CBCS SCHEME

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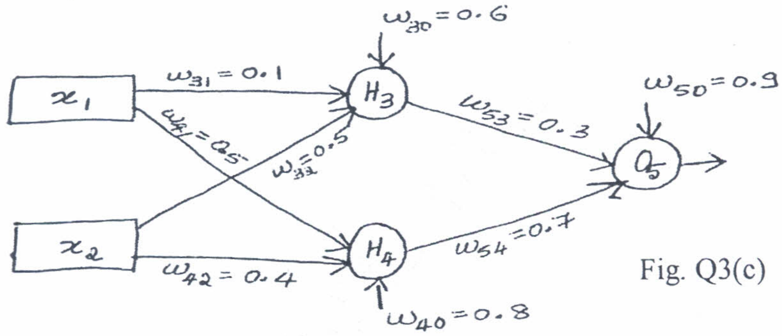
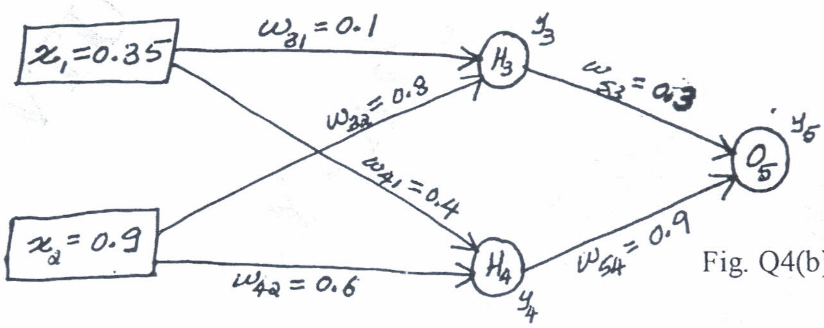
BCS405C

Fourth Semester B.E./B.Tech. Degree Examination, June/July 2025
Optimization Techniques

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M : Marks , L: Bloom's level , C: Course outcomes.

		Module – 1	M	L	C
Q.1	a.	Obtain the partial derivatives for : i) $f(x, y) = (x + 2y^3)^2$ ii) $f(x, y) = x^2y + xy^3$.	4	L3	CO1
	b.	If L is called a Least – squares loss function defined as $L(e) = \lVert e \rVert^2$ with $e(\theta) = y - \phi\,\theta$, where $\theta \in \mathbb{R}^D$ is a parameter vector, $\phi \in \mathbb{R}^{NXD}$ are input features and $y \in \mathbb{R}^N$ are the corresponding observations. Determine the dimensionality of the gradient $\frac{\partial L}{\partial \theta}$.	8	L3	CO1
	c.	Obtain Taylor's series expansion of $f(x, y) = x^2y + 3y - 2$ in terms of $(x-1)$ and $(y+2)$ upto second degree terms.	8	L3	CO1
		OR			
Q.2	a.	If $\vec{x}, \vec{y} \in \mathbb{R}^2$ and $y_1 = -2x_1 + x_2$, $y_2 = x_1 + x_2$. Show that the Jacobian determinant $\lvert\det J\rvert = 3$.	4	L3	CO1
	b.	Discuss the gradient of vector with respect to matrix. Hence obtain the gradient of vector $\vec{f} = \begin{bmatrix} e^{x_0x_1} & e^{x_2x_3} \end{bmatrix}$ with respect to the matrix $\vec{x} = \begin{bmatrix} x_0 & x_1 \\ x_2 & x_3 \end{bmatrix}$	8	L3	CO1
	c.	Obtain second order Taylor's series expansion of $f(x,y) = x^2y + 5xe^y$ about the point $a = 1$, $b = 0$.	8	L3	CO1
		Module – 2			
Q.3	a.	Construct computational graphs of the function $f(x) = \sqrt{x^2 + e^{x^2}} + \cos(x^2 + e^{x^2})$. Also find $\frac{df}{dx}$ using automatic differentiation.	6	L3	CO2
	b.	Obtain the gradient of quadratic cost.	7	L3	CO2

	c.	Find the output at neuron O_5, if input vector [0.7 , 0.3] using i) Logistic sigmoid ii) tan h x as the activation functions.  Fig. Q3(c)	7	L3	CO2
		OR			
Q.4	a.	Obtain the gradient of Mean Squared Error (MSE)..	8	L3	CO2
	b.	Assume that the neurons have a sigmoid activation function. Perform a forward pass and a backward pass on the network. Assume that the actual output of y is 0.5 and learning rate is 1. Perform another forward pass.  Fig. Q4(b)	12	L3	CO2
		Module – 3			
Q.5	a.	Define convex set. Explain separating hyper plane of convex of convex sets.	6	L2	CO3
	b.	Minimize $f(x) = 3x_1^2 + 4x_2^2 + 5x_3^2$, Subject to the constraint $x_1 + x_2 + x_3 = 10$.	7	L3	CO3
	c.	Find Max. f(x) = x(5π – x) on [0, 20] with ε = 0.1 by using 3 – point interval search method.	7	L3	CO3
		OR			
Q.6	a.	Define Hessian matrix. Use it to classify the relative extrema for the function, $f(x, y) = \frac{1}{3}x^3 + xy^2 - 8xy + 3$	10	L3	CO3
	b.	Write Fibonacci search algorithm and also use it to minimize f(x) = x(x – 1.5) over [0, 1] within the interval of uncertainty 0.25 of the initial interval of uncertainty.	10	L3	CO3

		Module – 4			
Q.7	**a.**	Write Newton Raphson algorithm and use it to find the approximate maximum of $f(x) = 2\sin x - \frac{x^2}{10}$ with initial guess of 2.5.	**10**	**L3**	**CO4**
	b.	Use Steepest descent method to minimize $f(x_1, x_2) = x_1 - x_2 + 2x_1^2 + 2x_1x_2 + x_2^2$ starting from the point $x_{(0)} = (0, 0)$ [perform 3 iterations].	**10**	**L3**	**CO4**
		OR			
Q.8	**a.**	i) Write the Stochastic Gradient Descent algorithm. ii) Write the differences between Stochastic Gradient Descent and Mini Batch Gradient Descent methods.	**10**	**L3**	**CO4**
	b.	Use Newton Raphson method to minimize $f(x_1, x_2) = x_1 - x_2 + 2x_1^2 + 2x_1 x_2 + x_2^2$, by taking the starting point $x_0 = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$.	**10**	**L3**	**CO4**
		Module – 5			
Q.9	**a.**	Explain i) Adagrad optimization strategy ii) RMS prop iii) Adam.	**15**	**L3**	**CO5**
	b.	Describe the saddle point problem in machine learning.	**5**	**L2**	**CO5**
		OR			
Q.10	**a.**	What is the difference between convex optimization and non – convex optimization?	**6**	**L2**	**CO5**
	b.	Write a note on stochastic gradient descent with momentum.	**7**	**L3**	**CO5**
	c.	Explain the advantages of RMS prop over Adagrad.	**7**	**L3**	**CO5**

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