Year / Semester: III B.Tech VI Semester   **Regulation: R23**

Subject and Code: DEEP LEARNING and 23CSM362T

UNIT-I: LINEAR ALGEBRA, PROBABILITY AND NUMERICAL COMPUTATION

Linear Algebra: Scalars, Vectors, Matrices and Tensors, Matrix operations, types of matrices, Norms, Eigen decomposition, Singular Value Decomposition, Principal Components Analysis.

Probability and Information Theory: Random Variables, Probability Distributions, Marginal Probability, Conditional Probability, Expectation, Variance and Covariance, Bayes' Rule, Information Theory.

Numerical Computation: Overflow and Underflow, Gradient-Based Optimization, Constrained Optimization, Linear Least Squares.

UNIT-II: MACHINE LEARNING AND DEEP FEED FORWARD NETWORKS

Machine Learning: Basics and Under fitting, Hyper parameters and Validation Sets, Estimators, Bias and Variance, Maximum Likelihood, Bayesian Statistics, Supervised and Unsupervised Learning, Stochastic Gradient Descent, Challenges Motivating Deep Learning.

Deep Feed forward Networks: Learning XOR, Gradient-Based Learning, Hidden Units, Architecture Design, Back-Propagation and other Differentiation Algorithms.

UNIT-III: REGULARIZATION AND OPTIMIZATION OF DL MODELS

Regularization for Deep Learning: Parameter Norm Penalties, Norm Penalties as Constrained Optimization, Regularization and Under-Constrained Problems, Dataset Augmentation, Noise Robustness, Semi-Supervised Learning, Multi-Task Learning, Early Stopping, Parameter Tying and Parameter Sharing, Sparse Representations, Bagging and Other Ensemble Methods, Dropout, Adversarial Training, Tangent Distance, Tangent Prop and Manifold Tangent Classifier. Optimization for Training Deep Models:

Pure Optimization, Challenges in Neural Network Optimization, Basic Algorithms, Parameter Initialization Strategies, Algorithms with Adaptive Learning Rates, Approximate Second-Order Methods, Optimization Strategies and Meta-Algorithms.

UNIT-IV: CONVOLUTIONAL NETWORKS

Convolutional Networks: The Convolution Operation, Pooling, Convolution, Basic Convolution Functions, Structured Outputs, Data Types, Efficient Convolution Algorithms, Random or Unsupervised Features, Basis for Convolutional Networks.

UNIT-V: SEQUENCE MODELING

Sequence Modeling: Recurrent and Recursive Nets: Unfolding Computational Graphs, Recurrent Neural Networks, Bidirectional RNNs, Encoder-Decoder Sequence to-Sequence Architectures, Deep Recurrent Networks, Recursive Neural Networks, Echo State Networks, LSTM, Gated RNNs, Optimization for Long-Term Dependencies, Auto encoders, Deep Generative Models.

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Max Marks: 10

S.No.	CO	Questions	BT
		Unit I: (LINEAR ALGEBRA, PROBABILITY AND NUMERICAL COMPUTATION)	
1	1	a. Define scalars, vectors, matrices, and tensors with examples b. **Explain norms and their importance in deep learning.**	L3
2	1	Define different types of matrix operations (addition, multiplication, transpose, inverse) and their significance.	L2
3	1	Discuss different types of probability distributions. Explain any three with examples.	L4
4	1	Apply Singular Value Decomposition (SVD) to the matrix $$A = \begin{bmatrix} 3 & 0 \\ 0 & 4 \end{bmatrix}$$	L2
5	1	Explain Eigen decomposition and its role in dimensionality reduction	L5
6	1	Find the eigenvalues and eigenvectors of $A = \begin{bmatrix} 4 & 1 \\ 2 & 3 \end{bmatrix}$	L2
7	1	Examine overflow and underflow problems in numerical computation	L2 L2
8	1	**Discuss about gradient-based optimization.**	L5
9	1	Discuss the role of constrained optimization techniques in ML problems.	L4 L4
10	1	a. State and Explain Bayes' Rule. Derive the formula using conditional probability. **Define Expectation and Variance of a random variable. Explain their significance in probability and machine learning.**	L3

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S.No.	CO	Questions	BT
		Unit II: (MACHINE LEARNING AND DEEP FEED FORWARD NETWORKS)	
1	2	a. Discuss about learning XOR problem	L4
		b. Explain the concepts of overfitting and underfitting with suitable examples.	L4
2	2	**Discuss the importance of Bayesian statistics in machine learning.**	L3
3	2	Differentiate between supervised and unsupervised learning with examples.	L3
4	2	**Describe the architecture and working principle of a Deep Feedforward Neural Network (DFNN) with a neat diagram.**	L4
			L4
5	2	**Explain the backpropagation algorithm in deep learning. Illustrate how errors are propagated and weights are updated during training.**	L5
6	2	A research team is developing a neural network model named LeafYield, designed to predict the crop yield (in kg) from leaf-level features extracted via sensors and imaging. Each sample contains 5 normalized numerical features: Leaf length, Leaf width, Color intensity, Water content, Light absorption level. The Deep Feed forward Neural Network as follows and the neurons in the hidden layer 1, Hidden layer 2 and output layer are having sigmoid activation function Given the input vector x= $[0.1, 0.5, 0.3, 0.7, 0.2]^T$ and	L3

