Course Outline -Fall 2025			
School / Department	School of Systems and Technology – SST / Department of Computer Science		
Course Code	**CS4152**		
Course Title	**Deep Learning and Neural Networks**		
Theory / Lab / FYP	Theory		
Degree Program	BS (CS)		
Credit Hours	3	**Contact Hours**	3 + 4.5
Pre-requisite	Common prerequisites include: **Linear Algebra:** Understanding of vectors, matrices, eigenvalues, and eigenvectors, which are essential for image transformations and processing in both spatial and frequency domains. **Calculus:** Knowledge of calculus, particularly differential equations and integrals, is required for understanding image gradients, optimization, and filtering techniques. **Probability and Statistics:** A foundation in probability and statistics is important for noise modeling, image restoration, and understanding algorithms related to machine learning and pattern recognition in image processing. **Programming Skills:** Proficiency in programming languages such as Python is required to implement algorithms and handle practical image processing tasks. **Signals and Systems:** An introductory course in signals and systems, including the basics of Fourier transforms and signal filtering, is often required, as it directly connects to processing images in the frequency domain.		
Methods of Assessment (Can be changed as per course requirement)	**Class Exercise/Class Activities**	10%	
	Assignments and Quizzes	15%	
	Mid-Term Examination	25%	
	Case Study/Projects/Complex Computing Problems (CCP)	15%	
	Final Examination	35%	
	Total	100%	
Course Moderator / Coordinator	**Dr. Jameel Ahmad**		
Contact	Jameel.ahmad@umt.edu.pk		
Counseling Hours	Tuesday and Wednesday (11am-2pm) Room STD 402		
Semester Offered	Fall 2025		

Course Synopsis	Deep learning has transformed artificial intelligence, achieving state-of-the-art performance in areas like computer vision, speech recognition, and natural language processing, with computer vision applications now ubiquitous in search, medicine, autonomous vehicles, drones, and more. This undergraduate course delves into the fundamentals of neural networks and deep learning, focusing on architectures such as convolutional neural networks (CNNs) and their application to visual recognition tasks like image classification, object localization, and detection. This course will introduce Deep Learning by focusing on: • Artificial Neural Network's basic architecture and how they mimic the human brain using simple mathematical models. • The mathematical models, understanding learning laws, selecting activation functions, and how to train the networks to solve classification problems. • This course will further introduce advanced topics in neural networks, the convolutional and recurrent network structures. • Generative deep models will also be taught in this course.
Course Objectives	• Gain hands-on experience designing, training, and evaluating deep learning models using frameworks like TensorFlow and PyTorch. • Implement and analyze key architectures, including CNNs, RNNs, GANs, and Transformers, for real-world applications. • Build a strong foundation to apply deep learning techniques in computer vision, NLP, and other advanced domains.
Textbook	• [CB] C. M. Bishop and H. Bishop, **Deep Learning Foundations and Concepts**. Springer, 2024. [Online]. Available: https://www.bishopbook.com/ • C. C. Aggarwal, **Neural Networks and Deep Learning: A Textbook**. Springer, 2018.
Reference Books	• I. Goodfellow, Y. Bengio, and A. Courville, Deep Learning. MIT Press, 2016. [Online]. Available: http://www.deeplearningbook.org/Rajkumar Tekchandani and Neeraj Kumar. **Applied Deep Learning Design and implement your own Neural Networks to solve real-world problems.** BPB Publications 2023. • A. Zhang, Z. C. Lipton, M. Li, and A. J. Smola, **Dive into Deep Learning**, 2021. [Online]. Available: https://d2l.ai/ • F. Chollet, **Deep Learning with Python**, 2nd ed. Manning, 2021. • E. Stevens, L. Antiga, and T. Viehmann, **Deep Learning with PyTorch**. Manning, 2020.
Technology	The course provides hands on experience on Python Programming

Course Learning Outcomes (CLOs)	**Domain & BT* Level**
After the successful completion of course, the students will be able to:	

