

UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For The Following Qualifications:–

B.Eng. *M.Eng.*

Biochemical Eng E125: Computer Aided Bioprocess Engineering

COURSE CODE : **BENGE125**

UNIT VALUE : **0.50**

DATE : **28-APR-04**

TIME : **14.30**

TIME ALLOWED : **2 Hours**

Answer **THREE QUESTIONS** including Question 1. Only the first three answers will be marked. The marks for each question distributed as shown []

Standard electronic calculators are permitted.

1.

- a) To solve a non – linear equation $f(x) = 0$, what error criteria can be used if the bisection method is employed and why? What is its convergent rate? [5]

- b) Give the Jacobean matrix of the following equations.

$$f_1 = x_1 x_2 - x_2^2 - 4$$

$$f_2 = 3x_1^2 - 2x_2 + 8$$

[5]

- c) What is the purpose of a function in Matlab? Write the code for a Matlab function to calculate the values of f_1 and f_2 for equations in (b). [5]

- d) List metrics that can be used to compare different flowsheets during process analysis. [5]

- e) Use the graphical method to solve the following linear programming problem:

$$\text{Maximise: } f(x) = 2x_1 + 0.5x_2$$

$$\text{s.t. } x_1 + 3x_2 \geq 5$$

$$4x_1 + x_2 \leq 8$$

$$2x_1 + x_2 \leq 2$$

$$x_1, x_2 \geq 0$$

[5]

2.

- a) Express the following equation as a set of first order differential equations and list the update equations using the Forward method and discuss its numerical features:

$$\frac{d^3 y}{dt^3} + t^2 \frac{d^2 y}{dt^2} + e^t y = 0$$

Initial Conditions:

$$y|_{t=0} = 1, \frac{dy}{dt}|_{t=0} = 2, \frac{d^2 y}{dt^2}|_{t=0} = 0 \quad [10]$$

- b) Write down a MATLAB program for solving the differential equation in (a) using the Forward method for $0 \leq t \leq 8$. Your program should include statements which will generate graphs of $y(t)$ and appropriate comments where necessary. [10]

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3.

- a) A biopharmaceutical drug company has three warehouses, denoted by W_1 , W_2 and W_3 . The first warehouse, W_1 , is in Brighton. The second, W_2 , is in Manchester, and the third warehouse, W_3 , is in Glasgow. It sells primarily to four major distributors, D_1 , D_2 , D_3 and D_4 , located in London, Birmingham, Liverpool and Cardiff. Due to the delivery distances involved, the costs of delivering a truckload of drugs from the different warehouses to the different distributors vary. They are given in the following table:

Costs of delivery (in pounds)

From/to	D_1	D_2	D_3	D_4	Supplies
W_1	220	360	440	630	20
W_2	310	190	220	360	30
W_3	650	450	260	220	50
Demands	20	30	30	20	

That is, to deliver a truckload of goods from warehouse 1 to distributor 2 costs £360. W_1 , W_2 and W_3 have respectively 20, 30, and 50 truckloads of drugs to be delivered, and that D_1 , D_2 , D_3 and D_4 need respectively 20, 30, 30, and 20 truckloads of drugs. The company wishes to find out the cheapest way of delivering the drugs so as to meet all the demands. Identify the decision variables and formulate the objective function and constraints as a linear programming problem. [10]

- b) Use the Simplex method to solve the following linear programming problem:

$$\begin{aligned}
 &\text{Maximise} && f = 2x_1 + 3x_2 \\
 &\text{s.t.} && 2x_1 + 3x_2 \leq 16 \\
 &&& 2x_1 + x_2 \leq 12 \\
 &&& x_2 \leq 4 \\
 &&& x_1, x_2 \geq 0
 \end{aligned}$$

[10]

4.

- a) List the key inputs and outputs for bioprocess simulation in SuperPro Designer. [10]
- b) Discuss the consequence on cost if a large chromatography column is replaced with a smaller one that requires more cycles? [5]
- c) Describe how to identify scheduling bottlenecks, size bottlenecks and resource bottlenecks of a process using SuperPro Designer. [5]

END OF PAPER