National University of Computer & Emerging Science

Department	Department of Computing	**Dept. Code**	AI
Course Title	Generative AI	**Course Code**	AI4009
Pre-requisite(s)	-	**Credit Hrs.**	3
Instructor	Omer Qureshi		

Course Objective:	Generative AI is crucial for innovation in art, language, and data-driven decisions. Understanding its creative processes is essential as technology and creativity intersect. This course explores Generative Artificial Intelligence, which captures human creativity within machine learning. We'll trace its evolution from philosophical origins to modern advancements and discover how it transforms our interaction with technology. This course will guide students through the complex and innovative theories, concepts, and applications propelling Generative AI forward. We will explore the intricate mechanisms of Generative Adversarial Networks (GANs), Variational Autoencoders (VAEs), and other generative models and examine their potential applications in various domains. Additionally, the course will explore the ethical considerations surrounding AI-driven creativity, including discussions on fairness, bias, and responsible deployment of these creative algorithms. Students will work on hands-on projects to explore Generative AI and solve real-world problems. The course ends with a project to explore the trends and possibilities in Generative AI, allowing students to unleash their creativity and drive innovation.

PLO	Program Learning Outcome (PLO) Statement
1	**Computing and Artificial Intelligence Knowledge:** Apply knowledge of mathematics, natural sciences, computing fundamentals, and a computing specialization to solve complex computing problems using artificial intelligence techniques
2	**Problem Analysis:** Identify, formulate, research literature, and analyze complex computational problems, reaching substantiated conclusions using first principles of mathematics, natural sciences, computing, and artificial intelligence
3	**Design/Develop Solutions:** Design solutions for complex computing problems and design systems, components, and processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations

4	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources and modern computing and artificial intelligence tools, including prediction and modelling for complex computing problems.
9	**Communication:** Communicate effectively on complex computing and AI activities with the computing and artificial intelligence community and with society at large**.**

CLO	Course Learning Outcome (CLO)	Domain	Taxonomy Level	PLO	Tools
01	Understand the fundamentals of the generative process and its roots in artificial intelligence.	Cognitive	C3	01	A1, M1, F
02	Understand the basics of generative models, such as GANs, variational autoencoders, Gaussian mixture models, and language models.	Cognitive	C4	02	A2, M1, M2, F
03	Develop critical thinking skills to evaluate the strengths and limitations of different generative AI techniques	Cognitive	C5	03	A4, M2, F
04	Applying generative AI techniques to develop projects on real-world problems while working in a team, using the skills and knowledge gained through the course, and being able to present their work to peers	Psychomotor	C5	04	A3, Project
05	Understand the ethical implications of designing and deploying generative AI models	Cognitive	C5	09	A5, F
Tool: A = Assignment, Q = Quiz, M = Midterm, F=Final, CEP = Complex Engineering Problem.					

Text Book(s)	David Foster - Generative Deep Learning_ Teaching Machines To Paint, Write, Compose, and Play-O'Reilly Media (2023)
Ref. Book(s)	1. Generative Deep Learning: Teaching Machines to Paint, Write, Compose, and Play 1st Edition by David Foste 2. Artificial Intelligence & Generative AI for Beginners: The Complete Guide Paperback, by David M. Patel (Author) 3. GANs in Action: Deep Learning with Generative Adversarial Networks First Edition 4. Hands-On Generative Adversarial Networks with PyTorch 2.x 5. Ripples of Generative AI: How Generative AI Impacts, Informs, and Transforms Our Lives by Jacob Emerson (Author)

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1. Topics to be covered:			
List of Topics	No. of Weeks	Contact Hours	CLO
Review of neural networks • Neural Network Architectures, activation functions, and CNN architecture. Backpropagation, optimization techniques, and regularization. • Installation of Installation of required tools (Python, TensorFlow, PyTorch) and basic programming exercises.	**1**	**3**	**1, 4**
Introduction to Generative AI, AutoEncoders and Variational AutoEncoders • Introduction to generative processes and their significance. • Introduction to Generative and Discriminative models. • Kullback-Leibler divergence • AutoEnoders • Variational AutoEncoders	**2**	**6**	**2, 4**
Generative Adversial Networks for Image Generation • Introduction to GAN • Deep Convolutional GAN • Wasserstein GAN • Wasserstein GAN with Gradient Penalty • Conditional GAN	**2**	**6**	**2, 4**
Midterm1	**0.5**	**1**	**1,2**
AutoRegressive Models • Introduction to AutoRegressive Models • LSTM • RNN and its variants • PixelCNN	**1.5**	**4.5**	**3, 4**
Normalizing Flow Models • Introdudction	**1**	**3**	**3, 4**

• RealNVP			
Energy Based Models • Introduction to EBM • Sampling using Langevin dynamics • Training using Contrastive divergence	**1**	**3**	**3,4**
Midterm 2	**0.5**	**1**	**2,3**
Diffusion Models • Introducution • Forward Diffusion • Reverse Diffusion • UNet Model • Denoising diffusion model (DDM)	**1.5**	**4.5**	**3, 4**
Transformers • Transformers for sequence generation. • In-depth study of advanced transformer models: Transformers, GPT-3, BERT, XLNet. • Multimodal models for text, speech, and vision.	**1.5**	**4.5**	**2,3**
Large Language Models OpenAI's GPT (Generative Pre-trained Transformer) series, such as GPT-3/GPT-4, 5., Chat GPT, Bard, LLaMA, Jurassic, Claudia	**1**	**3**	**1, 9**
Multimodel Models • Introduction • DALLE2 • Imagen • Stable Diffusion • Flamingo	**1.5**	**4.5**	**3,9**
Ethical and Societal Issues in Advanced Generative AI • Advanced topics in fairness, bias, and explainability. • Case studies on the societal impact of advanced generative AI. • Responsible AI and emerging ethical considerations	**0.5**	**1**	**9**
Project Presentations	**0.5**	**3**	**4**

Final	**1**	**3**	**1,2,3,9**
Total	**17**	**51 (Including 3 hours final exam)**	

Assessment Plan:

Assessment	Weightage
Assignments	15
Midterm Exams	30
Project	5
Final	50