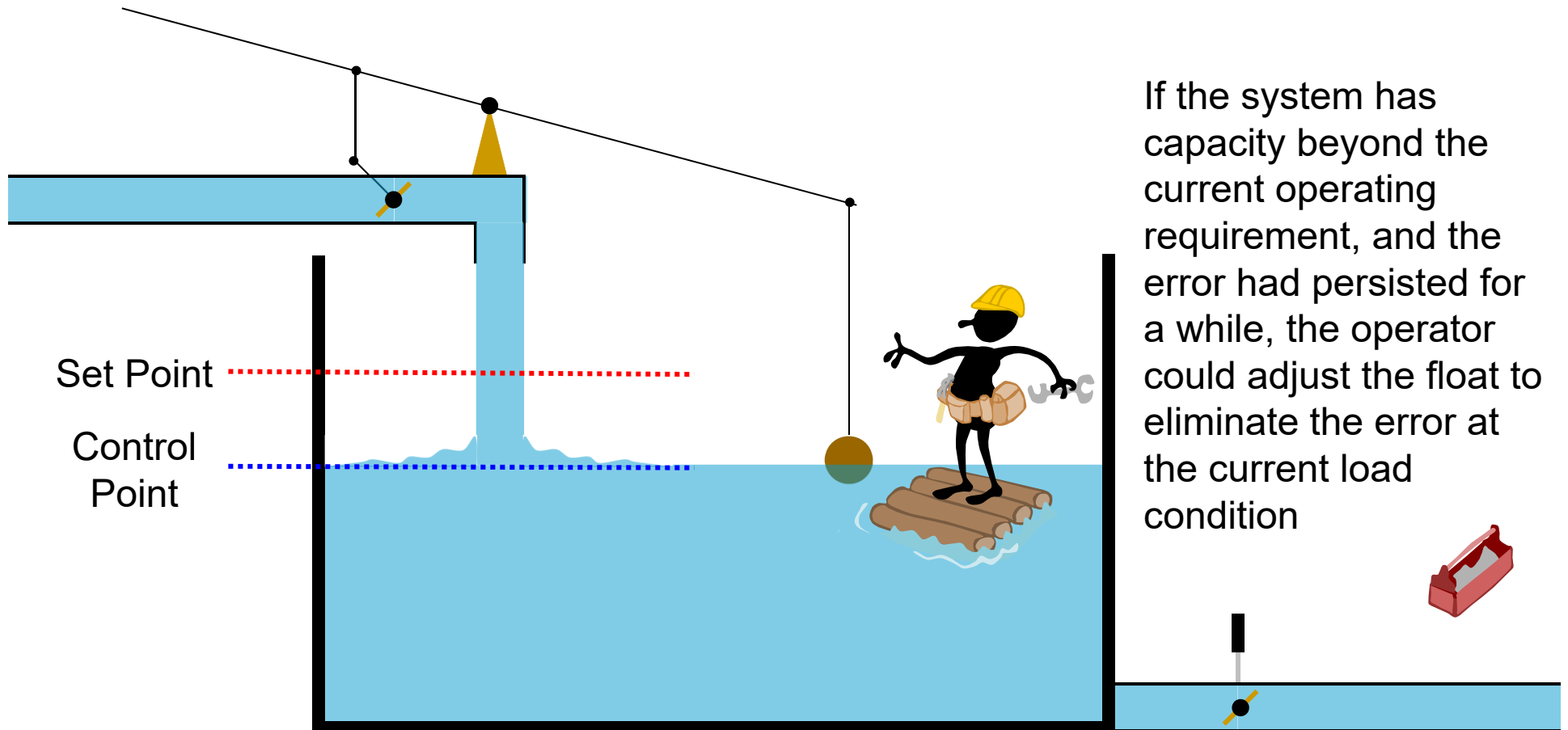
- Eliminate error
- Reduce the magnitude of a spike when a system is upset
- Reduce the settling time after an upset

Eliminating Proportional Error; A Simple Proportional Control System Becomes Less Simple

