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Last Name	Name	student ID (matricola)
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n = the last one or two digits from the student ID No. (*N. matricola*)

## Section 1: LINEAR PROGRAMMING

### IMPORTANT ALERT:

if you're using the Artificial Intelligence (AI), you're urged to declare:

1. in which part of the problem you've been using AI to assist the solution
2. which AI web site you've been invoking

A dietitian must prepare a diet that guarantees a daily intake of protein, iron and calcium of at least 20 mg, 30 mg, and 10 mg, respectively.

The dietitian focuses on the following food:

- a mix of vegetables (5 mg (protein)/hg, 6 mg (iron)/hg, and 5 mg (calcium)/hg, at a cost of 4 €/kg),
- meat (18000 mg (protein)/hg, 10 mg (iron)/hg, and 3 mg (calcium)/hg, at a cost of 20 €/kg),
- and a dry fruit blend (4 mg (protein)/hg, 5 mg (iron)/hg, and 12 mg (calcium)/hg, at a cost of 7 €/kg).

In addition:

- the amount of each food cannot exceed 1 kg/day
- a fixed cost of 1.50€/day is to be added as a general handling fee of the three foods
- a saving  $s = [(\text{hg of vegetables}) + (\text{hg of meat}) + (\text{hg of fruit}) / 100 [=] \text{€}/\text{day}$  is to be subtracted to the gross cost of the three foods.

Determine the diet with the lowest cost.

## 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 using **Simplex2p in Matlab®** and comment here **step by step** the approach to the **optimum**

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

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

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

## Section 2: EMPIRICAL MODELS

### IMPORTANT ALERT:

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**This section is alternative to Section 5: you are allowed to solve only one of both!**

In an experiment aimed at measuring temperature penetration in a food piece, data was obtained in the following file.

sect.2\_T(t)\_2026-04-08.txt

## Questions

First, carefully look at data and then use Matlab® and the CurveFitter App:

2.1.plot the original data

2.2.determine an **interpolation model** that you consider reasonably valid

2.3.obtain a **regression model** and explain why you consider it reasonably valid

2.4.discuss the **quality of the residuals** by generating and attaching the **Normal cumulative probability chart**

2.5.using the **regression model** adopted by you, calculate the **Extrapolated point** at an abscissa  $T=7000$  °C and discuss it

2.6.using the **regression model** adopted by you, calculate the **Extrapolated point** at an abscissa  $T=10$  °C and discuss it

2.7. calculate the **Accuracy Factor** with Matlab®

2.8. compare at your best the meaning and the outcome of the **interpolation model** and the **regression model**

2.9. Finally, propose an **alternative regression model** that for sure is bad performing with respect to the data, by explaining why.

### Section 3: FINITE DIFFERENCE METHODS for PDE

#### IMPORTANT ALERT:

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Solve 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

$$\Delta = 4$$

$$k = 0$$

$$L = 1$$

$$t_{\text{final}} = 5$$

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

BC:  $A=B=D = 4 \cdot \frac{n-0.1}{n+0.1}$

$$C(t) = 4 \cdot \frac{n-0.1}{n+0.1}$$

$$F(t) = 2 \cdot \frac{n-0.1}{n+0.1}$$

$$E=0$$

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### Questions

3.1. Make a reasonable choice of #Points and explain it. Then, calculate Delta\_x

3.2. once  $\Delta x$  is fixed, calculate a suitable **TIMESTEP** to keep the stability parameter valid for the **explicit method**

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

3.4. Make a new choice of *#Points* equal to half of the previous value and, as a consequence, a new value of **TIMESTEP** to keep the resulting stability parameter once more valid for the **explicit method**

3.5. using **MUC** and the **explicit method**, attach the graph and comment the final solution

3.6. compare the results of the above two cases

## Section 4: MATHEMATICAL MODELING

### IMPORTANT ALERT:

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### 4.1 Model classification and properties

Consider the following math model:

$$\frac{dc_1}{dt} = \frac{F_1}{V_1} c_{1,in} - \frac{F_1}{V_1} c_1, \quad \frac{dc_2}{dt} = \frac{F_2}{V_2} c_1 - \frac{F_2}{V_2} c_2.$$

where  $F_i$  and  $V_i$  are **parameters**.

- a) what is a **parameter**?

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- b) which are the **state variables** (if any) ?
  - c) how much is the **order** ?
  - d) which are the **input variables** (if any) ?
  - e) provide all relevant classification keys, according to the theory of Model Classification, e.g., 1, 2, 3, etc.

## Section 5: TIME SERIES

### IMPORTANT ALERT:

if you're using the Artificial Intelligence (AI), you're urged to declare:

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**This section is alternative to Section 2: you are allowed to solve only one of both!**

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

sect.5\_Time-series\_2026-04-08.csv

and the use of Matlab®,

- 5.1) Plot the original **time series**  $y$
- 5.2) Is the original time series  $y$  **stationary** or NOT ?

Then work on **detrending**:

- 5.3) What is the **detrending** ?
- 5.4) Propose and obtain a reasonable **regression trend**  $y_d$  for the original **time series**  $y$
- 5.5) Plot the **Detrended Time Series**
- 5.6) Try a further detrending by abandoning the **regression** and using instead **moving averages (MA)** from the original data points, with a suitable span  $M$ , to obtain a reasonable **trend**  $y_{ma}$ .

5.7) Plot the new **Detrended Time Series**

**HINT:**

Such a new Detrended Time Series can be obtained by subtracting the new one built with moving average  $y_{ma}$  from the original data points  $y$ .

5.8) Compare the outcome of the **regression detrending** to that of **MA detrending**