| Roll No. | | | | | | | | | | | |
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# PRESIDENCY UNIVERSITY

## BENGALURU

**End - Term Examinations – May/June 2026**

**Date:** 18-05-2026 **Time:** 01:00pm – 04:00pm

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|---|---|---|
| **School:** SOCSE | **Program:** CAI | |
| **Course Code:** CAI2506 | **Course Name:** Numerical optimization in AI | |
| **Semester**: VI | **Max Marks**: 100 | **Weightage**: 50% |

| CO - Levels | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| Marks | 24 | 24 | 44 | 44 | 44 |

**Instructions:**

*(i) Read all questions carefully and answer accordingly.*

*(ii) Do not write anything on the question paper other than roll number.*

## Part A

**Answer ALL the Questions. Each question carries 2marks.** **10Q x 2M=20M**

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|---|---|---|---|---|
| **1.** | Differentiate between local optimum and global optimum. | **2 Marks** | **L** | **CO1** |
| **2.** | Explain what happens if the learning rate is too large or too small in gradient-based optimization. | **2 Marks** | **L** | **CO1** |
| **3.** | Find the first-order partial derivatives of $f(x, y) = x^2y + xy^2$ | **2 Marks** | **L** | **CO2** |
| **4.** | Define hessian matrix For a function: $f\left(x_1, x_2, \ldots, x_n\right)$ | **2 Marks** | **L** | **CO2** |
| **5.** | Explain the importance of Quasi-Newton Methods | **2 Marks** | **L** | **CO3** |
| **6.** | Define line search? | **2 Marks** | **L** | **CO3** |
| **7.** | Differentiate between Interior Penalty Method and Exterior Penalty Method | **2 Marks** | **L** | **CO4** |
| **8.** | Define the Lagrange function for Multiple Constraints | **2 Marks** | **L** | **CO4** |
| **9.** | Explain RMSprop with suitable example | **2 Marks** | **L** | **CO5** |
| **10.** | Define Genetic Algorithm. | **2 Marks** | **L** | **CO5** |

## Part B

**Answer the Questions.** **Total Marks 80M**

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| **11.** | **a.** | Describe the classification of optimization problems into linear and nonlinear, and convex and non-convex types with suitable diagrams. | **10 Marks** | **L2** | **CO1** |
| | **b.** | Determine the stationary points of the function $f(x, y) = 3x^3 + 2y^2 - 6xy$ and classify the point | **10 Marks** | **L3** | **CO2** |
| **Or** | | | | | |
| **12.** | **a.** | Explain the necessary and sufficient conditions for optimality using first-order and second-order derivatives. | **10 Marks** | **L2** | **CO1** |
| | **b.** | compute the Hessian matrix for the function $f(x, y) = x^3 + y^3 + 6xy + 4x + y$ | **10 Marks** | **L3** | **CO2** |

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| **13.** | Minimize the loss function: $\boldsymbol{f(w,b) = \sum_{i=1}^{m}(\hat{y}_i - y_i)^2}$ using newtons method.<br>Given :<br>The model: $\boldsymbol{\hat{y} = wx + b}$<br>Data points: (5,12), (15,28), (25,45), (35,70)<br>Initial values: $\boldsymbol{w = 0, b = 0, x_0 = 0}$<br>perform 2 iterations. | **20 Marks** | **L3** | **CO3** |
| **Or** | | | | |
| **14.** | Consider a simple linear model $\hat{y} = wx$ with the following data point: $(x, y) = (2,4)$<br>The cost function is given by: $f(w) = \frac{1}{2}(\hat{y} - y)^2$<br>You are given:<br>Initial parameter: $w_0 = 1$<br>Initial velocity: $v_0 = 0$<br>Learning rate: $\alpha = 0.1$<br>Momentum coefficient: $\beta = 0.9$<br>Using Momentum-based Gradient Descent, perform 2 iterations and compute the updated values of $w$ and $v$ at each step. | **20 Marks** | **L3** | **CO3** |

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| **15.** | Minimize the function: $\boldsymbol{f(x,y) = x^2 + 2y^2 + xy}$<br>Subject to the constraints: $\boldsymbol{x + 2y \geq 2, x \geq 0}$<br>Derive the Karush-Kuhn-Tucker conditions and solve to determine the optimal values of $\boldsymbol{x}$ and $\boldsymbol{y}$ | **20 Marks** | **L3** | **CO4** |
| **Or** | | | | |
| **16.** | Minimize the function: $f(x, y) = x^2 + xy + y^2$<br>Subject to the constraints: $x + y > 1, x > 0$ using barrier method<br>You are given:<br>• Barrier parameter: $\mu = 1$<br>• Initial point: $(x_0, y_0) = (1,1)$<br>perform 2 iterations. | **20 Marks** | **L3** | **CO4** |

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| **17.** | **Consider the loss function**: $\boldsymbol{L(\theta) = (\theta x - y)^2}$<br>You are given the Data points:<br>$\left(\boldsymbol{x_1, y_1}\right) = (\mathbf{1}, \mathbf{2}),\ \left(\boldsymbol{x_2, y_2}\right) = (\mathbf{2}, \mathbf{4})$<br>Initial parameter: $\boldsymbol{\theta = 0}$<br>Learning rate: $\boldsymbol{\eta = 0.1}$<br>Perform SGD updates for 4 iterations, using one data point at a time in the given order:<br>$(\mathbf{1}, \mathbf{2}) \rightarrow (\mathbf{2}, \mathbf{4}) \rightarrow (\mathbf{1}, \mathbf{2}) \rightarrow (\mathbf{2}, \mathbf{4})$ | **20 Marks** | **L3** | **CO5** |
| | **Or** | | | |
| **18.** | Consider the loss function: $L(\theta) = (\theta x - y)^2$<br>You are given the dataset divided into mini-batches:<br>• Batch 1: (1,2), (2,4), (3,6)<br>• Batch 2: (4,8), (5,10), (6,12)<br>Initial parameter: $\theta = 0$<br>Learning rate: $\eta = 0.1$<br>Perform SGD updates and find the value of $\boldsymbol{\theta}$ after 4 iterations | **20 Marks** | **L3** | **CO5** |