		$W1 = \begin{pmatrix} 1 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 0 \\ 1 & -1 & 0 & 1 & 1 \\ 0 & 1 & 1 & 1 & 0 \end{pmatrix}$ Find the pre-activation vector for hidden layer 1, Apply sigmoid activation to the above vector obtained find the output from the hidden layer1 , Find the pre-activation vector for hidden layer 2, Apply sigmoid activation to the above vector obtained find the output from the hidden layer 2 and Find the pre-activation vector for output layer , Apply sigmoid activation to the above vector obtained find the output from the Output layer.	
7	2	Explain Stochastic Gradient Descent (SGD) and describe the challenges that motivate deep learning.	L5
8	2	Write short notes on Bias and Variance trade-off.	L4 L4
9	2	Explain how Batch, Mini-batch, and Stochastic Gradient Descent update model parameters during training.	L4
10	2	a. Compare the advantages and disadvantages of Batch, Mini-batch, and Stochastic Gradient Descent. b. Why is Mini-batch Gradient Descent commonly used in deep learning?	L3

S. No.	CO	Questions	BT
Unit III: (REGULARIZATION AND OPTIMIZATION OF DL MODELS)			
1	3	Explain regularization in deep learning. Discuss norm penalties, dropout, dataset augmentation, and early stopping.	L4
2	3	Discuss sparse representation and explain the major techniques used to achieve sparse representations in deep learning.	L3
3	3	a. Discuss the role of regularization in solving under-constrained problems. b. Describe semi-supervised learning with suitable examples	L4 L2
4	3	Explain the concept of dataset augmentation and describe various techniques used to improve noise robustness in deep learning models.	L3

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5	3	Describe the concept of multi-task learning and explain how it helps reduce overfitting.	L3
6	3	a.　Explain Adversarial Training and its importance. b.　Compare Tangent Propagation and Tangent Distance.	L4
7	3	Discuss adaptive learning rate algorithms: AdaGrad, RMSProp, Adam.	L2 L4
8	3	Explain how MTC uses manifold tangent vectors to improve classification robustness	L5
9	3	Explain Ensemble learning and discuss how it improves generalization in deep learning models	L4
10	3	a. Explain the concept of pure optimization and its objective in machine learning. b. Discuss the major challenges encountered in neural network optimization, such as local minima, saddle points, and vanishing gradients.	L4
11	3	Explain different parameter initialization strategies and analyze their impact on neural network training performance.	L4

S.No.	CO	Questions	BT
Unit IV: (CONVOLUTIONAL NETWORKS)			
1	4	Explain the convolution operation in CNNs and its role in feature extraction.	L2
2	4	a. Describe pooling (max & average pooling). b. Write notes on basic convolution functions.	L2
3	4	a.　Explain structured outputs in CNNs with applications. b.　Write short notes on data types used in CNNs.	L4
4	4	Discuss efficient convolution algorithms and computational optimizations in CNNs.	L2 L1
5	4	a.　Explain random/unsupervised features in CNNs. a.　Describe the basis and importance of CNNs in vision tasks.	L5

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6	4	a. Differentiate convolution layers and fully connected layers. b. Write notes on pooling for overfitting reduction.	L4
7	4	Explain CNN architecture including layers, activation functions, and feature maps.	L2
8	4	a. Discuss filters/kernels in feature detection. b. Explain CNN use in structured output tasks like segmentation.	L5
9	4	a. Explain feature maps and hierarchical learning. b. Write notes on FFT/GPU-based efficient convolution.	L4 L2
10	4	Explain complete CNN working with layers and applications.	L3

S.No.	CO	Questions	BT
		Unit V: (SEQUENCE MODELING)	
1	5	Explain the architecture and working of Recurrent Neural Networks (RNNs). Describe unfolding computational graphs in training RNNs.	L3
2	5	Discuss the architecture and working of Bidirectional RNNs and Deep Recurrent Networks. Compare their advantages over standard RNNs with suitable applications.	L4
3	5	Describe the Long Short-Term Memory (LSTM) network with gate mechanisms. Explain how LSTM solves the vanishing gradient problem.	L4
4	5	Explain the Encoder–Decoder (Sequence-to-Sequence) architecture. Describe how it is used in machine translation and discuss its limitations and improvements.	L5

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5	5	Explain the architecture of Long Short-Term Memory (LSTM) networks. Discuss how gating mechanisms help in overcoming the vanishing gradient problem.	L4
6	5	Discuss the vanishing and exploding gradient problems in RNNs. Explain the optimization strategies used to address long-term dependency issues.	L5
7	5	Explain the architecture and training of Autoencoders. Discuss different types of autoencoders and their applications in dimensionality reduction and feature learning.	L4
8	5	Discuss the concept of Deep Generative Models. Explain how generative models differ from discriminative models, with examples.	L4
9	5	Design a sequence modeling framework for a real-world application (e.g., speech recognition or machine translation) using LSTM-based encoder–decoder architecture. Discuss training strategy, optimization methods, and evaluation metrics.	L6
10	5	Explain the architecture of Gated Recurrent Neural Networks (GRU).	L3

Note: L1-Remembering, L2-Understanding, L3-Applying, L4-Analyzing, L5-Evaluating, and L6-Creating

Instruction to Faculty Members:

The Six Levels of Bloom's Taxonomy:

1. **Remembering:** Retrieving, recognizing, and recalling relevant knowledge from long-term memory (e.g., list, define, name, locate).

2. **Understanding:** Constructing meaning, explaining ideas, or concepts (e.g., summarize, interpret, classify, compare).

3. **Applying:** Using information in new situations or implementing procedures to solve problems (e.g., solve, use, demonstrate, implement).

4. **Analyzing:** Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure (e.g., contrast, categorize, distinguish, diagram).

5. **Evaluating:** Making judgments based on criteria and standards through checking and critiquing (e.g., judge, critique, justify, defend, argue).

6. **Creating:** Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure (e.g., design, construct, develop, formulate).