

ఆంధ్రప్రదేశ్ కేంద్రీయ విశ్వవిద్యాలయం
ఆంధ్రప్రదేశ్ కేంద్రీయ విశ్వవిద్యాలయ
Central University of Andhra Pradesh
Jnana Seema, Ananthapuramu

School of Interdisciplinary and Applied Sciences

Department of Computer Science and AI



Vidya Dadati Vinayam
(Education Gives Humility)

PG Diploma in Quantum Computing & Machine Learning

w.e.f. Academic Year 2025 - 2026

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PG Diploma in Quantum Computing and Machine Learning

Introduction to the Programme

The Post Graduate Diploma in Quantum Computing and Machine Learning (PGDQC) is an exciting new program from CUAP, starting in the 2025-26 academic year. Imagine a future where computers tap into the strange and powerful world of quantum mechanics, solving problems much faster and smarter than today. This program will empower you to step confidently into that future, blending advanced quantum computing concepts with the practical magic of machine learning.

Objectives:

- Help you understand both the basics and the cutting-edge advances in quantum computing and machine learning, so you feel confident entering these exciting fields.
- Work with quantum coding platforms, tackle real-life challenges, and show off your project work to the world.
- Understand what makes quantum computers different and spot opportunities where they shine.

A Student completing this programme will be capable of taking a career path in the domain of Quantum Computing.

Learning Outcomes:

On successful completion of the programme student should be able to:

- To use the principles of quantum mechanics and quantum programming tools to solve real-world problems and build innovative models.
- Design and implement intelligent systems—like quantum-enhanced neural networks and clustering algorithms—that can tackle complex data challenges.
- Understand the ethical implications of quantum computing and machine learning

Programme Structure:

- Post Graduate Diploma is a one-year program divided into two semesters with a total of around 40 credits.
- The program is designed with a combination of Core Courses and MOOCs.
- Students need to complete 2 MOOC courses in I,II semester.
- In semester II students will undergo for Dissertation Work.

Programme Structure

S. No	Course Code	Title of the Course	Total Credits	Credits Distributions		
				L*	T*	P*
Semester– I						
1.	PDQCM101	Introduction to Machine Learning	4	3	0	1
2.	PDQCM102	Quantum Computing	4	3	0	1
3.	PDQCM103	Generative AI and Large Language Models	4	3	0	1
4.	PDQCM111	MOOCs/NPTEL/SWAYAM*	3	3	-	-
5.	PDQCM112	MOOCs/NPTEL/SWAYAM*	3	3	-	-
6.	PDQCM125	Internship/Lab	2	-	-	2
Total			20	15	0	5
S.No	Course Code	Title of the Course	Total Credits	Credits Distribution		
				L*	T*	P*
Semester– II						
1.	PDQCM201	Quantum Mechanics	4	3	0	1
2.	PDQCM202	Quantum Algorithms	4	3	0	1
3.	PDQCM211	MOOC/NPTEL/SWAYAM*	3	3	-	-
4.	PDQCM212	MOOC/NPTEL/SWAYAM*	3	3	-	-
5.	PDQCM228	#Project Work/Dissertation	6	-	-	6
Total			20	12	0	8

*L: Lectures, *T: Tutorials, *P: Practical

* **Appropriate online Content available recommended by dept at the time of enrollment**

#: Project Work is compulsory and have to submit to the department one week before second semester examination.
Department faculty will allot a supervisor to each student at the end of first semester.

Note: 1. MOOCs are chosen by the student based on the availability of the courses offered on SWAYAM & other related platforms as suggested/recommended by the Department.

2. The desired changes may be made by the Department in the programme structure as and when necessary with the prior approval of the BOS.

