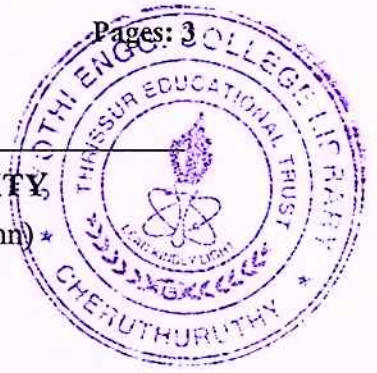


Reg No.: _____

Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
B.Tech Degree S4 (Hons.) Examinations April 2026 (2024 Admn)



Course Code: HNAIT409

Course Name: Mathematics for Intelligent Computing Systems

Max. Marks: 60

Duration: 2 hours 30 minutes

PART A

(Answer all questions. Each question carries 3 marks)

		CO	Marks
1	Find the modular inverse of 17 modulo 43 using the Extended Euclidean Algorithm.	1	(3)
2	State Euler's Theorem.	1	(3)
3	Define a convex function mathematically and state the geometric interpretation of its epigraph.	2	(3)
4	How does gradient descent minimize a loss function?	2	(3)
5	What is a conjugate prior? Give an example.	3	(3)
6	Explain how Credible Intervals in Bayesian Statistics differ fundamentally from Confidence Intervals.	3	(3)
7	Derive the mathematical formulation of L1 regularization (Lasso).	4	(3)
8	What is a Markov Decision Process?	4	(3)

PART B

(Answer any one full question from each module, each question carries 9 marks)

Module -1

- | | | | |
|---|--|---|-----|
| 9 | a) Find the Greatest Common Divisor (GCD) of 1320 and 546 using the Extended Euclidean Algorithm, and express it as a linear combination of the two numbers: $d = 1320x + 546y$. | 1 | (5) |
| | b) In an RSA cryptosystem, a user chooses prime numbers $p = 11$ and $q = 13$. Given the public encryption key $e = 7$, compute the private decryption key d , and encrypt the message $M = 5$. | 1 | (4) |

- 10 a) Solve the following system of simultaneous linear congruence equations: 1 (5)
- $$x \equiv 2 \pmod{5}$$
- $$x \equiv 4 \pmod{7}$$
- $$x \equiv 1 \pmod{9}$$
- b) Explain the concept of Miller-Rabin Primality Testing. Demonstrate its application by checking whether $n = 65$ is a prime or a composite number using the base $a = 2$. 1 (4)

Module -2

- 11 a) Perform two complete iterations of the Gradient Descent algorithm to minimize the function $f(x, y) = x^2 + 2y^2$. Start from the initial point $(x_0, y_0) = (2, 2)$ with a learning rate of $\eta = 0.1$. 2 (5)
- b) Formulate the mathematical definitions of a convex set and a convex function. Prove analytically that the function $f(x) = x^4$ is strictly convex on the real line. 2 (4)
- 12 a) Consider a linear regression model $y = wx$. Derive the exact gradient update rule for the weight parameter w using the Mean Squared Error (MSE) loss function over a dataset of N training samples. 2 (5)
- b) Compare Batch Gradient Descent, Stochastic Gradient Descent (SGD), and Mini-batch Gradient Descent. Highlight their trade-offs in terms of computational speed, variance in updates, and convergence paths. 2 (4)

Module -3

- 13 a) Derive the conjugate prior for a Poisson likelihood distribution with parameter λ . Show that if the prior distribution is Gamma(α, β), the posterior distribution is also a Gamma distribution, and determine its parameters. 3 (5)
- b) Implement Bayesian inference for coin toss experiment with Beta prior and Binomial likelihood 3 (4)
- 14 a) Explain the fundamental principles of Markov Chain Monte Carlo (MCMC) sampling. Discuss specifically how the Metropolis-Hastings algorithm operates and why it is indispensable for evaluating complex, intractable posterior distributions. 3 (5)
- b) Compare MLE and Bayesian approach 3 (4)

Module -4

- 15 a) Derive the mathematical update equations for Momentum-based Gradient Descent and the Adam (Adaptive Moment Estimation) optimizer. Explain how Adam combines the principles of momentum and adaptive learning rates. 4 (5)
- b) Explain the Value Iteration algorithm used to solve a Markov Decision Process (MDP). Outline its algorithmic steps and discuss its convergence property based on the Bellman Optimality Operator. 4 (4)
- 16 a) Explain Bellman equation in reinforcement learning with an example 4 (5)
- b) Provide a detailed mathematical overview of Principal Component Analysis (PCA). Explain how the Singular Value Decomposition (SVD) of a data covariance matrix is utilized to achieve optimal low-dimensional projections. 4 (4)

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