INDIAN INSTITUTE OF SCIENCE EDUCATION AND RESEARCH PUNE
End-Semester Examination, 2023 August Semester

Course Name: **Mathematics of Network Algorithms**	Course Code: **DS4114/DS6144 and MT4154/MT6174**
Date of Exam: **November 20, 2023**	Duration: **2 hours**
Instructor: **Prafullkumar Tale**	Total Score: **40**

Instructions: All questions are compulsory. No queries will be entertained during the mid-term exam. Use your judgment about any possible doubts.

Q.I. (a) (5 pts) Justify why *cross-entroy cost function* is more useful than *quadratic cost function* when the activation function is sigmoid.

(b) (4 pts) Define *regularisation*. Explain techniques for it.

Q.II. (a) (5 pts) Describe a flow of designing ML/DL algorithm.

(b) (4 pts) Define *constrained optimization* and *Karush–Kuhn–Tucker* approach.

Q.III. (a) (5 pts) Consider a continuous function $f : \mathbb{R}^n \mapsto \mathbb{R}$. Justify that there an artificial neural network that uses sigmoid as an activation function and approximates the function f.

(b) (4 pts) Explain *convolutional neural networks* and *recurrent neural networks*.

Q.IV. (a) (3 pts) Use gradient based optimisation to find $\mathbf{x}$ that minimizes $f(\mathbf{x}) = 1/2 \cdot ||\mathbf{Ax - b}||_2^2$.

(b) (2 pts) Define the following terms with examples:
(i) Iterated k-fold validation, and (ii) Feature Engineering.

(c) (2 pts) Consider the sigmoid function $\sigma(z)$. Prove that $\sigma'(z) = \sigma(z) \cdot (1 - \sigma(z))$.

Q.V. (a) (2 pts) Explain *stochastic gradient descent* method and justify its use.

(b) (2 pts) Define soft-max activation function and justify its use.

(c) (2 pts) Explain vanishing gradient problem using a simple artificial neural network.