Credit Distribution

Semester	Total Credits
Semester-I	20
Semester-II	20
Total	40

Important Information to Students

1. Eligibility:

- a. Students pursuing/completed PG/Ph.D. programmes in any other educational institution with B.Sc in Computer Science/Mathematics/Physics or any B.Tech/MTech/MCA/M.Sc in Computer Science/Mathematics/Physics
 - b. CUAP/Non CUAP students pursuing any PG/PhD Programmes can enroll for PG Diploma Programmes offered by the University
 - c. Non CUAP students shall have to appear for an Entrance Examination conducted by the University
 - d. A student can enroll for as many PG Diploma Programmes as he/she wishes to
2. The minimum duration for completion of any Postgraduate Diploma Programme is two semesters (one academic year).
 3. Maximum duration of completion of programme is two years.
 4. A student should have minimum 75% attendance in classes, seminars, practical/ lab in each course of study without which he/she will not be allowed for the Semester - end examination.
 5. All theory courses in the programme shall have Continuous Internal Assessment (CIA) component of 40 marks and a Semester-end component of 60 marks. The minimum pass marks for a course is 50%.
 6. The student has to appear 3 CIA tests of 15 marks each per semester in each course from which the best 2 performances shall be considered for the purpose of calculating the marks. A record of the continuous assessment is maintained by the department. The remaining 10 marks are awarded based on participation and performance in:
 - Assignments
 - Class presentations
 - Seminars
 - Quizzes
 7. A student should pass separately in both CIA and the Semester-end Examination.
 8. Semester-end examination shall consist of objective type questions, descriptive type questions, short answer questions and case studies or any others.
 9. A student failing to secure the minimum pass marks in the CIA is not allowed to take the semester-end examination of that course. She/He has to redo the course by attending special classes for that course and get the pass percentage in the internal tests to become eligible to take the semester-end examination.
 10. Students failing a course due to lack of attendance should redo the course.

SEMESTER-I

Course Objectives

Course Code: PDQCM101 Core/ Elective: Core No. of Credits: 4 No. of Hours: 75	Introduction to Machine Learning
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- Introduce the foundational mathematics for machine learning, including probability, linear algebra, and optimization.
- Explore supervised learning techniques such as regression, classification, and neural networks.
- Study decision trees, ensemble methods, and evaluation metrics for model performance.
- Understand unsupervised learning, graphical models, clustering, and basics of reinforcement learning.

Learning Outcomes

Students will be able to:

- Apply statistical decision theory and mathematical tools to machine learning problems.
- Implement and analyze supervised learning models including SVMs, neural networks, and logistic regression.
- Build and evaluate decision trees and ensemble learning models like boosting and random forests.
- Perform clustering using algorithms like K-means, GMM, and hierarchical clustering.
- Understand graphical models, HMMs, and gain introductory knowledge of reinforcement learning concepts.

Course Outline:

UNIT-I

15 hrs

Probability Theory, Linear Algebra, Convex Optimization, Introduction: Statistical Decision Theory - Regression, Classification, Bias Variance, Linear Regression, Multivariate Regression, Subset Selection, Shrinkage Methods, Principal Component Regression, Partial Least Squares

UNIT-II

15 hrs

Linear Classification, Logistic Regression, Linear Discriminant Analysis, Perceptron, Support Vector Machines, Neural Networks - Introduction, Early Models, Perceptron Learning, Backpropagation, Initialization, Training & Validation, Parameter Estimation - MLE, MAP, Bayesian Estimation

UNIT-III**10 hrs**

Decision Trees, Regression Trees, Stopping Criterion & Pruning loss functions, Categorical Attributes, Multiway Splits, Missing Values, Decision Trees - Instability Evaluation Measures Bootstrapping & Cross Validation, Class Evaluation Measures, ROC curve, MDL,

UNIT-IV**15 hrs**

Ensemble Methods - Bagging, Committee Machines and Stacking, Boosting, Gradient Boosting, Random Forests, Multi-class Classification, Naive Bayes, Bayesian Networks Undirected Graphical Models, HMM, Variable Elimination, Belief Propagation, Partitional Clustering, Hierarchical Clustering, Birch Algorithm,

UNIT-V**20 hrs**

CURE Algorithm, Density-based Clustering Gaussian Mixture Models, Expectation Maximization, Learning Theory, Introduction to Reinforcement Learning, Optional videos (RL framework, TD learning, Solution Methods, Applications).

References:

1. The Elements of Statistical Learning, by Trevor Hastie, Robert Tibshirani, Jerome H. Friedman (freely available online)
2. Pattern Recognition and Machine Learning, by Christopher Bishop.

Course Code: PDQCM102 Core/ Elective: Core No. of Credits: 4 No. of Hours: 75	Quantum Computing
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Course Objectives

- Introduce foundational principles of quantum mechanics relevant to computing, including superposition, entanglement, and quantum measurement.
- Explore quantum circuits, gates, and algorithms such as Grover’s and Shor’s algorithms.
- Understand error correction, quantum cryptography, and implementation challenges in quantum computing.
- Examine various hardware approaches like optical systems, spintronics, and QED, and assess prospects.

