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

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

Section 1: LINEAR PROGRAMMING

A plastic recycling plant produces two products A and B, whose daily production cost per quintal is equal to 200 and 300 €/q, respectively.
Each day a maximum of 8 quintals must be produced of A and B together, from which at least 2 q of product A and a maximum of 5 q of product B.
Furthermore, the ratio between the daily productions of A and B must be below a maximum of 3.
What are the daily productions expressed in quintals of A and B, what minimize the daily cost of total production?

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. At the **optimum**, provide comments on special or unexpected features, if any

Section 2: EMPIRICAL MODELS

In an experiment, the data was obtained in the following file.

sect.2_concentration data.txt

Questions

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

2.1. determine one **regression model** that you consider reasonably valid

2.2. is the regression model adopted by you a LINEAR or NON-LINEAR one?

2.3. calculate and plot the **residuals**

2.4. discuss the **residuals**

2.5. using the predictions of the regression model adopted by you, plot the **Equivalent Graph (or Parity Line)**

2.6. using the regression model adopted by you, calculate the **Interpolated point** at an abscissa of 7.5

2.7. using the regression model adopted by you, calculate the **Extrapolated point** at a new abscissa of 12

2.8. propose and determine another regression model that you consider "**overfitting**" the data

Section 3: FINITE DIFFERENCE METHODS for PDE

Solve the following parabolic PDE $$\frac{\partial u(x,t)}{\partial t} = \Delta \frac{\partial^2 u(x,t)}{\partial x^2} + k u(x,t)$$

with

$\Delta = 2$

$k = 1$

$L = 10$

$t_{final} = 0.5$

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

BC: C(t) = t

$F(t) = t \cdot \exp(-t)$

A=D=1

B=E=0

Questions

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

3.2.adopt the **explicit method** and, using **MUC**, explain the procedure briefly, attach the graph and comment the final solution

3.3.how much is Delta_x ?

3.4.once Delta_x is fixed, how much should TIMESTEP be to get LAMBDA=0.5 ?

3.5.take a double value of t_{final}, maintain the **explicit method** and, using **MUC**, attach the graph

3.6.compare the results of the two cases

Section 4: MATHEMATICAL MODELING

4.1 Classification of a model

With ref. to the following model:

$$\dot{x_1} = 1 + \frac{x_1}{1.1} + \frac{\sqrt{x_1 x_2}}{2.2}$$

$$\dot{x_2} = 2 + \frac{x_1}{2.1} + \frac{x_2}{2.2}$$

$$with\ x_1 = x_1(t);\ x_2 = x_2(t)$$

$$IC: x_1(0) = 0;\ x_2(0) = 0$$

a) identify at least one general classification to which this model can be attributed

b) within the classification you've chosen, provide all attributes and categories you consider pertinent to this model

c) if the following further eq. is added

$$x_3(t) = x_1(t)^2 + x_2(t)^2$$

does the **model order** change? How much?

Section 5: TIME SERIES

5 Moving average

a) what are meaning and objective of moving average in **time series** data analysis?

The demand for a product in 7 months is shown by the short **time series** in the file:

sect.5_Time Series_2025-07-14.txt

b) obtain a new **filtered time series** from the above data by adopting a **moving average** with the **span** M=4

c) plot the new **filtered time series** against the original one and comment them