# AI Lab Manual: Theory Sections

## Experiment 1: McCulloch–Pitts Neuron (AND & NOT Functions)

The McCulloch–Pitts (MP) neuron, introduced in 1943, is the seminal mathematical model of a biological neuron. It demonstrates how simple thresholding can implement Boolean logic. Given binary inputs x₁, x₂,…,xₙ∈{0,1}, each is multiplied by a fixed weight wᵢ, summed to form:

u = Σ₁ⁿ wᵢ xᵢ,

and then compared against a threshold θ. The output is:

y = { 1 if u≥θ; 0 if u<θ }.

To implement an AND gate with two inputs, set w₁=w₂=1 and θ=2. Only when x₁=1 and x₂=1 does u=2≥2, so the neuron fires. An inhibitory weight (w=-1, θ=0) yields a NOT gate.

Graphical illustration: Draw the step function y(u) with threshold θ and annotate the input pairs.

## Experiment 2: Perceptron Learning (Bipolar AND)

The Perceptron extends the MP model with trainable weights and bias, handling inputs and targets in bipolar form {−1,+1}. Its activation is:

u = wᵀx + b, y = sign(u)

Weights update by Δw = α (t - y) x, Δb = α (t - y). For linearly separable problems like bipolar AND, this converges in finite epochs.

Graphical illustration: Plot the 2D input space with decision boundary evolution.

## Experiment 3: Backpropagation Neural Network

Backpropagation enables training of multilayer perceptrons (MLPs). For an MLP with one hidden layer:

Forward pass:  
u\_j¹ = Σ\_i w\_{ji}¹ x\_i + b\_j¹, h\_j = σ(u\_j¹)  
u\_k² = Σ\_j w\_{kj}² h\_j + b\_k², o\_k = σ(u\_k²)

Backward pass:  
δ\_k² = (t\_k - o\_k) σ'(u\_k²), δ\_j¹ = Σ\_k w\_{kj}² δ\_k² σ'(u\_j¹)  
Updates: Δw = η δ input

Graphical illustration: Network diagram and loss vs. epoch.

## Experiment 4: MATLAB Membership Functions

Fuzzy logic uses membership functions (MFs) μ\_A(x)∈[0,1]. Common forms:  
• Triangular μ\_tri(x;a,b,c)  
• Trapezoidal μ\_trap(x;a,b,c,d)  
• Generalized Bell μ\_bell(x;a,b,c)

Illustration: Plot each MF over x∈[0,10].

## Experiment 5: Fuzzy Toolbox Tip Model

A fuzzy inference system maps Service and Food quality to Tip:  
1. Fuzzification: compute μ for inputs.  
2. Rule evaluation: IF–THEN using min/max.  
3. Aggregation: pointwise max.  
4. Defuzzification: centroid y\* = ∫ x μ\_agg(x) dx / ∫ μ\_agg(x) dx.

Illustration: 3D rule surface.

## Experiment 6: FIS Editor (MATLAB GUI)

MATLAB’s FIS Editor GUI:  
- Define variables and MFs.  
- Enter rules visually.  
- View 2D/3D input-output surfaces.

Illustration: Screenshots of the editor and surface viewer.

## Experiment 7: Genetic Algorithm Basics

GAs evolve a population of bit-strings:  
1. Encoding  
2. Evaluation (fitness f)  
3. Selection  
4. Crossover  
5. Mutation

Illustration: Best/average fitness vs. generation.

## Experiment 8: Prolog Knowledge Representation

Prolog uses facts and rules in Horn-clause form. Example:  
parent(alice,bob).  
grandparent(X,Y):- parent(X,Z), parent(Z,Y).

Queries: ?- grandparent(alice,Who).  
Illustration: Search tree for unification and backtracking.