Learning Outcomes

Students will be able to:

- Understand core quantum phenomena such as entanglement, superposition, and decoherence.
- Analyze quantum gates, teleportation, and fundamental algorithms like Deutsch-Jozsa, Grover’s, and Shor’s.
- Explain the principles of quantum error correction, fault tolerance, and quantum cryptographic techniques.
- Evaluate different quantum computing implementation methods and identify scalability and fidelity issues.
- Critically assess the current state and potential future of quantum computing technologies.

Course Outline:

UNIT-I **15 hrs**

Quantum Measurements Density Matrices; • Positive-Operator Valued Measure, Fragility of quantum information: Decoherence; • Quantum Superposition and Entanglement, Quantum Gates and Circuits; • No cloning theorem & Quantum Teleportation

UNIT-II **15 hrs**

Bell’s inequality and its implications; • Quantum Algorithms & Circuits, Deutsch and Deutsch–Jozsa algorithms;

UNIT-III **15 hrs**

Grover’s Search Algorithm, Quantum Fourier Transform; • Shore’s Factorization Algorithm Quantum Error Correction: Fault tolerance; • Quantum Cryptography,

UNIT-IV**15 hrs**

Implementing Quantum Computing: issues of fidelity; • Scalability in quantum computing, NMR Quantum Computing; Spintronics and QED approaches

UNIT-V**15 hrs**

Linear Optical Approaches; • Nonlinear Optical Approaches; Limits of all the discussed approaches. How promising is the future

References:

1. Michael A. Nielsen and Issac L. Chuang, "Quantum Computation and Information", Cambridge (2002).
2. Riley Tipton Perry, "Quantum Computing from the Ground Up", World Scientific Publishing Ltd (2012).
3. Scott Aaronson, "Quantum Computing since Democritus", Cambridge (2013).
4. P. Kok, B. Lovett, "Introduction to Optical Quantum Information Processing", Cambridge (2010).

Course Code: PDQCM103 Core/ Elective: Core No. of Credits: 4 No.of Hours: 75	Generative AI and Large Language Models
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Course Objectives

- Explain and analyze the *Transformer architecture* and modern generative models such as GANs, Autoencoders, Diffusion Models, and CLIP.
- Apply *prompt engineering techniques*, instruction tuning, and Parameter Efficient Fine-Tuning (PEFT) to guide models toward desired outputs.
- Explain wireless communication concepts including frequency reuse, interference, handoff, and capacity.
- Evaluate and implement *Reinforcement Learning with Human Feedback (RLHF)* and other model-improvement strategies.

Learning Outcomes

Students will be able to:

- Define and articulate key ideas in Generative AI, LLMs, and deep learning approaches used for content generation.
- Illustrate how Transformers work, including self-attention, embeddings, and encoder/decoder structures.
- Differentiate between generative models (GANs, VAEs, Diffusion Models, CLIP) and explain their applications.
- Design effective prompts and apply prompt engineering strategies for zero-shot, few-shot, and chain-of-thought tasks.

Course Outline:

UNIT-I

15 hrs

Fundamentals of Generative AI: Fundamental Concepts of Generative AI, Difference between Discriminative vs Generative Models, Applications of Generative AI across industries, Deep Learning Foundations required for Generative AI: Neural Networks, Representation learning, Sequence modeling basics, Introduction to Large Language Models (LLMs), Evolution of AI → NLP → LLMs, Overview of popular Generative AI systems (GPT, Gemini, Claude, LLaMA, Midjourney).

UNIT-II

15 hrs

Transformers & Generative Image Models: Transformer Architecture: Self-attention mechanism, Multi-head attention, Encoder–decoder vs decoder-only models, Positional encoding, Tokenization & embeddings, How Transformers enable language generation.
 Generative Image Models: Autoencoders & Variational Autoencoders (VAEs), Generative Adversarial Networks (GANs), Diffusion Models, OpenAI CLIP and multimodal alignment.

UNIT- III

15 hrs

Prompt Engineering, Fine-Tuning & RLHF: Prompt Engineering: Types of prompts (zero-shot, few-shot, chain-of-thought), Instruction design principles, Controlling style, tone, constraints, Prompt testing & evaluation

Fine-Tuning of LLMs: Instruction fine-tuning, Parameter Efficient Fine-Tuning (PEFT)-LoRA, Prefix tuning, Adapters, Model adaptation for domain-specific tasks.

Reinforcement Learning with Human Feedback (RLHF): Reward modelling, Human feedback loops, Safety alignment, Improving model usefulness through RLHF.

