## ✅ **Practical 1: Introduction to MathWorks: Fuzzy Logic Toolbox, Fuzzy Logic Simulink Demo**

### 🎯 Objective:

To understand the basics of fuzzy logic and explore the MathWorks Fuzzy Logic Toolbox and Simulink demonstration.

### 🔧 Software:

* MATLAB with Fuzzy Logic Toolbox

### 📝 Steps:

#### 1. **Open Fuzzy Logic Designer**

Open MATLAB and type in the command window:

fuzzy

This opens the **Fuzzy Inference System (FIS) Editor**.

#### 2. **Create a New FIS**

* Click File > New > Mamdani (or Sugeno, based on need).
* Save it as basicFIS.fis.

#### 3. **Add Inputs and Outputs**

* Add **Input 1**: “Temperature”
  + Range: [0, 100]
  + Membership Functions:
    - Low: triangular (0 0 50)
    - Medium: triangular (25 50 75)
    - High: triangular (50 100 100)
* Add **Output 1**: “Fan Speed”
  + Range: [0, 10]
  + Membership Functions:
    - Slow: triangular (0 0 5)
    - Medium: triangular (3 5 7)
    - Fast: triangular (5 10 10)

#### 4. **Define Rules**

Use the **Rule Editor**:

* IF Temperature is Low THEN Fan Speed is Slow
* IF Temperature is Medium THEN Fan Speed is Medium
* IF Temperature is High THEN Fan Speed is Fast

#### 5. **Simulate and Observe**

* Use “Rule Viewer” to simulate inputs and outputs.
* Use “Surface Viewer” to view the fuzzy surface plot.

#### 6. **Simulink Demo**

* Type simulink in MATLAB.
* Open Library Browser → Fuzzy Logic Toolbox → Drag Fuzzy Logic Controller block.
* Load basicFIS.fis.
* Connect with input/output blocks.
* Run and observe simulation.

## ✅ **Practical 2: Fuzzy Logic Controller (FLC) Implementation**

### 🎯 Objective:

To implement a fuzzy logic controller (FLC) using a user-defined FIS for controlling a physical parameter (e.g., Fan Speed based on Temperature).

### 📝 Steps:

#### 1. **Design FIS (Fuzzy Inference System)**

Create or modify fancontrol.fis as in Practical 1 using:

fuzzy

#### 2. **Launch Simulink**

simulink

#### 3. **Build Simulink Model**

**Blocks Required**:

* Constant (input temperature)
* Fuzzy Logic Controller (link with fancontrol.fis)
* Scope (to view output)
* Gain (if required)

#### 4. **Connect Blocks**

Constant → Fuzzy Logic Controller → Scope

* Double-click on the Fuzzy Logic Controller and **load the FIS file**.

#### 5. **Simulation Settings**

* Set time to 10 seconds
* Set input values (e.g., constant 70°C)

#### 6. **Run and Interpret Results**

The output from the scope will show **fan speed** depending on the temperature value as processed by the fuzzy logic rules.

## ✅ **Practical 3: Simulink Fuzzy Logic Controller (FLC) Implementation**

### 🎯 Objective:

To create a feedback-based control system using FLC in Simulink.

### Example System: **Water Tank Level Control**

#### 📝 Steps:

#### 1. **Design a FIS**

* Inputs: Error (difference between desired and actual level)
* Outputs: Valve Opening (%)
* Use MFs like:
  + Error: Negative, Zero, Positive
  + Output: Close, Medium, Open

#### 2. **Simulink Model Blocks**

* Step (desired level)
* Subtract (desired - actual = error)
* Fuzzy Logic Controller (load FIS)
* Gain/Transfer Function (model tank dynamics)
* Scope (output)

#### 3. **Sample Connection**

Step → Subtract (+)

→ Subtract (-) ← Feedback from Tank Level (output of Integrator)

Subtract → FLC → Valve Control (gain) → Tank Level (Integrator)

Tank Level → Scope and back to Subtract

#### 4. **Simulation Settings**

* Run simulation for 30 seconds
* Observe how the level is adjusted dynamically

#### 5. **Result Interpretation**

* Scope should show stable water level reaching the target, controlled by FLC

## ✅ **Practical 4: Applications of FLC to Control System**

### 🎯 Objective:

To apply FLC to a real-world control system (e.g., DC Motor Speed Control or Temperature Regulation).

### Example: **DC Motor Speed Control using FLC**

#### 1. **Create FIS**

* Inputs:
  + Speed Error (Set Speed - Actual Speed)
  + Change in Error
* Output:
  + Control Voltage
* Define fuzzy rules such as:
  + IF Error is Positive AND Change is Positive → Output is High

#### 2. **Simulink Blocks**:

* Step: Desired speed
* Feedback loop: Motor output
* FLC: Control voltage
* Transfer Function: Motor Model
* Scope: Monitor motor speed

#### 3. **Connection Flow**:

Step → Subtract (+)

→ Subtract (-) ← Feedback from Motor Output

Subtract → FLC → Gain → Transfer Function (Motor)

Motor Output → Scope and back to Subtract

#### 4. **Motor Transfer Function Example**:

Use standard DC Motor transfer function:

H(s) = K / (s \* T + 1)

#### 5. **Simulation Result**:

* Speed should reach the set point smoothly.
* The fuzzy controller adapts based on error and change in error.

## 📘 Summary Table

| **Practical No.** | **Title** | **Tool Used** | **Output** |
| --- | --- | --- | --- |
| 1 | Intro to Fuzzy Toolbox & Simulink Demo | FIS Editor, Simulink | Fuzzy model visualization |
| 2 | FLC Implementation | Simulink | Fuzzy-controlled output |
| 3 | Simulink FLC with Feedback | Simulink + FIS | Dynamic system response |
| 4 | Application of FLC to Control System | Simulink + FIS | System under fuzzy control |