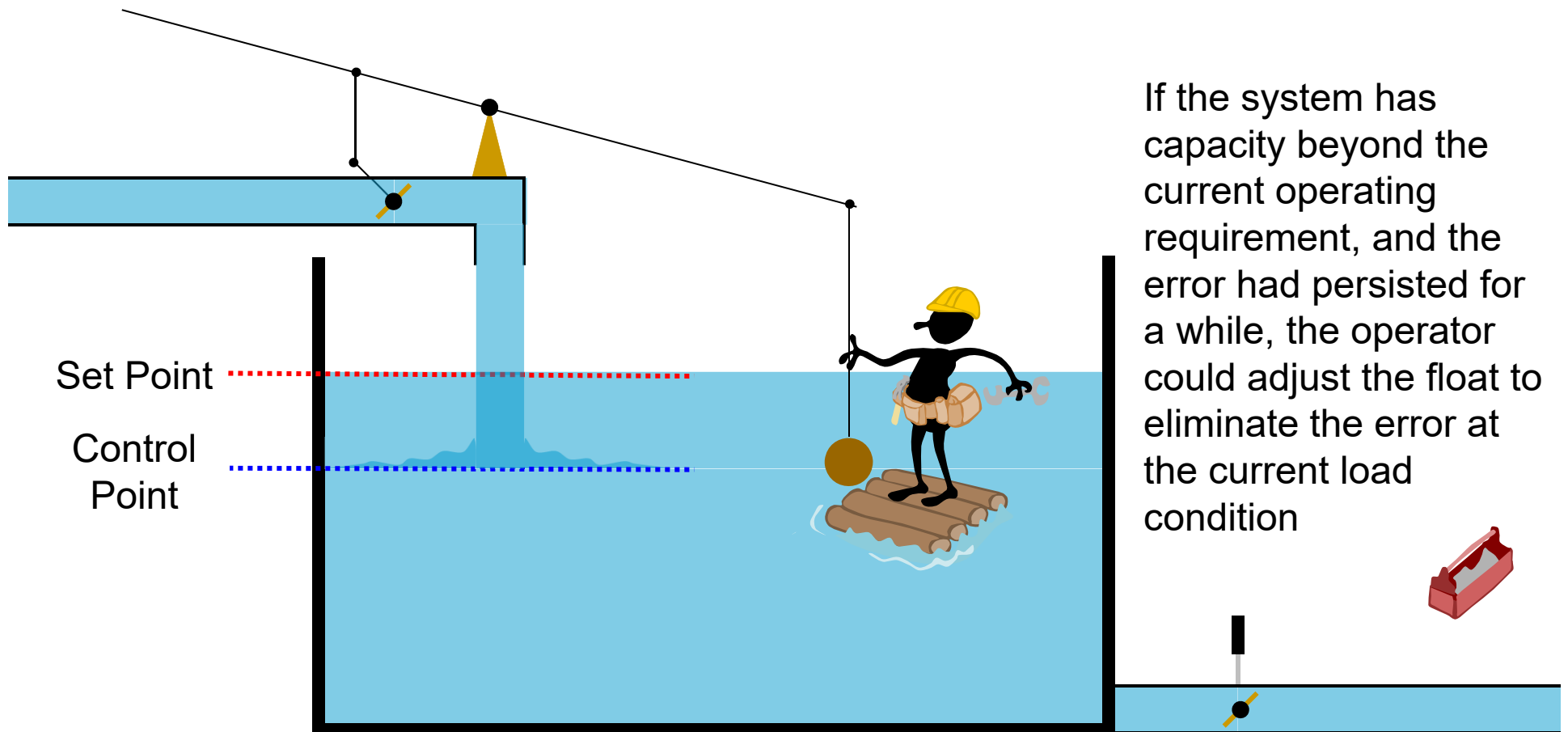
By its nature, a proportional control system will always have a difference or “error” between the set point and the control point except at one specific condition



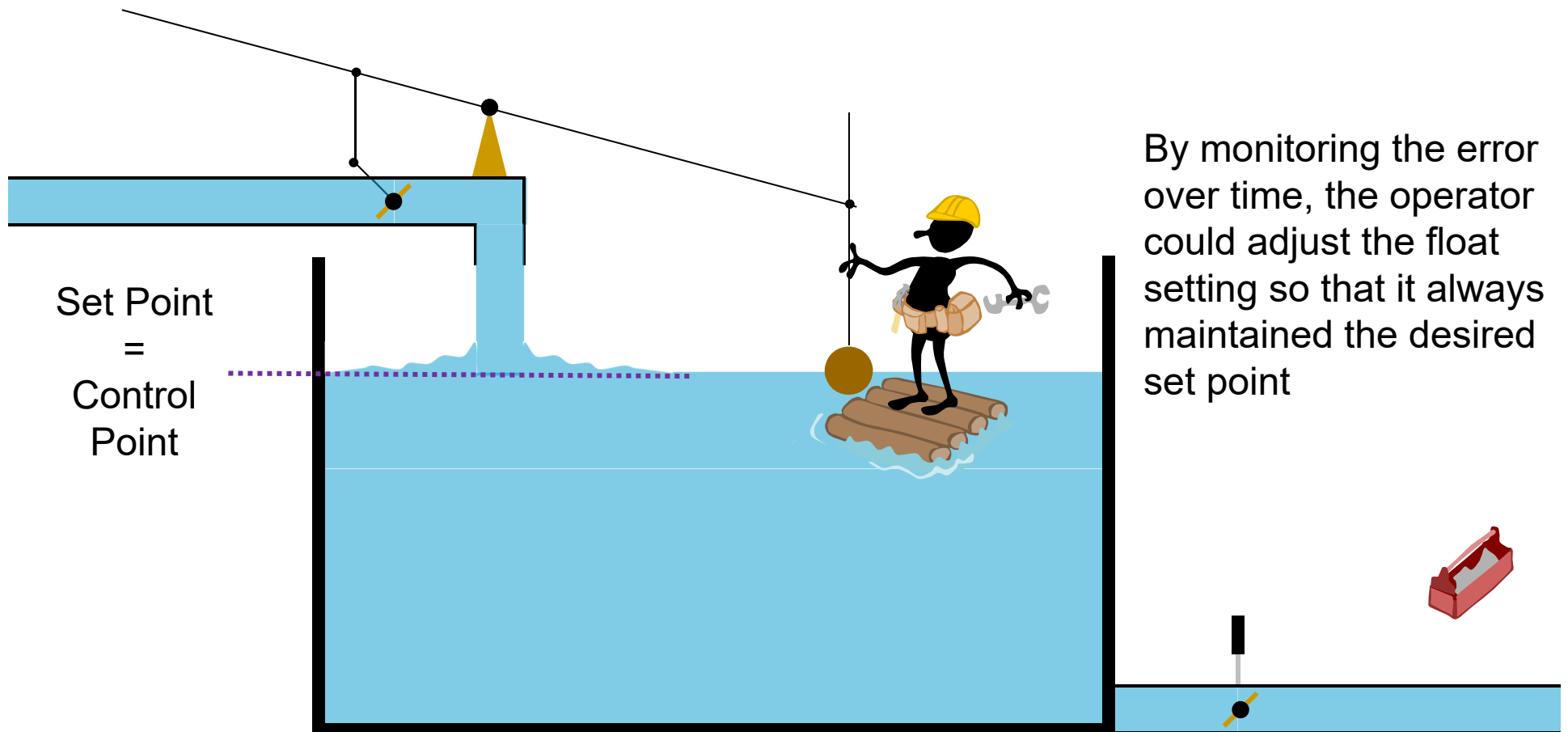
Eliminating Proportional Error; A Simple Proportional Control System Becomes Less Simple



