Course Code	DEEP LEARNING	L	T	P	C
AM5402		3	0	2	4

COURSE OBJECTIVES

- To introduce the foundational principles of deep learning, including neural network architecture, activation functions, training algorithms, and development frameworks.
- To explore the structure, training strategies, and applications of convolutional neural networks for image-based learning tasks.
- To understand the modelling of sequential data using RNNs, gated architectures, and attention mechanisms for tasks involving time and language.
- To study unsupervised feature learning and data generation using various forms of auto encoders and generative models such as GANs and VAEs.
- To introduce reinforcement learning concepts and demonstrate how deep learning methods are integrated for autonomous and decision-making applications.

UNIT I – FUNDAMENTALS OF DEEP LEARNING **9**

Introduction to Deep Learning: definition, scope, differences from machine learning, and real-world applications. Neurons (biological, artificial), McCulloch-Pitts model, perceptron, MLPs, XOR, feedforward networks, activation (Sigmoid, Tanh, ReLU, Leaky ReLU, Softmax), backpropagation, delta rule, optimization (GD, SGD, Momentum, Nesterov, Adagrad, RMSProp, Adam), regularization (L1/L2, dropout, early stopping, batch norm), overfitting, underfitting, bias-variance, hyperparameters, validation/testing, TensorFlow, PyTorch.

UNIT II – CONVOLUTIONAL NEURAL NETWORKS **9**

Convolution (filters, stride, padding), pooling (max, avg), CNN structure, architectures: LeNet, AlexNet, ZFNet, VGG, GoogLeNet, ResNet, DenseNet, MobileNet, transfer/self-supervised learning, object detection (R-CNN, Fast/Faster R-CNN, YOLO, RFCN), segmentation (FCN, U-Net), batch norm, activation functions, vision applications.

UNIT III – RECURRENT NEURAL NETWORKS & ATTENTION **9**

RNNs (vanilla, bi-RNN, deep), gated units (LSTM, GRU, BLSTM), seq2seq learning, beam search, BPTT, vanishing/exploding gradients, language modeling, attention (cues, pooling, scoring), self-attention, positional encoding, Transformer (encoder-decoder), pretrained: BERT, GPT, ELMO, visual transformers.

UNIT IV – AUTOENCODERS & GENERATIVE MODELS **9**

Auto encoders (basic, stacked, sparse, denoising, contractive), VAEs, GANs (DCGAN, cGAN), generative models (RBM, DBN, DBM, conv-Boltzmann), DALL·E, IMAGEN, applications: image generation, style transfer, data imputation.

UNIT V – DEEP REINFORCEMENT LEARNING & APPLICATIONS **9**

RL (policy, reward, MDP), Monte Carlo, TD learning, Q-learning, DQN, policy gradient, REINFORCE, actor-critic (A2C, A3C), model-based RL, applications: imitation learning, ChaufferNet, driving policy, DL in cloud/edge.

Theory :45 Periods

COURSE OUTCOMES

CO1. Demonstrate the ability to design, train, and evaluate fundamental neural network models using optimization and regularization techniques within modern deep learning frameworks.

CO2. Construct and apply convolutional neural network (CNN) architectures for solving tasks such as image classification, object detection, and image segmentation.

CO3. Develop and utilize recurrent neural networks (RNNs) and transformer-based models for processing sequential data and natural language applications.

CO4. Implement and analyze autoencoders, generative adversarial networks (GANs), and related generative models for tasks involving data reconstruction and synthesis.

CO5. Design and apply deep reinforcement learning algorithms for practical applications including autonomous systems and cloud-based intelligent decision-making.

Lab Experiments **30Hrs**

UNIT I – Fundamentals of Deep Learning

1: Implement perceptron and multilayer perceptron (MLP) using NumPy.
2: Demonstrate backpropagation algorithm on a small feedforward neural network.
3: Compare activation functions (ReLU, Sigmoid, Tanh) on a classification task.
4: Build a neural network using PyTorch/TensorFlow on MNIST

UNIT II – Convolutional Neural Networks

5: Implement basic CNN for CIFAR-10 or MNIST image classification.
6: Analyze the effect of pooling and padding in CNNs.
7: Transfer learning using pretrained models like VGG16 or ResNet on a custom dataset.
8: Object detection using YOLOv5/Faster R-CNN

UNIT III – Recurrent Neural Networks & Attention

9: Build a character-level RNN for text generation.
10: Implement LSTM for sentiment analysis on IMDB reviews.
11: Visualize attention weights using a pretrained BERT model on a QA task.

UNIT IV – Autoencoders & Generative Models

12: Implement a basic autoencoder for image compression.
13: Denoising autoencoder for removing noise from images.

14: Use a VAE to generate variations of handwritten digits.

UNIT V – Deep Reinforcement Learning & Applications

15: Train a DQN agent to solve the CartPole balancing task.
16: Implement policy gradient method on a simple grid world environment.
17: Evaluate performance of actor-critic algorithm (A2C) in OpenAI Gym environment.

Total Hrs: 75Hrs

TEXTBOOKS

1. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning, MIT Press, 2016. (Comprehensive foundational text widely used in academic deep learning courses.)
2. François Chollet, Deep Learning with Python, 2nd Edition, Manning Publications, 2021. (Practical implementation-focused book using Keras and TensorFlow.)

REFERENCE BOOKS

1. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 3rd Edition, O'Reilly, 2022. (Application-oriented resource for building deep learning systems.)
2. Sebastian Raschka and Yuxi Liu, Machine Learning with PyTorch and Scikit-Learn, 2nd Edition, Packt, 2022. (Hands-on guide for implementing ML and DL models using PyTorch.)
3. Charu C. Aggarwal, Neural Networks and Deep Learning: A Textbook, Springer, 2018. (Well-structured academic resource covering theoretical and practical aspects.)
4. Michael Nielsen, Neural Networks and Deep Learning, Determination Press, 2015. (Open-access introductory book focusing on intuition and math foundations.)
5. Richard S. Sutton and Andrew G. Barto, Reinforcement Learning: An Introduction, 2nd Edition, MIT Press, 2018. (Definitive text on reinforcement learning, essential for Unit V.)

CO's- PO's & PSO's MAPPING

	PO's												PSO's		
CO's	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	2	2	3	1	1	1	3	2	2	1	3	3	1
2	3	3	2	2	3	1	1	1	3	2	2	1	1	2	2
3	3	3	2	2	3	1	1	1	3	2	2	1	1	3	3
4	3	3	2	2	3	1	1	1	3	2	2	1	3	3	3
5	3	3	2	2	3	1	1	1	3	2	2	1	3	2	2
AVG	3	3	2	2	3	1	1	1	3	2	2	1	2.2	2.6	2.2