UNIT-IV

15 hrs

Applications, RAG, LangChain & Deployment: LLM-powered Applications-Text generation, Image generation, Creative writing, design, business workflows, Chatbots, copilots, automation.

Building LLM Apps with LangChain: Chains and agents, Tools & tool-calling, Memory management, Building custom AI workflows, Simple RAG + LangChain project.

UNIT-V

15 hrs

Training, Deployment, Ethics & Case Studies: Training & Deployment Strategies – Data preparation, GPU/TPU considerations, Model hosting (HuggingFace, AWS, Azure, GCP), Edge deployment & quantization, Model monitoring & evaluation

Case Studies & Use Cases: Generative AI in business, healthcare, education, e-commerce, LLM-based enterprise solutions, Successful deployments (ChatGPT, Copilot, DALL·E, Adobe Firefly), Student project discussions / mini-capstones.

References:

1. Denis Rothman, “Transformers for Natural Language Processing,” 2nd Edition, Packt Publishing, 2023.
2. Richard S. Sutton and Andrew G. Barto, “Reinforcement Learning: An Introduction,” MIT Press, 2nd Edition, 2018.
3. Jakub Langr and Vladimír Bok, “GANs in Action: Deep Learning with Generative Adversarial Networks,” Manning Publications, 2020.
4. Chip Huyen, “Designing Machine Learning Systems: An Iterative Process for Production-Ready Applications,” O’Reilly Media, 2022.
5. Jakub M. Tomczak and Max Welling, “Deep Generative Models,” Foundations and Trends in Machine Learning, 2022.

SEMESTER-II

Course Code: PDQCM201 Core/ Elective: Core No. of Credits: 4 No. of Hours: 75	Quantum Mechanics
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Course Objectives

- Introduce the foundational concepts of quantum mechanics, including wave functions, potential wells, and bound states.
- Develop understanding of linear vector spaces, quantum operators, and postulates of quantum theory.
- Explore quantum systems such as the hydrogen atom, harmonic oscillator, and identical particles.
- Study angular momentum, rotation groups, and advanced algebraic methods including Clebsch-Gordan coefficients and tensor operators.

Learning Outcomes

Students will be able to:

- Analyze one-dimensional quantum systems and apply boundary conditions to find bound state solutions.
- Understand the mathematical formalism of quantum mechanics using vector spaces and operator theory.
- Compare classical and quantum mechanical systems and interpret the significance of observables and measurements.
- Solve problems involving hydrogen atom wavefunctions, angular momentum, and identical particle systems.
- Apply group theory concepts, perform angular momentum addition, and utilize Clebsch-Gordan coefficients in multi-particle systems.

Course Outline:

UNIT-I

15 hrs

Introduction to Quantum Mechanics-I, Introduction to Quantum Mechanics-II, Review of Particle in Box, Potential Well, Barrier, Harmonic Oscillator-I, Review of Particle in Box, Potential Well, Barrier, Harmonic Oscillator-II, Bound States-I, Bound States-II

UNIT-II

15 hrs

Conditions and Solutions for One Dimensional Bound States - I, Conditions and Solutions for One Dimensional Bound States – II, Linear Vector Space (LVS) - I, Linear Vector Space (LVS) - II, Linear Vector Space (LVS) - III, Basis for Operators and States in LVS – I Function Spaces - I, Function Spaces - II, Postulates of Quantum Mechanics - I, Postulates of Quantum Mechanics – II

UNIT-III**15 hrs**

Classical Vs Quantum Mechanics - I, Classical Vs Quantum Mechanics - II, Compatible Vs Incompatible Observables - I, Compatible Vs Incompatible Observables – II, Schrodinger and Heisenberg Pictures - I, Schrodinger and Heisenberg

Pictures - II, Solutions to Other Coupled Potential Energies-I, Solutions to Other Coupled Potential Energies-II

UNIT-IV**20hrs**

Hydrogen Atom Wave Functions, Angular Momentum Operators, Identical Particles-I, Hydrogen Atom Wave Functions, Angular Momentum Operators, Identical Particles-II, Identical Particles, Quantum Computer-I, Identical Particles, Quantum Computer-II Harmonic Oscillator -I, Harmonic Oscillator -II, Ladder Operators -I, Ladder Operators -II, Stern-Gerlach Experiment-I, Stern-Gerlach Experiment-II, Oscillator Algebra Applications-I

UNIT-V**10 hrs**

Angular Momentum-1 -I, Angular Momentum-1 -II, Rotations Groups -I, Rotations Groups - II, Addition of Angular Momentum-I, Addition of Angular Momentum-II, Clebsch-Gordan Coefficient -I, Clebsch-Gordan Coefficient -II, Clebsch-Gordan Coefficient -III, Tensor Operators & Wigner-Eckart Theorem-I, Tensor Operators & Wigner-Eckart Theorem-II, Tensor Operators & Wigner-Eckart Theorem-III.