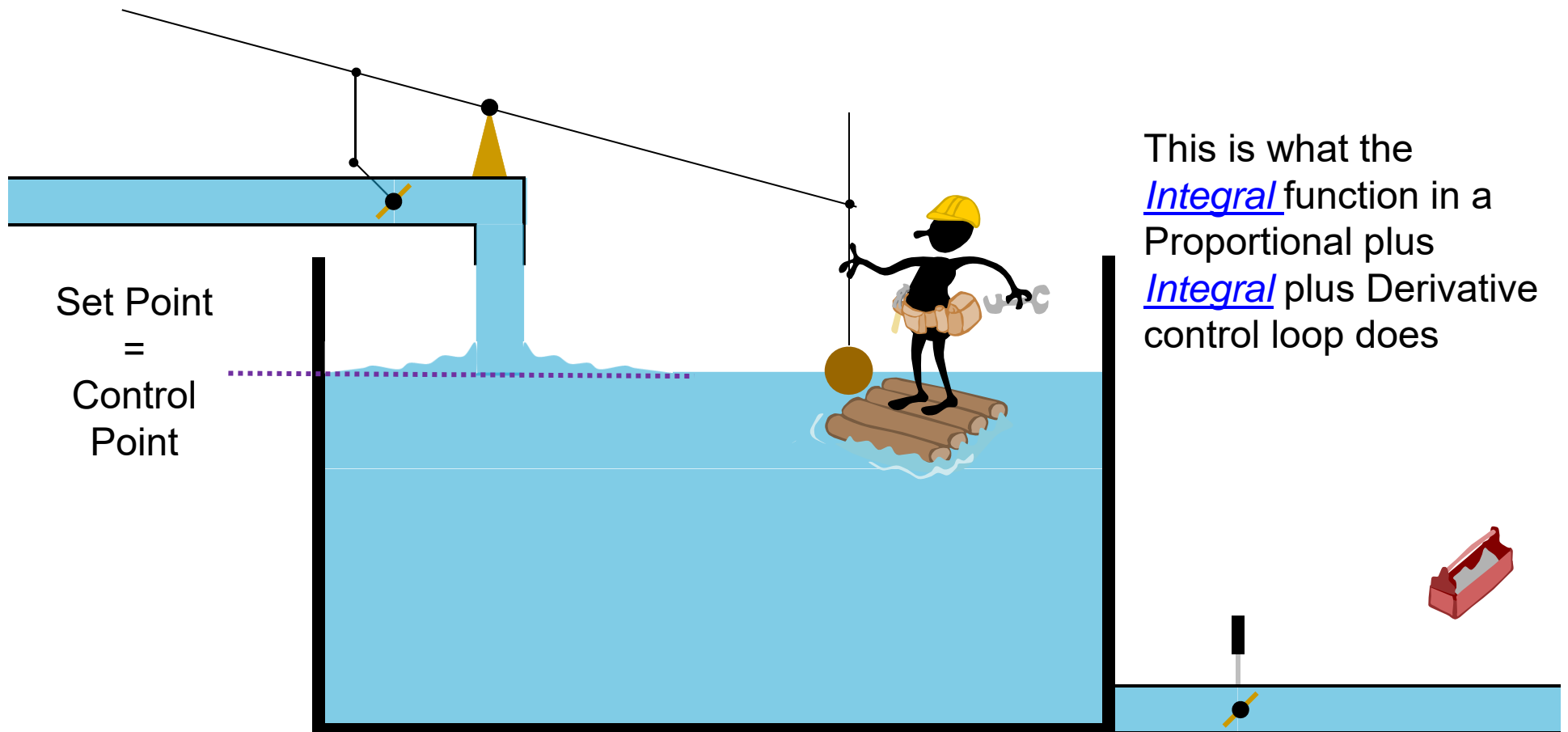
Eliminating Proportional Error; A Simple Proportional Control System Becomes Less Simple



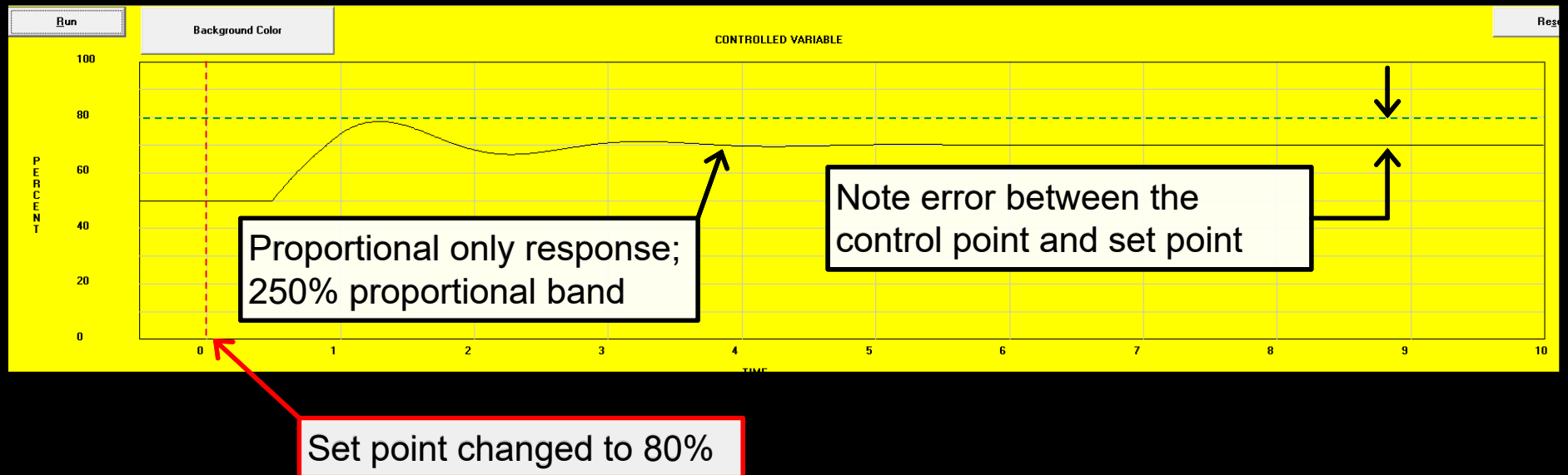
Eliminating Proportional Error; A Simple Proportional Control System Becomes Less Simple



