DEL616MJ: Deep Learning		
Teaching Scheme: **Theory Session**: Total 45 Hours	**Credit: 03**	**Examination Scheme:** **Internal (TH)**: 25 Marks **External (TH)**: 50 Marks **Total :**75 Marks

Prerequisites:

1. Strong foundation in linear algebra, calculus, probability, and programming (preferably Python).
2. Basic understanding of machine learning concepts, optimization techniques, and data pre-processing.

Course Objectives:

- To introduce students to the fundamentals of deep learning, neural networks, and optimization techniques.
- To enable students to design, train, and evaluate deep learning models using frameworks like TensorFlow and PyTorch.
- To teach advanced deep learning techniques such as CNNs, RNNs, transformers, and generative models.
- To prepare students for real-world applications of deep learning in areas such as computer vision, natural language processing, and reinforcement learning.
- To Emphasize ethical considerations and responsible AI practices.

Course Outcomes:

On completion of the course, learners should be able to

CO #	Cognitive Domain	Course Outcomes
CO1	Understand	Understand the fundamentals of deep learning, neural network architectures, optimization techniques, and deep learning frameworks.
CO2	Apply	Develop proficiency in applying Convolutional Neural Networks (CNNs) and Vision Transformers (ViTs) for image classification, object detection, and image segmentation.
CO3	Analyse	Use RNNs, LSTMs, GRUs, and Transformers for NLP tasks like sentiment analysis, machine translation, and text summarization.
CO4	Create	Design and implement advanced deep learning models, including generative models, reinforcement learning, and hyperparameter optimization techniques.
CO5	Evaluate	Apply deep learning to real-world problems, culminating in a **capstone project** involving end-to-end model development, deployment, and ethical considerations.

Unit No.	Contents	Weightage in %	No of Sessions
1	1.1 **Introduction to Deep Learning:**	20	9

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	• Evolution, history, and real-world applications. • Differences between deep learning, machine learning, and AI. 1.2 **Mathematical Foundations:** • Linear algebra (eigenvalues, SVD, matrix operations). • Calculus (partial derivatives, chain rule). • Probability (Bayes' theorem, distributions). 1.3 **Neural Network Basics:** • Artificial neurons, perceptron model. • Activation functions (ReLU, Leaky ReLU, GELU). 1.4 **Training Neural Networks:** • Loss functions (cross-entropy, MSE). • Gradient descent, backpropagation. • Optimization techniques (SGD, Adam, AdamW, RAdam). 1.5 **Deep Learning Frameworks:** • TensorFlow, PyTorch, and Keras. • Environment setup and basic operations.		
*Mapping of Course Outcomes for Unit 1: CO1			
2	**2. Convolutional Neural Networks (CNNs) and Computer Vision** 2.1 **Fundamentals of CNNs:** • Convolutional layers, pooling, fully connected layers. • Feature maps and receptive fields. 2.2 **CNN Architectures:** • AlexNet, VGG, ResNet, EfficientNet. 2.3 **Image Classification:** • Training CNNs, transfer learning, and fine-tuning (e.g., ImageNet). 2.4 **Object Detection and Segmentation:** • YOLO, SSD, Mask R-CNN. 2.5 **Advanced Computer Vision:** • Vision Transformers (ViTs). • Diffusion models for image generation.	20	9
*Mapping of Course Outcomes for Unit 2: CO2			
3	**3. Recurrent Neural Networks (RNNs) and Natural Language Processing (NLP)** 3.1 **Introduction to RNNs:** • Sequential data processing, vanishing/exploding gradients. 3.2 **LSTM and GRU Networks:** • Architecture and applications. 3.3 **Text Processing:**	20	9

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	• Word2Vec, GloVe, FastText. 3.4 **Transformers and Attention Mechanisms:** • BERT, GPT, T5. • Multimodal models (e.g., CLIP, DALL-E). 3.5 **NLP Tasks:** • Sequence-to-sequence models, machine translation, chatbots.		
*Mapping of Course Outcomes for Unit 3: CO3			