CLO 1: Explain fundamental concepts of artificial neural networks (ANN) and deep learning architectures.	Cognitive, (C2)
CLO 2: Implement and train different neural network models using programming frameworks (e.g., TensorFlow, PyTorch).	Cognitive, (C3)
CLO 3: Apply optimization techniques such as gradient descent, backpropagation, and regularization to train deep learning models for computational efficiency	Cognitive, (C3)
CLO 4: Design deep learning solutions for real-world problems.	Cognitive, (C5)
CLO 5: Evaluate and interpret the performance of deep learning models using appropriate metrics and visualization tools	Cognitive, (C5)
* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain	

CLOs / PLOs	CLO 1	CLO 2	CLO 3	CLO4	CLO 5
PLO1: Academic Education	✓				
PLO2: Knowledge for Solving Computing Problems		✓			
PLO3: Problem Analysis			✓		
PLO4: Design/ Development of Solutions				✓	
PLO5: Modern Tool Usage					✓
PLO6: Individual and Team Work					
PLO7: Communication					
PLO8: Computing Professionalism and Society					
PLO9: Ethics					
PLO10: Life-long Learning					

Tentative Lecture-wise list of topics

L No	Topics	Reading	Sessional Assessment	CLOs
L 1	**What is Deep Learning?** History and Evolution of Neural Networks Applications of Deep Learning Course objectives and assessment criteria	**CB: Ch 6**		**CLO 1**
L 2	**Mathematical Foundations** Linear Algebra: Vectors, Matrices, Tensors Calculus: Gradients, Chain Rule Probability and Statistics: Distributions, Bayes Theorem	**Notes**		
L 3	**Introduction to Neural Networks** Neural Nets as Universal Approximators Biological vs. Artificial Neurons Perceptron and Activation Functions	**CB: Ch 6**		

Tentative Lecture-wise list of topics				
L No	**Topics**	**Reading**	**Sessional Assessment**	**CLOs**
L 4	**Feedforward Neural Networks (FNN)** Architecture and Forward Propagation Loss Functions and Gradient Descent Convergence Issues Momentum	**CB: Ch 7**	**Assignment-1**	
L 5	**Backpropagation Algorithm** Chain Rule in Backpropagation Implementation of Backpropagation	**CB: Ch 8**	**Quiz 1**	
L 6	**Training Neural Networks, I** Activation functions Data preprocessing Weight initialization Optimization Techniques Stochastic Gradient Descent (SGD) Momentum, RMSProp, Adam Optimizers, 2nd order methods	**CB: Ch 8**	**Case Study Project**	**CLO 2**
L 7	**Training Neural Networks II** Data augmentation, Overfitting/Regularization Techniques (L1/,L2), choosing a loss function, Batch Normalization, Dropout	**CB: Ch 9**		
L 8	**Hyperparameter Tuning** o Learning Rate, Batch Size, Epochs o Grid Search and Random Search			
L 9	**Implementing Neural Networks with TensorFlow & PyTorch (Lab)** Writing code for simple feedforward networks Basics of Python for Deep Learning NumPy, Pandas, Matplotlib Training and evaluating ANN models **Hands-on Lab: Building and Training FNN**	**Notes**	**Assignment 2**	
L 10	**Introduction to CNNs** (Convolutional Neural Networks) Convolutional Layers, Pooling Layers, fully connected Layers, Feature Maps and Filters, Learning	**CB: Ch 10**		**CLO 3**
L 11	**CNN Architectures I** Batch Normalization, Transfer learning and fine-tuning pre-trained models AlexNet, VGG, GoogLeNet, ResNet and its variants	**CB: Ch 10**	**Quiz 2**	
L 12	**Advanced CNN Architectures** Efficient architectures: , Inception U-Net			
L 13	**Applications of CNNs** Image Classification, Object Detection: Single-stage detectors, Two-stage detectors Semantic/Instance/Panoptic Segmentation	**Notes**	Class Activity	
	Object Detection with Deep Learning: R-CNN, Fast R-CNN, Faster R-CNN, YOLO, SSD		**Assignment-3**	
L 14	**Semantic Segmentation**: Fully Convolutional Networks (FCNs), U-Net, DeepLab	**Notes**		

