Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ECC604	Artificial Neural Networks and Fuzzy Logic	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme							
		Theory Marks				Exam Duration (Hrs.)	Term Work	Practical and Oral	Total
		Internal Assessment			End Sem. Exam.				
		Test1	Test2	Avg.					
ECC604	Artificial Neural Networks and Fuzzy Logic	20	20	20	80	03	--	--	100

Course Prerequisites:

1. Basic linear Algebra
2. Engineering Mathematics-I to IV

Course Objectives:

1. To introduce the concepts and understanding of artificial neural networks
2. To provide adequate knowledge about supervised and unsupervised neural networks
3. To introduce neural network design concepts
4. To expose neural networks based methods to solve real world complex problems
5. To study the architecture of CNN and its application in image classification.
6. To introduce fuzzy logic and fuzzy inference systems

Course Outcomes:

After successful completion of the course, the student will be able to:

1. Comprehend the concepts of biological neurons and artificial neurons
2. Analyze the feed-forward and feedback neural networks and their learning algorithms.
3. Comprehend the neural network training and design concepts
4. Build a simple CNN model and apply in image classification
5. Analyze the application of neural networks and fuzzy logic to real world problems.

Module No.	Topics	Hrs.
1.0	**Introduction to Neural Networks and their Basic Concepts**	**07**
	Biological neuron and Artificial neuron, McCulloch-Pitts Model, Activation Function, various types of Activation Functions and types of Neural Network Architectures, Prerequisites for Training of Neural Networks. Linearly Separable and Linearly Non-Separable Systems with examples, Concepts of Supervised Learning, Unsupervised Learning, and Reinforcement Learning. Brief survey of applications of Neural Networks.	
2.0	**Supervised Learning Neural Networks**	**07**
	Perceptron - Single Layer Perceptron, Multilayer Perceptron and their Architecture. Error Functions: Mean Square Error and Sum Squared Error. Gradient Descent, Generalized delta rule, Error back propagation, Stopping Criterions for Training.	
3.0	**Unsupervised Learning Neural Networks**	**07**
	Competitive Learning Network – Kohonen Self-Organizing Networks – Architecture, Training Algorithm, Discrete Hopfield Network- Hopfield Matrix, Testing Algorithm, K-Means Clustering Algorithm.	
4.0	**Algorithms of Neural Networks**	**04**
	Basic concept of Machine Learning, Support Vector Machine (SVM) - Introduction and SVM based Binary Classifier, LMS Algorithm.	
5.0	**Convolution Neural Network (CNN)**	**07**
	Basic concept of Deep Learning, Convolution Operation, Overview of CNN Architecture, Input layer, Convolution layers, Pooling layers, Padding, Strided Convolutions, Rectified Linear Unit (ReLU), One Layer of a Convolutional Network, Fully Connected Layers, Complex Image Classification using CNN.	
6.0	**Introduction to Fuzzy Inference System**	**07**
	Introduction to Fuzzy Logic, Fuzzy Rules, Fuzzy Properties - Operations, Membership Functions, Fuzzification - Membership Value Assignments using Intuition Method, Defuzzification Methods -- Mean of Maxima and Centroid (Centre of Area) Methods, Fuzzy Inference System with reference to Mamdani Model, Brief Review of Applications of Fuzzy Logic to Speed Control of DC Motor and Washing Machine.	
	Total	**39**

Text Books:

1. S. N. Sivanandam and S. N. Deepa, Introduction to Soft Computing, Wiley India Publications, 3rd Edition.
2. Simon Haykin, Neural Networks and Learning Machines, Pearson Prentice Hall, 3rd Edition
3. S. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic, and Genetic Algorithms, PHI Learning Pvt. Ltd, 2003.
4. Practical Convolutional Neural Networks by Mohit Sewak, Md. Rezaul Karim, Pradeep Pujari, Packt Publishing, 2018.
5. Timothy J. Ross, Fuzzy Logic with Engineering Applications, Wiley India Publications, 3rd Edition.

References:

1. Hagan, Demuth, and Beale, Neural Network Design, Thomson Learning, 2nd Edition.
2. Simon Haykin, Neural Network- A Comprehensive Foundation, Pearson Education, 2nd Edition.
3. Christopher M. Bishop, Neural Networks for Pattern Recognition, Oxford University Press, 2005.
4. William W. Hsieh, Machine Learning Methods in the Environmental Sciences: Neural Network and Kernels, Cambridge University Press, 2009.
5. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press, 2016
6. S. N. Sivanandam, S. Sumathi, and S. N. Deepa, Introduction to Neural Network using Matlab, Tata McGraw-Hill Publications, 2006.
7. Mehrotra Kishan, Mohan C. K. Ranka Sanjay, Elements of Artificial Neural Networks, Penram International Publishing Pvt. Ltd, 2nd Edition.
8. J. M. Zurada, Introduction to Artificial Neural Systems, Jaico Publishers, 2006.
9. Bart Kosko, Neural Networks and Fuzzy Systems, Pearson Education, 2007.

Recommended NPTEL / Swayam Course and Online resources:

1. Course: Fuzzy Logic and Neural Networks by Prof. Dilip Kumar Pratihar, IIT Kharagpur
2. Course: Neural Network and Applications by Prof. Somnath Sengupta, IIT Kharagpur
3. Michael Nielsen, "Neural Networks and Deep Learning", Determination Press, 2015. http://neuralnetworksanddeeplearning.com/

List of Suggested Experiments to be conducted in IPMV Laboratory (ECL 603):

1. Classification of Non-linearly Separable Binary Pattern using Multilayer Perceptron Neural Network.
2. Pattern Clustering using K-means Algorithm.
3. Binary Pattern Restoration using Discrete Hopfield Neural Network.
4. Image Classification using Support Vector Machine.
5. Object Recognition using Convolutional Neural Network.
6. Design Fuzzy Controller for Washing Machine

Internal Assessment (20-Marks):

Internal Assessment (IA) consists of two class tests of 20 marks each. IA-1 is to be conducted on approximately 40% of the syllabus completed, and IA-2 will be based on remaining contents (approximately 40% syllabus but excluding contents covered in IA-I). Duration of each test shall be one hour. Average of the two tests will be considered as IA marks.

End Semester Examination (80-Marks):

Weightage to each of the modules in end-semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2. **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3. Remaining questions will be mixed in nature and randomly selected from all the modules.
4. Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5. **Total 04 questions** need to be solved.