4	4.1 **Generative Models:** • VAEs, GANs, and Diffusion Models. 4.2 **Reinforcement Learning (RL):** • Deep Q-Networks (DQN), Proximal Policy Optimization (PPO). 4.3 **Optimization Techniques:** • Hyperparameter tuning (Grid search, random search, Bayesian optimization). 4.4 **Edge AI and TinyML:** • Deploying models on resource-constrained devices. 4.5 **Ethics and Responsible AI:** • Bias detection, fairness metrics, AI regulations (e.g., GDPR).	20	9
*Mapping of Course Outcomes for Unit 4: CO4			
5	**5. Real-World Applications and Capstone Project** 5.1 **Industry Use Cases:** • Healthcare: Medical imaging, drug discovery. • Finance: Fraud detection, algorithmic trading. • E-commerce: Recommendation systems. • Autonomous Systems: Use of deep learning in robotics, drones, and self-driving cars. • Social Good: Applications in climate change, disaster prediction, and accessibility solutions. 5.2 **Model Deployment and MLOps:** • TensorFlow Serving, ONNX, TorchServe. • MLOps tools (e.g., MLflow, Kubeflow). 5.3 **Capstone Project:** • Problem identification, data collection, model design, training, evaluation, and deployment.	20	9
*Mapping of Course Outcomes for Unit 5: CO5			

Notes

1. The course should be taught using **Python**.
2. Incorporate **hands-on labs, case studies, and industry-relevant projects** for practical learning.
3. Encourage students to participate in **Kaggle competitions** or **open-source projects** for real-world experience.
4. **Numerical problems** should be covered wherever required

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Learning Resources

Text Books

- **Deep Learning** by Ian Goodfellow, Yoshua Bengio, and Aaron Courville, MIT Press
- **Deep Learning with Python** by François Chollet, Manning Publications
- **Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow** by Aurélien Géron, O'Reilly
- **Neural Networks and Deep Learning: A Textbook** by Charu C. Aggarwal, Springer
- **Deep Learning for Computer Vision** by Rajalingappaa Shanmugamani,Packt Publishing

Reference Books

1. **Deep Learning with PyTorch** by Eli Stevens, Luca Antiga, and Thomas Viehmann (Manning Publications).
2. **Generative Deep Learning** by David Foster (O'Reilly).
3. **Natural Language Processing with Transformers** by Lewis Tunstall, Leandro von Werra, and Thomas Wolf (O'Reilly).

Recommended Learning Material

Online Resources:

- **TensorFlow Tutorials:** https://www.tensorflow.org/tutorials
- **PyTorch Tutorials:** https://pytorch.org/tutorials/
- **Hugging Face Courses:** https://huggingface.co/course

Tutorials and Guides

1. **TensorFlow Tutorials**
   - Official TensorFlow tutorials for beginners and advanced users.
     Link: https://www.tensorflow.org/tutorials
2. **PyTorch Tutorials**
   - Official PyTorch tutorials for deep learning.
     Link: https://pytorch.org/tutorials/
3. **Keras Documentation and Tutorials**
   - Official Keras guides and examples.
     Link: https://keras.io/guides/
4. **Deep Learning Tutorials by Analytics Vidhya**
   - Beginner-friendly tutorials on deep learning concepts and implementations.
     Link: https://www.analyticsvidhya.com/blog/category/deep-learning/

Recommended Certification

1. **Deep Learning by Prof. Mitesh Khapra (IIT Madras)**
   - Link:https://nptel.ac.in/courses/106106184
2. **Introduction to Machine Learning by Prof. Balaraman Ravindran (IIT Madras)**

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- Link: https://nptel.ac.in/courses/106105174

Google AI

1. **Machine Learning Crash Course (Free)**
   - Link: https://developers.google.com/machine-learning/crash-course
2. **TensorFlow Certification Program**
   - Link: https://www.tensorflow.org/certificate

Coursera

1. **Deep Learning Specialization by Andrew Ng (offered by DeepLearning.AI)**
   - Link: https://www.coursera.org/specializations/deep-learning
2. **Advanced Computer Vision with TensorFlow (offered by DeepLearning.AI)**
   - Link: https://www.coursera.org/learn/advanced-computer-vision-with-tensorflow

edX

1. **Deep Learning Fundamentals by IBM**
   - Link: https://www.edx.org/course/deep-learning-fundamentals
2. **Deep Learning for Computer Vision by Microsoft**
   - Link: https://www.edx.org/course/deep-learning-for-computer-vision

Udemy

1. **Deep Learning A-Z: Hands-On Artificial Neural Networks**
   - Link: https://www.udemy.com/course/deeplearning/
2. **Python for Computer Vision with OpenCV and Deep Learning**
   - Link: https://www.udemy.com/course/python-for-computer-vision-with-opencv-and-deep-learning/

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