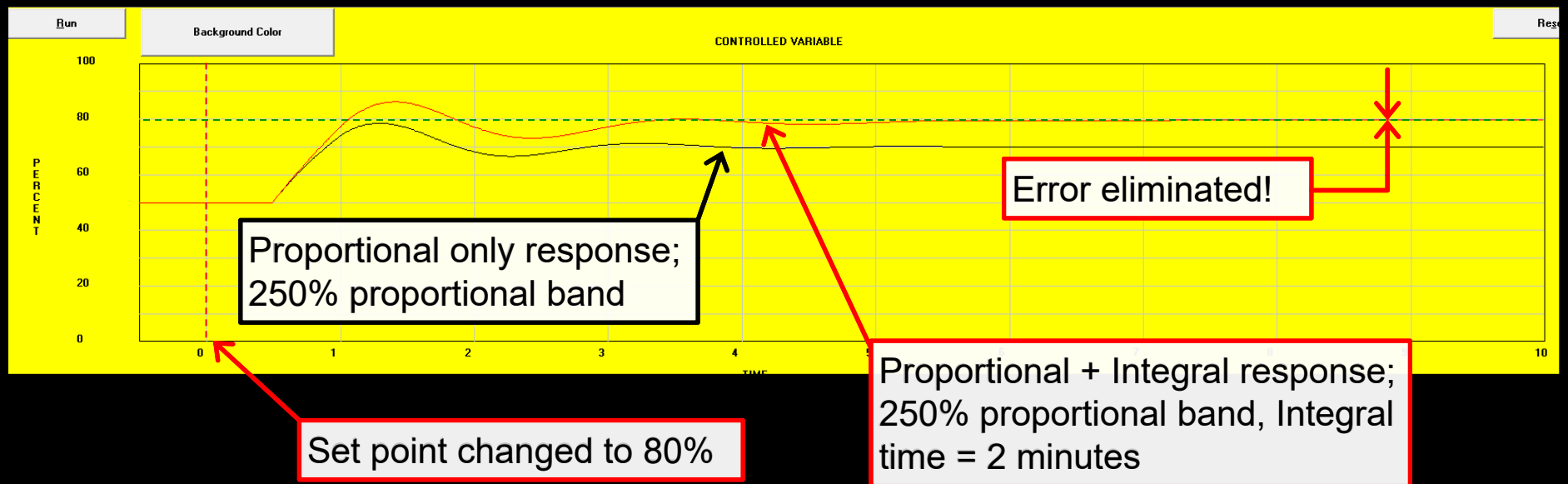
Eliminating Proportional Error; A Simple Proportional Control System Becomes Less Simple



