Semester: III	
Programme: M.Sc. Data Science	
Course: Deep Learning	
Paper code: M2C4DS26034CT / M2C4DS26034CP	**Credits: 6**
Hours/week: 8 (4Th + 4Pr)	
Category: Core/MDC/SEC/VAC: Core	
Theory / Practical / Composite: Composite	
No of Modules: 1	

Course Outcome:

Remember the foundational concepts of deep learning, including representation learning, biological inspiration, McCulloch-Pitts neurons, perceptron networks, sigmoid neurons, and historical milestones of AI.

Understand the structural principles of feedforward neural networks, backpropagation mechanisms, sequence modelling architectures (RNN, LSTM, GRU, Transformers), and attention mechanisms.

Apply network training strategies—such as optimization algorithms, weight initialization, batch normalization, regularization techniques (dropout, early stopping, data augmentation), and transfer learning—to train deep models.

Analyze the operational mechanics of Convolutional Neural Networks (convolutions, kernels, padding, stride, pooling) and sequence architectures (vanishing/exploding gradients, backpropagation through time).

Evaluate deep neural network performance, training versus testing errors, and architectural suitability across computer vision and natural language processing tasks.

Create comprehensive deep learning solutions by synthesizing advanced network architectures—including CNNs, sequence models, and transformers—to solve complex real-world problems in computer vision and natural language processing.

Prerequisites: Knowledge about Supervised Machine Learning

SYLLABUS

UNIT/Module	CONTENT	HOURS or NUMBER OF CLASSES	CO Mapping	COGNITIVE LEVEL
I.	**Introduction to Deep Learning (DL):** Drawbacks of machine learning; Representation learning; From Spring to Winter of AI; Biological inspiration; McCulloch Pitts Neuron; The Perceptron; Power of a network of Perceptrons; The Sigmoid Neuron; Power of a network of Sigmoid neurons.	**6**		
II.	**Feedforward Neural Networks:** Learning parameters; Backpropagation (BP); Gradient calculation: output units, hidden units, parameters, activation function.	**4**		
III.	**Training deep neural networks:** Optimizers: gradient descent and its variations; Train error v/s test error; Dataset augmentation; Early stopping; Dropout; Initialization strategies; Batch Normalization; More activation functions.	**10**		
IV.	**Convolutional Neural Networks (CNN):** The convolution operation: kernel, padding, stride; The pooling operation: max pooling, average pooling; BP in CNN; Success stories on the ImageNet dataset; Transfer learning.	**10**		
V.	**Sequence Modelling:** Recurrent Neural Network (RNN); Types of RNN; Drawbacks of RNN:	**12**		

	vanishing gradient and exploding gradient; BP through time; Long Short-Term Memory (LSTM); Gated Recurrent Unit (GRU); Embedding layer; Attention mechanism; Transformer architecture.			
VI.	**Applications:** Computer Vision, Natural Language Processing.	**10**		

Text Books		
1. Goodfellow, I, Bengio, Y, and Courville, A (2016): Deep Learning. MIT Press		
2. Nikhil Buduma and Nicholas Locascio. 2017. Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms (1st. ed.). O'Reilly Media, Inc.		
Suggested readings		
1. Josh Patterson, Adam Gibson "Deep Learning: A Practitioner's Approach", O'Reilly Media, 2017		
2. Francois Chollet "Deep Learning with Python", Manning Publications, 2017		
Web Resources		
1. NPTEL: Deep Learning by Prof. Sudarshan Iyengar, IIT Ropar, Link to course		
2. Deep Learning Specialization by Andrew Ng, Link to course		
Evaluation		
Marks	CIA: Class Performance: 2 Attendance: 3 Mid-term Exam: 10 Total: 15 End Semester Exam: 45	Continuous Assessment: 40
Paper Structure for Theory Semester Exam	Short Questions: 5 marks each	Long Questions: 10 marks each
	3 out of 5	3 out of 5

Course outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive levels
CO1	**Remember** the foundational concepts of deep learning, including representation learning, biological inspiration, McCulloch-Pitts neurons, perceptron networks, sigmoid neurons, and historical milestones of AI.	K1
CO2	**Understand** the structural principles of feedforward neural networks, backpropagation mechanisms, sequence modelling architectures (RNN, LSTM, GRU, Transformers), and attention mechanisms.	K2
CO3	**Apply** network training strategies—such as optimization algorithms, weight initialization, batch normalization, regularization techniques (dropout, early stopping, data augmentation), and transfer learning—to train deep models.	K3
CO4	**Analyze** the operational mechanics of Convolutional Neural Networks (convolutions, kernels, padding, stride, pooling) and sequence architectures (vanishing/exploding gradients, backpropagation through time).	K4
CO5	**Evaluate** deep neural network performance, training versus testing errors, and architectural suitability across computer vision and natural language processing tasks.	K5
CO6	**Create** comprehensive deep learning solutions by synthesizing advanced network architectures—including CNNs, sequence models, and transformers—to solve complex real-world problems in computer vision and natural language processing.	K6