References:

1. Sakurai, J.J., Modern Quantum Mechanics, Benjamin Cummings, 1985.
2. Merzbacher, E., Quantum Mechanics, 2nd Edn. Wiley International Edn., 1970.
3. Thankappan, V. K., Quantum Mechanics, Wiley Eastern Ltd., 1993.
4. R.P. Feynman, R.B. Leighton, and M. Sands, The Feynman Lectures in Physics, Vol. 3, Narosa Publishing House, 1992.
5. Schiff, L. I., Quantum Mechanics, McGraw-Hill, New York, 1968.
6. Shankar, R., Principles of Quantum Mechanics, Plenum, New York, 1970.
7. Landau, L. D. and Lifshitz E. M., Quantum Mechanics, Pergamon, New York, 1974.
8. P.M. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata McGraw Hill, 1977.

Course Code: PDQCM202 Core/ Elective: Core No. of Credits: 4 No. of Hours: 75	Quantum Algorithms
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Course Objectives

- Introduce the foundational concepts of quantum information and the principles behind quantum algorithms.
- Explore quantum speedups through algorithms like Deutsch-Jozsa, Simon's, Grover's, and Shor's.
- Examine classical and post-quantum cryptographic techniques in light of quantum advancements.
- Understand quantum encryption models including QKD, quantum one-time pad, and fully homomorphic encryption.

Learning Outcomes

Students will be able to:

- Explain fundamental quantum concepts such as entanglement, no-cloning, and quantum parallelism.
- Implement and analyze core quantum algorithms like Deutsch-Jozsa, Grover's, and Shor's.
- Understand the impact of quantum computing on classical cryptography and post-quantum crypto approaches.
- Apply quantum key distribution and explain quantum encryption techniques including quantum homomorphic encryption.
- Evaluate the role of quantum algorithms in solving classically hard problems and in secure communications.

Course Outline:

UNIT-I	10 hrs
Basics of Quantum Information, Entanglement, No Cloning, Quantum Parallelism. Quantum Algorithms: Deutsch-Jozsa, Simons, Bernstein-Vazirani	
UNIT-II	20 hrs
Introduction to Cryptography, principles of cryptographic design, building cryptography from RSA, Discrete Log, Key exchange,	
UNIT-III	15 hrs
Symmetric and public key encryption, Random Oracle Model, RSA and Elgamal encryption, Boolean Fourier Analysis, Grover's Algorithm, Quantum Fourier Transform	
UNIT-IV	15 hrs
Shor's Algorithm, Hidden subgroup problem, Post Quantum Crypto: Introduction to lattices,	

Useful Lattice Problems. Learning with Errors and Short Integer Solution problem. Connection to dihedral hidden subgroup problem. Public key encryption and fully homomorphic encryption

UNIT-V

15 hrs

Quantum key distribution, Quantum one time pad, Quantum public key encryption, Quantum fully homomorphic encryption

References:

1. The [Qiskit textbook](#) and the Nielsen and Chuang's "Quantum Computation and Quantum Information

Course Code: PDQCM228 Core/ Elective: Core No. of Credits: 6 No. of Hours: One Semester	Project Work/Dissertation
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Objective:

Implement some of the existing techniques and develop new algorithms, models, or tools in the domain of Quantum Computing and Machine Learning, to produce meaningful research outputs. Apply the knowledge of quantum algorithms, quantum mechanics, quantum communication, and machine learning techniques for solving a variety of real-world and computationally hard problems. Identify dissertation problems through a literature survey of standard research articles and explore state-of-the-art methods. Use relevant quantum computing frameworks, simulation platforms, and ML libraries to demonstrate results with physical/realistic meaning and build necessary research components.

Student is required to submit a detailed project report on the selected topic for their project as per the guidelines decided by the department. The project work is to be evaluated through presentations and viva-voceduring the semester and final evaluation will be done at the end of the semester as per the guidelines decided by the department from time to time.

However, candidate may visit research labs/institutions with the due permission of chairperson on recommendation of supervisor concerned.