ELIZADE UNIVERSITY

ILARA-MOKIN

FACULTY: BASIC AND APPLIED SCIENCES

DEPARTMENT: MATHEMATICS AND COMPUTER SCIENCE

1st SEMESTER EXAMINATION 2020 / 2021 **ACADEMIC SESSION**

COURSE CODE: CSC 435 **COURSE TITLE:** Numerical Analysis

COURSE LEADER: Dr. Vincent Akpan **DURATION:** 2 Hours

HOD's SIGNATURE

INSTRUCTION: Answer any **THREE** (3) questions.
Students are warned that possession of any unauthorized materials in an examination is a serious assessment offence. Students are permitted to use ONLY a scientific calculator.

1. (b) Given the following data points,

x	0	2	3
y	7	11	28

Use the Lagrange's method to determine y at $x = 1$.

(b) Determine the parameters a and b so that $f(x) = ae^{bx}$ fits the following data in the least-squares sense:

x	1.2	2.8	4.3	5.4	6.8	7.9
y	7.5	16.1	38.9	67.0	146.6	266.2

Fit $\ln y_i$ and compute the standard deviation.

2. (a) Distinguish between the following terms:
   (i) Interpolation
   (ii) Curve fitting
   (iii) Time-Series
   (b) (i) What is least-squares fit?
   (ii) What is linear regression?
   (c) Suppose that following data points lie on a polynomial.

x	-2	1	4	-1	3	-4
y	-1	2	59	4	24	-53

Determine the degree of this polynomial by constructing the divided difference table.

3. (a) The behaviour of a fairly large class of discrete-time systems can be modeled by the following general mathematical formula:

$$A(z^{-1})Y(k) = z^{-d}\frac{B(z^{-1})}{F(z^{-1})}U(k) + \frac{C(z^{-1})}{D(z^{-1})}e(k)$$

(where all symbols have their usual meaning).
Using the above equation, deduce the mathematical model structure that corresponds to the:
(i) AutoRegressive with eXogenous inputs (ARX) model.
(ii) AutoRegressive Moving Average with eXogenous inputs (ARMAX) model.
(iii) Output Error (OE) model.

(b) Using the results in (c) and starting from any known principles, deduce an expression and draw the resulting neural network model structure that corresponds to the:
(i) Neural Network AutoRegressive with eXogenous inputs (NNARX) model.
(ii) Neural Network AutoRegressive Moving Average with eXogenous inputs (NNARMAX) model.
(iii) Neural Network Output Error (NNOE) model.

4. (a) Fuzzy logic model comes in two flavours, namely: Mamdani-type and Sugeno-type (also called Takagi-Sugeno-Kang (TKS)).
(i) State where each type of the above fuzzy logic models can find applications.
(ii) Briefly state three advantages each for the two model types.
(b) (i) What is the main argument for the introduction of the Adaptive neural fuzzy inference system (ANFIS).
(ii) Draw the typical architecture of a five-layer ANFIS and state the function of each layer.

5. (a) (i) With the aid of a suitable diagram, obtain the mathematical description of a single layer neural network.
(ii) Write the basic perceptron learning algorithm that can be used to adjust the weight and bias of a single layer neuron.

(b) A single layer perceptron is initialized with weights $w_1 = 1$ and $w_2 = 2$ with bias $b = -2$ for a simple output classification problem. Given the inputs $u = [0.5, 0.5]$ and the target output as $y = +1$. Assuming that the network has an Heaviside activation function where $F(\cdot) = 1$, if $(\cdot) > 0$ and $F(\cdot) = -1$, otherwise.
(i) What are the final values of the weights and bias?
(ii) In how many iterations does the perceptron output converge to the desired target output?

(c) Assuming that 3 past inputs and outputs are sufficient to model a 5-input 3-output system using a dynamic feedforward neural network autoregressive moving average with exogenous inputs (NNARMAX) model with 15 input-to-hidden layer neurons.
(i) What is the number of output neurons?
(ii) Compute the total number of inputs to the neural network.
(iii) Compute the dimension of the input-to-hidden layer weight.
(iv) Compute the dimension of the hidden-to-output layer weight.