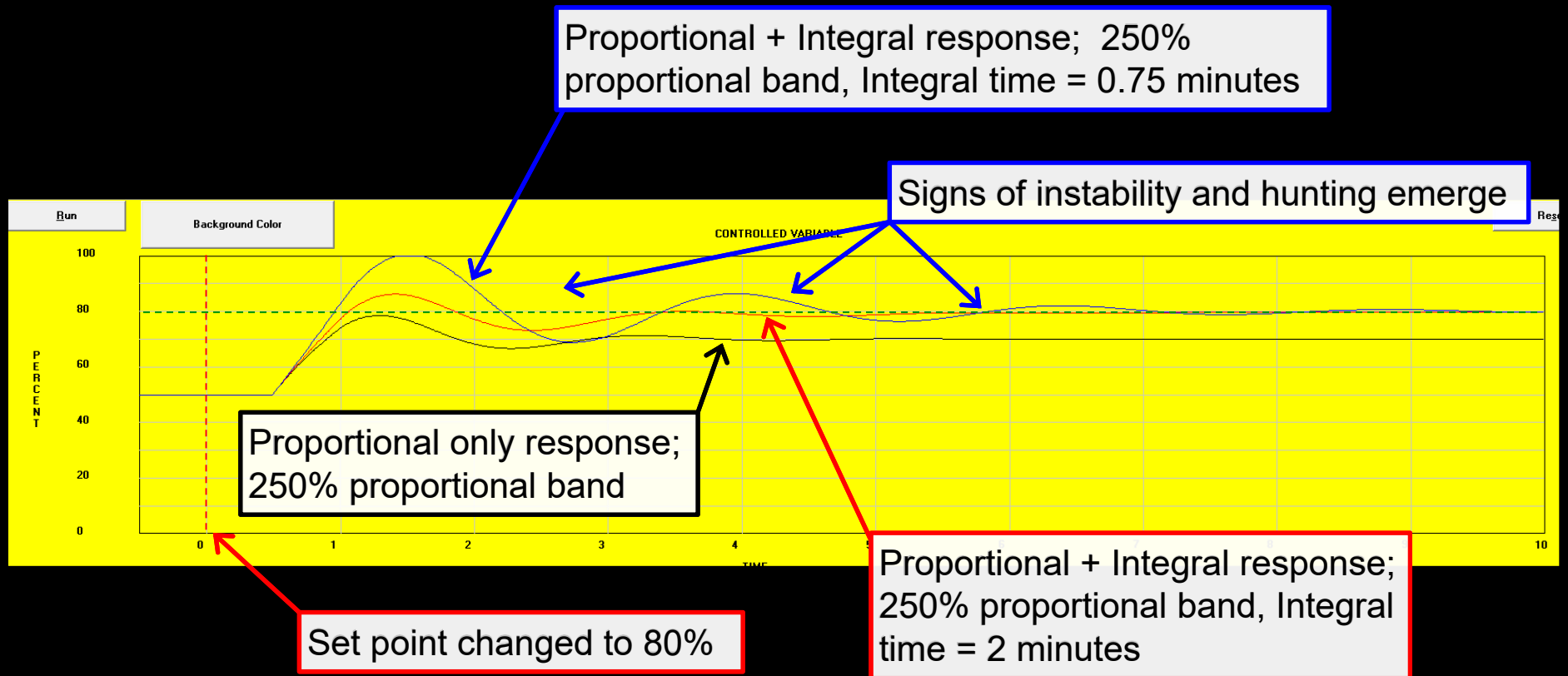
The Impact of Adding Integral Gain



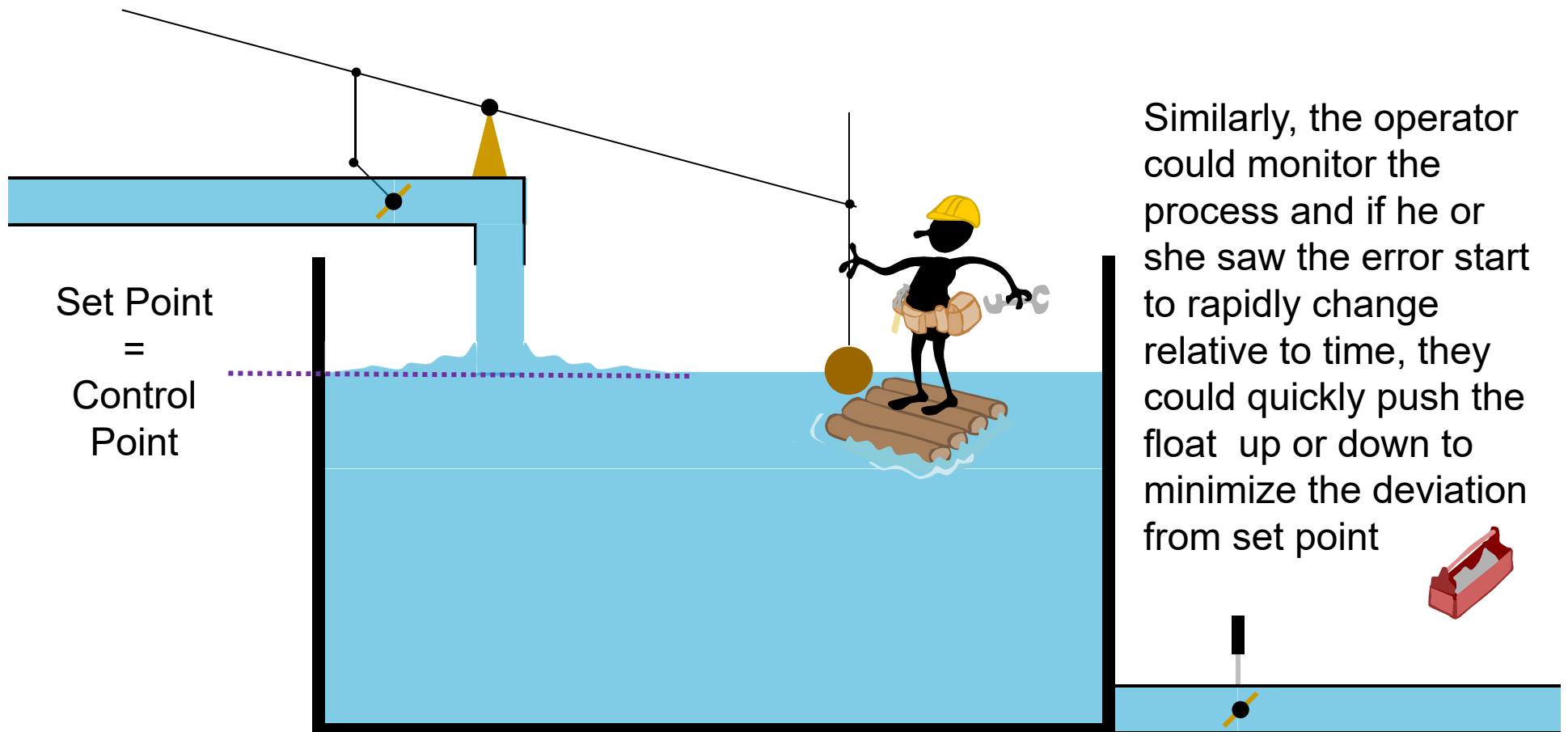
The Impact of Adding Integral Gain



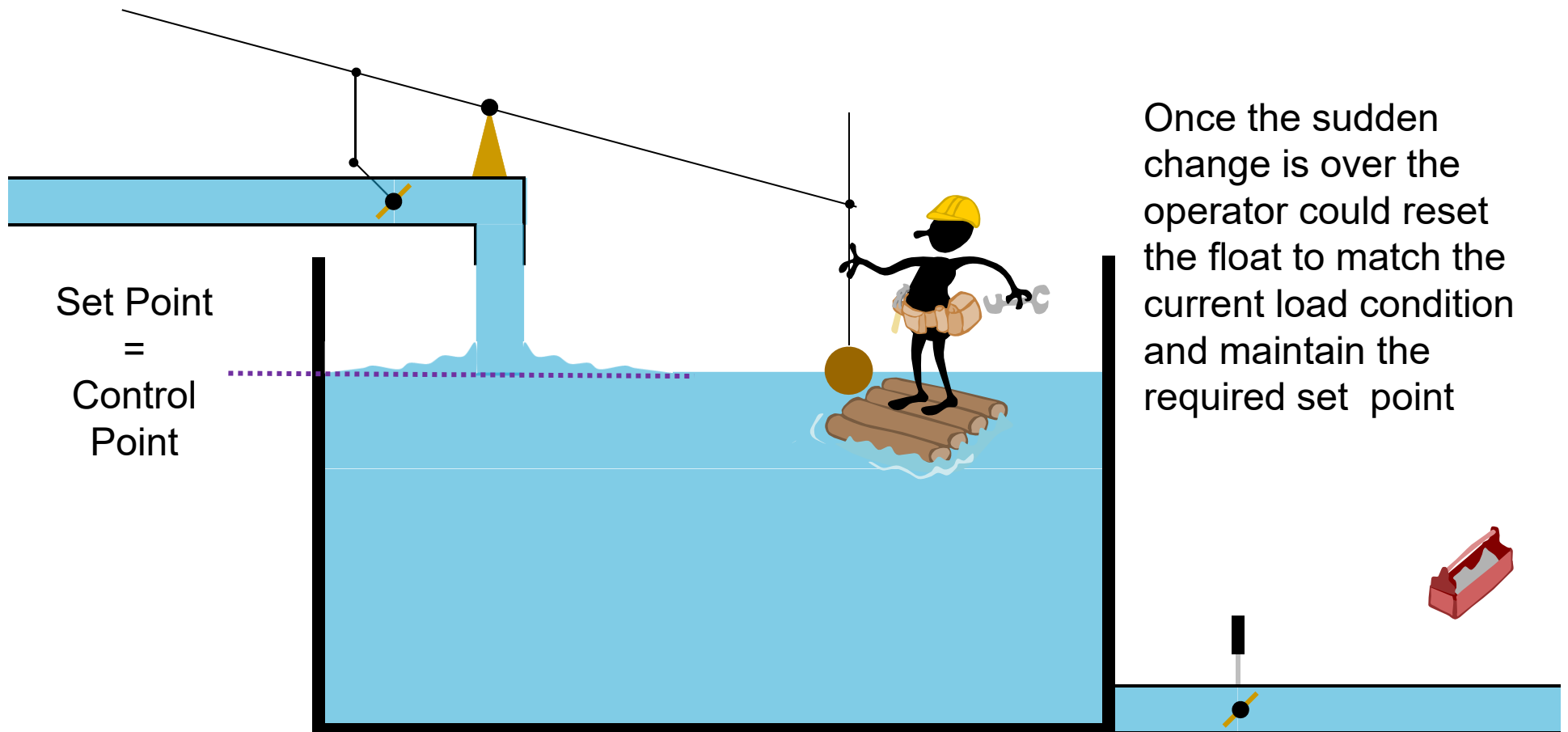
