

**Course Outline (OBE Format)**  
**Program: M.Sc. in Computer Science & Engineering**  
**Course Title: Deep Learning**  
**Course Code: CSE-5111**  
**Credit: 3.0**  
**Level/Semester: Master's, 1st Semester**  
**Contact Hours: 3 hours/week**  
**Course Teacher: Dr. Mahmudul Hasan, Dept. of CSE, Comilla University**  
**Prerequisites: Machine Learning, Linear Algebra, Probability & Statistics, Python Programming**

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### 1. Course Description

This course provides a rigorous foundation in deep learning, covering theoretical principles, model architectures, and practical implementation. Topics include neural networks, optimization, convolutional and recurrent networks, attention mechanisms, transformers, generative models, and modern deep learning applications. The course emphasizes both mathematical understanding and hands-on system design.

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### 2. Course Educational Objectives (CEOs)

After completing this course, students will be able to:

- **CEO1:** Develop a strong theoretical foundation of deep learning architectures and algorithms
  - **CEO2:** Design and implement deep learning models for real-world problems
  - **CEO3:** Analyze and optimize model performance using modern techniques
  - **CEO4:** Conduct research-oriented tasks in emerging deep learning domains
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### 3. Course Learning Outcomes (CLOs)

<b>CLO Code</b>	<b>Description</b>	<b>Bloom's Level</b>
<b>CLO1</b>	Explain core concepts of deep neural networks and learning paradigms	Understand
<b>CLO2</b>	Apply deep learning frameworks to build models	Apply
<b>CLO3</b>	Analyze different architectures (CNN, RNN, Transformers)	Analyze
<b>CLO4</b>	Evaluate model performance and optimization strategies	Evaluate
<b>CLO5</b>	Design advanced deep learning solutions for research problems	Create

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#### 4. CLO to PLO Mapping

CLO \ PLO	PLO1 (Knowledge)	PLO2 (Problem Analysis)	PLO3 (Design)	PLO4 (Investigation)	PLO5 (Modern Tools)	PLO6 (Ethics)
CLO1	✓					
CLO2	✓	✓			✓	
CLO3	✓	✓	✓			
CLO4		✓	✓	✓	✓	
CLO5		✓	✓	✓	✓	✓

#### 5. Teaching-Learning Strategy (TLS)

- Lectures with mathematical derivation
- Case studies from recent research papers
- Hands-on coding (PyTorch / TensorFlow)
- Group discussions and presentations
- Project-based learning

#### 6. Assessment Strategy

Assessment Type	Weight (%)
Mid-Term Exam	20%
Final Exam	60%
Assignments + Attendance	10%
Class Test+ Presentation	10%

#### 7. Detailed Lecture Outline (14 Weeks)

##### Week 1: Introduction to Deep Learning

- History and evolution
- Neural networks vs traditional ML
- Applications and challenges

##### Week 2: Mathematical Foundations

- Linear algebra review
- Probability and optimization basics
- Gradient descent and variants

##### Week 3: Neural Networks Fundamentals

- Perceptron, MLP
- Activation functions

- Loss functions

#### **Week 4: Backpropagation**

- Chain rule
- Computation graph
- Vanishing/exploding gradients

#### **Week 5: Optimization Techniques**

- SGD, Momentum, Adam
- Learning rate scheduling
- Regularization methods

#### **Week 6: Convolutional Neural Networks (CNN)**

- Convolution operations
- Pooling
- CNN architectures (LeNet, AlexNet)

#### **Week 7: Advanced CNN Architectures**

- VGG, ResNet, DenseNet
- Transfer learning
- Fine-tuning

#### **Week 8: Recurrent Neural Networks (RNN)**

- Sequence modeling
- BPTT
- LSTM, GRU

#### **Week 9: Attention Mechanism**

- Attention basics
- Self-attention
- Seq2Seq models

#### **Week 10: Transformers**

- Transformer architecture
- BERT, GPT models
- Applications in NLP

#### **Week 11: Generative Models**

- Autoencoders
- Variational Autoencoders (VAE)
- Generative Adversarial Networks (GANs)

## Week 12: Deep Learning for Computer Vision

- Object detection (YOLO, RCNN)
- Image segmentation

## Week 13: Deep Learning for Speech & Multimodal Systems

- Audio processing
- Audio-visual fusion
- Emotion recognition

## Week 14: Emerging Topics

- Explainable AI (XAI)
  - Federated learning
  - Ethical issues
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## 8. Tools and Technologies

- Python
  - PyTorch / TensorFlow
  - Google Colab / GPU computing
  - OpenCV, HuggingFace
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## 9. Suggested Books

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville — *Deep Learning*
  2. Christopher Bishop — *Pattern Recognition and Machine Learning*
  3. Aurélien Géron — *Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow*
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## 10. Reference Materials

- Research papers from NeurIPS, ICML, CVPR
- Stanford CS231n, CS224n lecture notes
- IEEE Xplore Digital Library