

# Process Control: Flow

Catalogue Number	77-3043-0002
Category	Process Control
Duration	15 Hours

## Activity 1: Introduction to Process Control

What is Process Control?  
What is a Control Mechanism?  
Flow Rate  
What is a Controller?  
Manual and Automatic Flow Control Systems  
The Need for Controlling Systems

## Activity 2: Introduction to ProcessMotion Simulation Software

ProcessMotion Software  
ProcessMotion Panel  
Simulation Software  
Manipulating the ProcessMotion Panel Display  
Task: Running ProcessMotion and Opening Multiple Displays  
Review of Process Control  
Task: Running an Experiment  
Output Analysis  
Task: Analyzing the Output Graph  
Experimenting with an Ineffective Controller  
Interpreting the Output Graph  
Experimenting with an Effective Controller  
Task: Experimenting with an Effective Controller  
Interpreting the Output Graph

### **Activity 3: Block Diagrams and Gain**

- Systems and Control Systems
- Sample Control Systems
- Block Diagrams
- Open Loop Control Systems and Gain
- Testing a Control System
- Task: Testing a Control System
- Testing Another Control System

### **Activity 4: The System Block Diagram and the Final Control Element Gain**

- Review of Gain
- ProcessMotion Panel Control System
- Task: Constructing the Block Diagram of the System
- The Structure and Functioning of the Pump
- Final Control Element Gain to the ProcessMotion System
- Calculating the Final Control Element Gain
- Task: Determining the Pump Gain
- Task: Recording the Data
- Task: Calculating the Pump Gain

### **Activity 5: Calculating Process Gain**

- Review of Gain
- Defining Process Gain of the ProcessMotion System
- Calculating the Process Gain Analytically
- Determining the Process Gain Experimentally
- Task: Determining the Process Gain
- Task: Recording the Results
- Task: Changing the Resistance of the Load Value
- Task: Calculating the Process Gain Values
- Experiment Conclusions
- Task: Calculating Process Gain Analytically

## **Activity 6: First Order Systems**

Steady State Response  
Dynamic Response  
The Time Constant  
First Order Systems  
First Order System Laplace Transforms  
Step Inputs  
First Order System Response to a Step Input  
Notes on the Time Constant  
Task: Constructing a Graph of System Response to a Step Input  
Task: Interpreting a System Response Graph

## **Activity 7: The Flow System Time Constant**

Review of the Time Constant  
The System Order of the Flow System  
Task: Measuring the Time Constant of the Flow System Experimentally  
Task: Recording the Data

## **Activity 8: Controlling the Flow System Using Open Loop Control**

Categorizing Control Systems  
Closed Loop Control  
Open Loop Control  
Controlling the Flow System Using Open Loop Control  
Task: Using Open Loop Control to Control the Flow Rate into the Tank  
Task: Recording the Data  
Task: Controlling the Flow System with the Load Valve Open  
Task: Recording Data  
Experiment Conclusions  
Task: Investigating the Effect of an External Load on the Flow System Under Open Loop Control  
Task: Adjusting the Pump Setting  
Results and Conclusions

