Last Name **Name** **student ID (matricola)**

n = _____ (student ID No. /// *N. matricola, per intero oppure cifre finali*)

Section 1: LINEAR PROGRAMMING

A farm is specialized in growing corn and raising calves. These two goods are produced using three different systems:

- **System 1**: 1,000 calves are raised using 30 man-months of labor, 20 hectares of land, but 200 tons of corn are necessarily consumed, too.
- **System 2**: 100 tons of corn are produced using 20 man-months of labor and 40 hectares of land.
- **System 3**: 200 tons of corn and 500 calves are produced using 40 man-months of labor and 50 hectares of land.

The farm owns 70 hectares of land and has 50 man-months of labor available.

Corn is sold at ITL 100,000 per ton, and calves are sold at ITL 30,000 each.

The goal is to determine how much to produce with each of the three systems in order to maximize selling revenues.

Hint

Let:
- x1 = number of times System 1 is used
- x2 = number of times System 2 is used
- x3 = number of times System 3 is used

Questions

1.I. Formulate and write the LP math model of this problem.

1.II. What type of LP problem is this❓

1.III. Solve it by using the most convenient tool in Matlab and describe `step by step` the obtainment of the **optimum**

1.IV. Determine the optimal value of the **objective function**

1.V. Determine the optimal values, if any, of the **decision variables**

1.VI. Provide comments, if any, on role and value of the **decision variables at optimim**

Section 2: EMPIRICAL MODELS

The following attached file contains engineering data:
Sect.2_flow data.TXT

Questions

First, carefully look at data and then use Matlab® tools:

2.1. Plot the original data

2.2.try a **regression model** that you consider reasonably valid, by using the Matlab resources

2.3.Report and comment the regression Performance Metrics (R^2 score, etc.)

2.4.calculate and plot the **residuals** of the **regression model**

2.5.discuss the **quality of the residuals** by using and showing the **Normal Probability Plot**

2.6.estimate the "missing datum" at % Valve opening = 30 by **the above regression model**

2.7.estimate the "missing datum" at % Valve opening = 30 by **linear interpolation**

2.8.estimate the "missing datum" at % Valve opening = 30 by a suitable **spline interpolation**

Section 3: FINITE DIFFERENCE METHODS for PDE

You are assigned the following parabolic PDE $\frac{\partial u(x,t)}{\partial t} = \Delta \frac{\partial^2 u(x,t)}{\partial x^2} + ku(x,t)$

with

$\Delta = k = (4n + 0.05)/n$

$L = 4\pi$

$t_{final} = 5$

IC: $t = 0$ $u(x,0) = \sin(x)$

BC: $A \cdot u(x,t)|_{x=0} + B \left.\frac{\partial u(x,t)}{\partial x}\right|_{x=0} = \frac{n+0.05}{4n}$

$D \cdot u(x,t)|_{x=L} + E \left.\frac{\partial u(x,t)}{\partial x}\right|_{x=L} = \sqrt{\frac{n+0.05}{4n}\, t}$

$A = D = (n + 0.05)/n$

$B = E = 0$

where n = _____ (student ID No. /// *N. matricola, per intero oppure cifre finali*)

Questions

3.1.which type are the **Boundary Conditions**?

3.2.Choose a value of **Delta_x** such as the **explicit method**, using **MUC**, remains always stable for 3 cases:

Delta_t = 0.01

Delta_t = 0.1

Delta_t = 1

3.3.attach the final graph at t_{final} as obtained with Delta_t = 0.01

3.4.attach the final graph at t_{final} as obtained with Delta_t = 0.1

3.5. attach the final graph at t_{final} as obtained with Delta_t = 1

3.6.comment and compare the 3 final solutions

Section 4: MATHEMATICAL MODELING

4.1 Model properties

a) What order is the following model❓

$$a_1\left(\frac{dy}{dt}\right)^2 + a_2 y(t) = a_3 t^3$$

b) Is it autonomous❓

4.2 Linear vs NON-linear models

c) Discuss the difference

Section 5: TIME SERIES

With ref. to the **time series** data in the file:

Sect.5 daily_sales_90_days.txt

and the use of Matlab®,
first perform and comment the **exploratory data analysis**:

5.a. plot the original **time series**

5.b. Calculate standard deviation

5.c. Calculate skewness

5.d. Calculate kurtosis

Then, using the Matlab® command to reduce noise and highlight trends:

5.e. Apply a suitable **Moving Average Smoothing**

5.f. Plot the new "**smoothed**" time series against the original data and comment it

5.g. What happens if you change the **Moving Average Span**?

5.h. What is time series forecasting?