Tentative Lecture-wise list of topics				
L No	**Topics**	**Reading**	**Sessional Assessment**	**CLOs**
L 15	**Instance Segmentation**: Mask R-CNN, panoptic segmentation			
L 16	**Hands-on Lab:** Image Detection, Classification and segmentation with CNNs			
	MIDTERM			
L 17	**Generative Models** Autoencoders and variational autoencoders (VAEs)	**CB: Ch 19**		
L 18	**Generative Adversarial Networks** (GANs): DCGAN, CycleGAN, StyleGAN, Applictiona DeepDream, Style Transfer	**CB: Ch 17**		
L 19	**Introduction to RNNs (Recurrent Neural Networks)** Sequence Modeling and Time Series Data RNN Architecture and Challenges, Hopfield Networks, Stochastic RNN (e.g. Boltzmann Machines, RBM)	**CB: Ch 12**	**Quiz 3**	
L 20	**Long Short-Term Memory (LSTM) and GRU** Vanishing Gradient Problem LSTM and GRU Architectures	**CB: Ch 12**	Class Activity	
L 21	**Applications of RNNs** Text Generation, Sentiment Analysis Speech Recognition			
L 22	**Hands-on Lab:** Text Classification with RNNs			
	Case Study: Real-world RNN Application		Class Activity	CLO 4
L 23	**Attention Mechanisms and Transformers**	**CB: Ch 12**		
L 24	**Self-Attention,** BERT, GPT, Vision Transformers (ViTs) Applications in image classification and object detection	**CB: Ch 12**		
L 25	**Large Language Models (LLMs)** GPT (Generative Pre-trained Transformer) series (e.g., GPT-3, GPT-4). BERT (Bidirectional Encoder Representations from Transformers). T5 (Text-to-Text Transfer Transformer) and PaLM (Pathways Language Model).	Notes/Slides		
L 26	**Diffusion Models** DDPM (Denoising Diffusion Probabilistic Models). DDIM (Denoising Diffusion Implicit Models). Latent Diffusion Models (e.g., Stable Diffusion).	**CB: Ch 20**		
L 27	**Applications of Diffusion Models:** Image generation (e.g., DALL·E 2, Stable Diffusion). Video generation, audio synthesis, and molecular design.	**CB: Ch 20**		

Tentative Lecture-wise list of topics				
L No	**Topics**	**Reading**	**Sessional Assessment**	**CLOs**
L 28	**Multimodal Learning**: Vision-language models (CLIP, DALL-E), image captioning, VQA ○			
L 29	**Reinforcement Learning with Deep Networks** **Q-Learning and Deep Q-Networks (DQN), Policy Gradients,** .	Notes/slides		
L 30	**Neural Rendering and 3D Vision,** PyTorch3D, TensorFlow Graphics, and NeRF-specific libraries (e.g., NeRF-pytorch).	Notes/slides		
L 31	**Tools and Frameworks** **Hands-on Lab** • **LLMs**: ○ Hugging Face Transformers, OpenAI API, and TensorFlow/PyTorch implementations. • **Diffusion Models**: Hugging Face Diffusers, PyTorch implementations, and open-source projects like Stable Diffusion	Notes/slides		
L 32	FINAL			

Assessments

CLOs	Quiz 1	Quiz 2	Quiz 3	Assignment 1	Assignment 2	Assignment 3	CCP	Mid Term	Final Term
1	✓			✓				✓	
2		✓			✓		✓	✓	
3			✓			✓	✓		✓
4							✓		✓
5				✓	✓	✓	✓		

Course Moderator Name: ____**Dr. Jameel Ahmad**_____

Course Moderator Signature. _____