### **Activity 9: Introduction to On-Off Control**

Open and Closed Loop Control Systems

Closed Loop Control Systems

On-Off Control Algorithm

Task: Analyzing a Control System

Applying On-Off Control

On-Off Control Using Dead Band

Tolerance

### **Activity 10: On-Off Control - Tasks**

On-Off Control

Step Inputs

Task: Step Inputs

Task: Calculating General System Information

System Behavior

Task: Calculating the System Output Over Time

The Descent of the System Response

Task: Plotting the System Descent

Investigating the Effects of Changing the Dead Band

Task: Investigating the Effects of Changing the Dead Band

### **Activity 11: Controlling the Flow System Using On-Off Control**

Review of Open Loop Control of the Flow System

On-Off Control of the Flow System

Task: Controlling the Flow System Using On-Off Control

Analysis of the System Output

Task: Analysis of the Output Graph

Task: Completing the Experiment

Analysis of the Experiment Results

Experiment Conclusions

### **Activity 12: Proportional Control**

Proportional Control Algorithm

Saturation

Proportional Band

Steady State System Characteristics Under Proportional Control

Dynamic System Characteristics Under Proportional Control

### **Activity 13: First Order Systems Under Proportional Control**

Review of Proportional Control

System Response to a Step Input

Task: Calculating Time Values

Task: Calculating the System Output for  $K_c = 0.5$

Task: Calculating the System Output for  $K_c = 1$

Task: Calculating the System Output for  $K_c = 2$

Task: Calculating the System Output for  $K_c = 4$

Task: Calculating the System Output for  $K_c = 10$

### **Activity 14: Controlling the Flow System Using Proportional Control**

Materials

Review of On-Off Control of the Flow System

Proportional Control of the Flow System

Task: Controlling the Flow System Using Proportional Control

Task: Recording the Experiment Results

Task: Testing Other Set Point Values

Task: Controlling the Flow System for a New Value of  $K_c$

Task Recording the Experiment Results

Task: Testing Other Set Point Values

Results and Conclusions

Task: Controlling the Flow System with Proportional Control in the Presence of an External Load

Task: Recording the Experiment Results

Results and Conclusions

Task: Measuring the Effect of  $K_c$  on the Nature of System Response

Task: Recording the Data

### **Activity 15: Proportional Integral Control**

- First Order Systems Under Proportional Control
- Higher Order Systems Under Proportional Control
- Integral Control
- Proportional Integral Control
- Task: Constructing a Graph of the Output of a PI Controller
- How Integral Control Eliminates Offset
- Disadvantages of PI Control
- Applying Laplace Transform to PI Control

### **Activity 16: Controlling the Flow System Using Proportional Integral Control**

- Review of Proportional Control
- Controlling the Flow System Using PI Control
- Task: Controlling the Flow System Using PI Control
- Task: Recording the Data
- Task: Controlling the Flow System with Proportional Integral Control
- Experiment 1: Results and Conclusions
- Task: Investigating PI Control in the Presence of an External Load
- Task: Recording the Data
- Task: Completing the Experiments
- Experiment 2: Results and Conclusions

### **Activity 17: PID Control**

- Review of Proportional Control
- Review of Proportional Integral Control
- Derivative Control
- Advantages of Applying a Derivative Action to a PI Controller
- Proportional Integral Derivative Control
- Demonstrating PID Control
- Task: Investigating the Effect of Changing PID Parameters
- Task: The Effect of Changing the Value of  $K_c$
- Task: The Effect of Changing the Value of  $T_i$
- Task: The Effect of Changing the Value of  $T_d$

### **Activity 18: Controlling the Flow System Using Proportional Integral Derivative Control**

Review of P and PI Control

Control of Higher Order Systems

Review of PID Control

Task: Controlling the ProcessMotion Flow System with a PID Controller

Task: Recording Data

Task: Completing the Experiments

Results and Conclusions

Task: Investigating the Effect of PID Control on a Higher Order System

Task: Adjusting the Value of  $K_c$  When Using P Control

Task: Adjusting the Value of  $T_i$  When Using PI Control

Task: Adjusting the Value of  $T_d$  When Using PID Control

### **Activity 19: Controller Selection and Design**

Designing a Control System

Stage 1: Selecting an Appropriate Control Algorithm

Stage 2: Determining the Correct Parameters

Stage 3: Fine Tuning

Setting the Parameters for a PID Control System

Task: Determining the Critical Gain Value

Task: Determining the Cycle Time

Task: Fine-tuning the PID Controller

## **Activity 20: Designing Controllers for the Flow System**

Review of the Controller Design Process

Designing a Controller for the Flow System: 1

Task: Experimenting with the Controller

Task: Examining the Controller Performance

Task: Evaluating the Controller Performance

Designing a Controller for the Flow System: 2

Task: Testing the Controller

Task: Examining the Controller Performance

Task: Evaluating the Controller Performance

Experiment Results

Designing a Controller for the Flow System: 3

Task: Testing the Controller

Task: Examining the Controller Performance

Task: Evaluating the Controller Performance

Experiment Results

### **Post-test**