The Impact of Adding Integral Gain



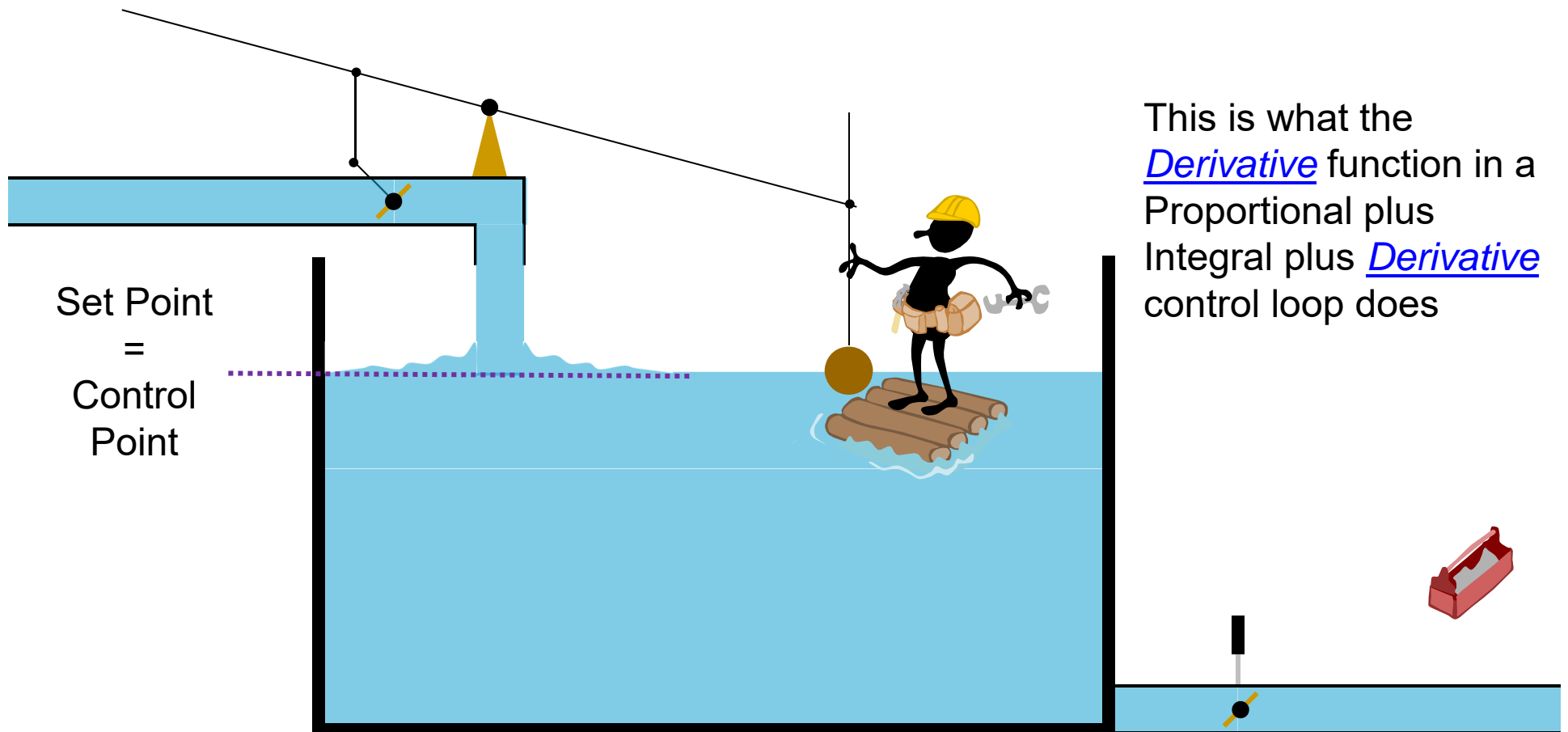
Eliminating Proportional Error; A Simple Proportional Control System Becomes Less Simple



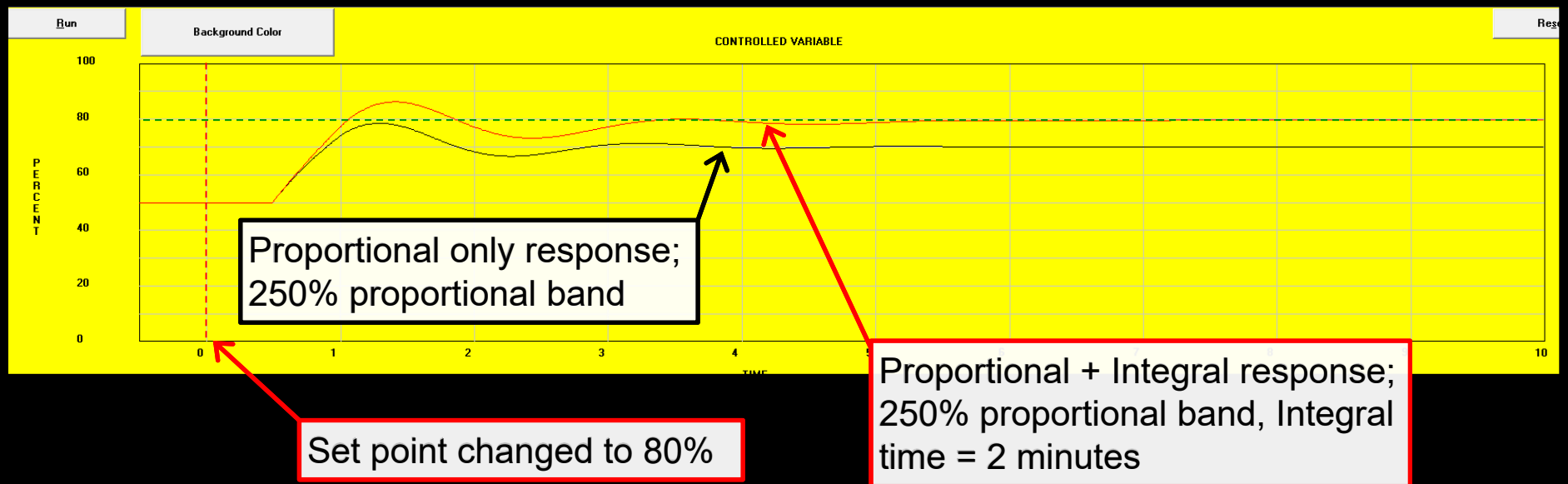
Eliminating Proportional Error; A Simple Proportional Control System Becomes Less Simple



Eliminating Proportional Error; A Simple Proportional Control System Becomes Less Simple

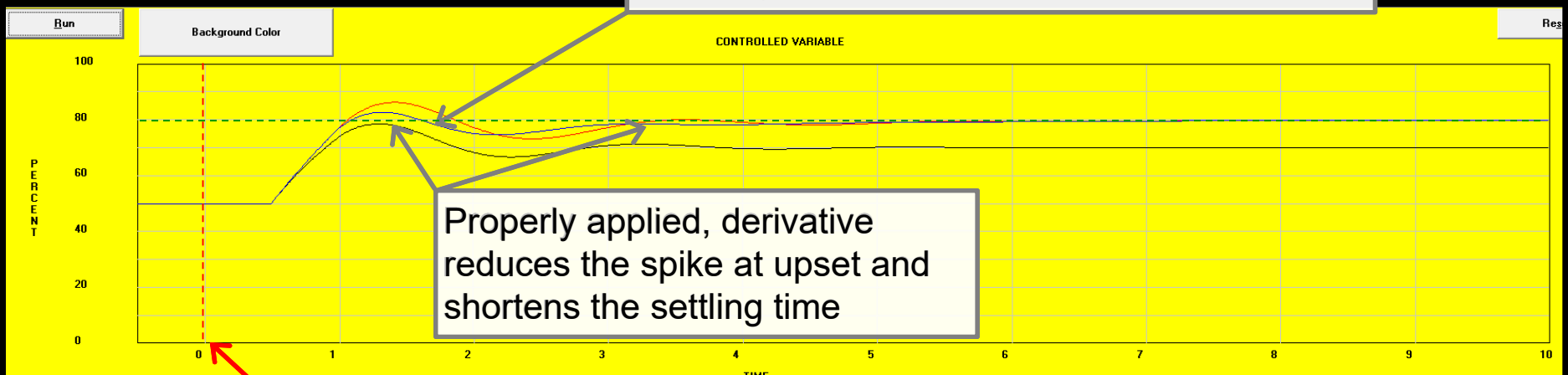


The Impact of Adding Derivative Gain



The Impact of Adding Derivative Gain

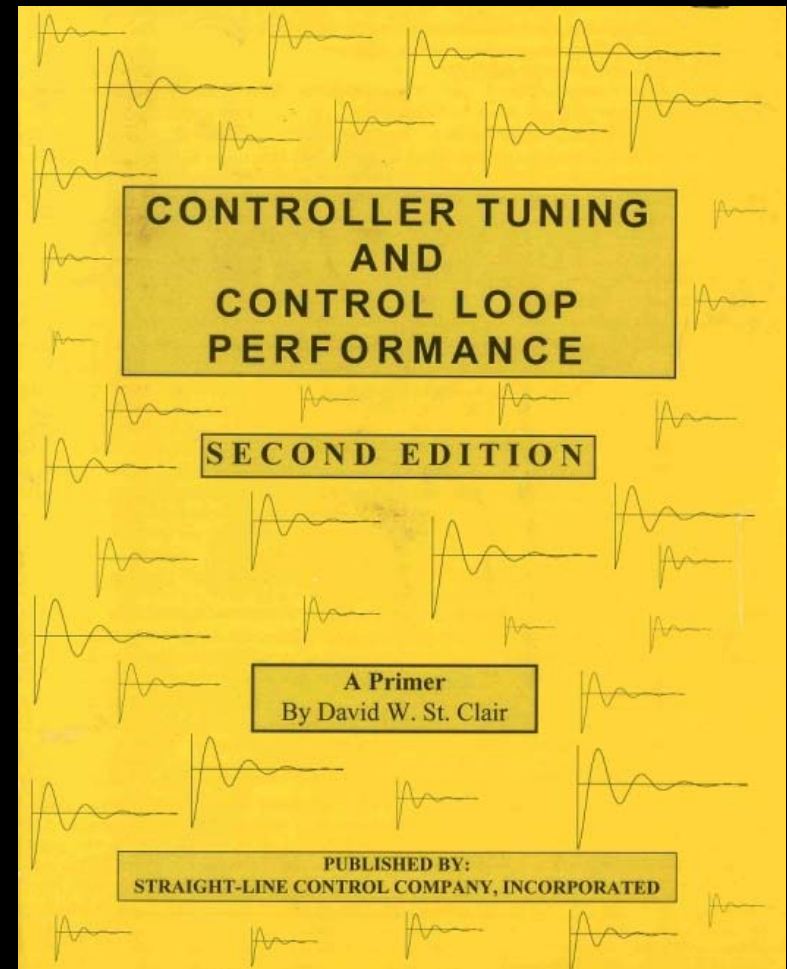
Proportional + Integral + Derivative response;
250% proportional band, Integral time = 0.75
minutes, Derivative time = 0.1 minutes



PID Resources

Controller Tuning and Control Loop Performance by David W. St. Clair

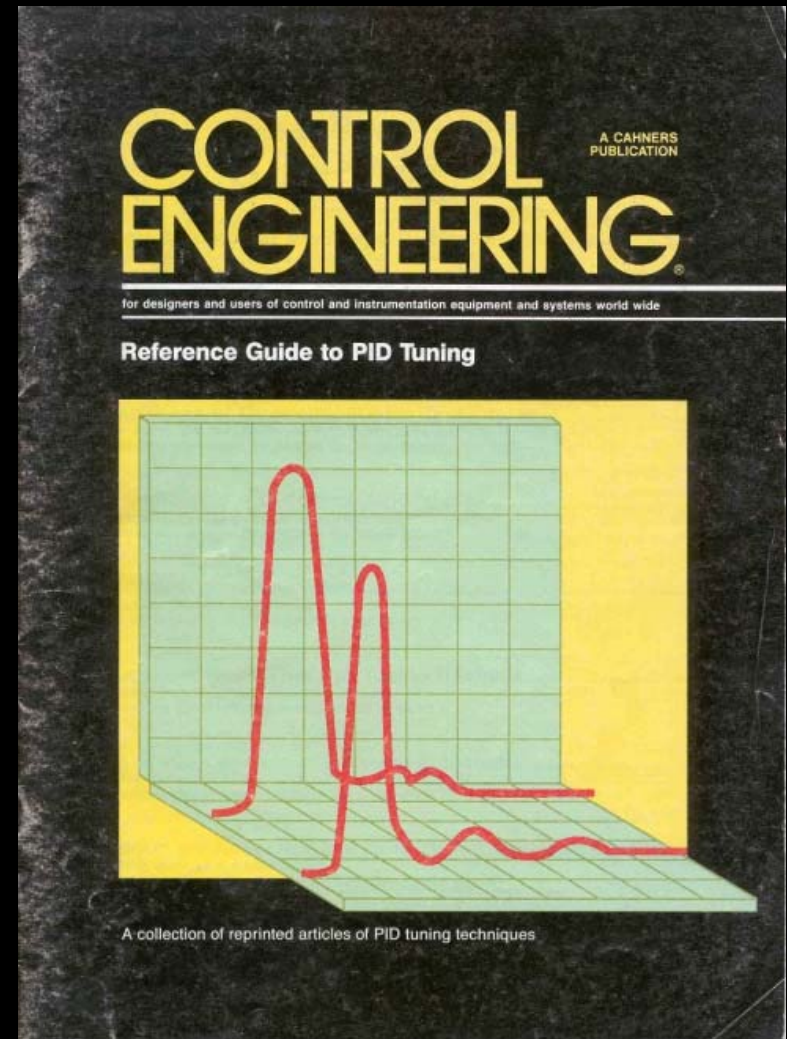
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Fax: 612-869-2761
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<http://www.straightlinecontrol.com>



PID Resources

Reference Guide to PID Tuning

- Available from the publishers of Control Engineering
- See *A Field Perspective on Engineering Blog Post for Links*



PID Resources

See *An Overview of Proportional plus Integral plus Derivative Control and Suggestions for Its Successful Application and Implementation* from the proceedings of the 2001 International Conference on Enhanced Building Operations