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   : **22-MAY-03**

TIME   : **14.30**

TIME ALLOWED   : **2 Hours**

TURN OVER

Answer THREE QUESTIONS. The first question is compulsory. The marks for each question distributed as shown [ ]

1.

a). What is the key formula for solving the following first order differential equation using the Runge-Kutta (RK2) technique:

$$\frac{dy}{dt} = -0.5y^2 + \sqrt{y} + 2$$

List the characteristics of this method and explain the importance of step size selection. [5]

b). Use a graphical method to solve the following linear programming problem. [5]

Maximise $f(x) = 3x_1 + 2x_2$
s.t. $5x_1 + x_2 \leq 40$
     $-x_1 + x_2 \leq 4$
     $x_1, x_2 \geq 0$

c). List the steps required to set-up a bioprocess simulation and perform the mass balance and economic analysis within SuperPro Designer. [5]

d). List the steps required to solve a linear programming problem in EXCEL? [5]

e). Write a function of MATLAB code to calculate the value of y for a given t

$$y = \begin{cases} t^2 & \text{if} & t \leq 1 \\ t & 1 < t \leq 10 \\ 10 & t > 10 \end{cases}$$
[5]

PLEASE TURN OVER

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2.

a)   A MATLAB program was developed to solve the following ordinary differential equation for $0 \le t \le 5$, using Forward Euler's Method

$$\frac{dy}{dt} = y\cos(y).$$

It was found that the program did not work. Find five errors in the program and correct them accordingly.   [10]

mainprogram.m

```
% choose the step size.
h=0.2;

% use y to record the solution as a vector and T to record the time points
y=[ ];
T=[ ];

% initial conditions
y(0)=1;
t=0;
T=[T t];

% use FOR loop to calculate the solution y

n=(5-0)/h;
for i=1:n

% use function to calculate f(y,t), named as fvalue.m
f=fvalue(y(i));

y(i)=h*f;
T=[T (i-1)*h];
end

%plot the figure of y vs. t using symbol *

plot(y, t, '*')

end
```

fvalue.m

```
function f=fvalue(y)
f=y*cosy
```

CONTINUED

b).   Write down a MATLAB program required for solving the differential equation in (a) using the Backward Euler's method for $0 \leq t \leq 10$. Your program should include statements which will generate graphs of y(t) and appropriate comments where necessary for helping others to understand your program. [10]

3.

a) A biopharmaceutical company manufactures 2 drugs: DRUG1 and DRUG2. Each batch of drug is produced as a bulk product first and then formulated as a tablet. The number of weeks for bulk manufacture and formulation are 3 and 2 for DRUG1 and 2 and 1 for DRUG2 respectively. In a year the manufacturer has 25 weeks available for bulk manufacture and 20 weeks for formulation. The revenue from each batch of product is £800 for DRUG1 and £600 for DRUG2. The operating costs for each batch of drug are £200 for DRUG1 and £150 for DRUG2. From sales forecasts the maximum number of batches for both drugs is 8. Use simplex method to find out how many batches of each drug the company should produce so that the constraints are satisfied and the profit maximised.   [10]

b) If the maximum batch number for DRUG2 increases from 8 to 10, discuss how the company may change its plan.   [5]

c) Perform an analysis to see if the company can reduce the weeks for formulation and if so how many weeks can be reduced.   [5]

PLEASE TURN OVER

4.

a). Describe the key features of a rating/simulation problem (mode). Give examples of the key inputs you would specify and outputs you would expect for homogenisation.   [5]

b). The table below shows the equipment capacity utilisation for a process. If the market demand for the product increases, how can the company increase the throughput? Discuss the consequence of implementing the strategy.   [5]

EQUIPMENT CAPACITY UTILIZATION AND UPTIME (Entire Flowsheet)

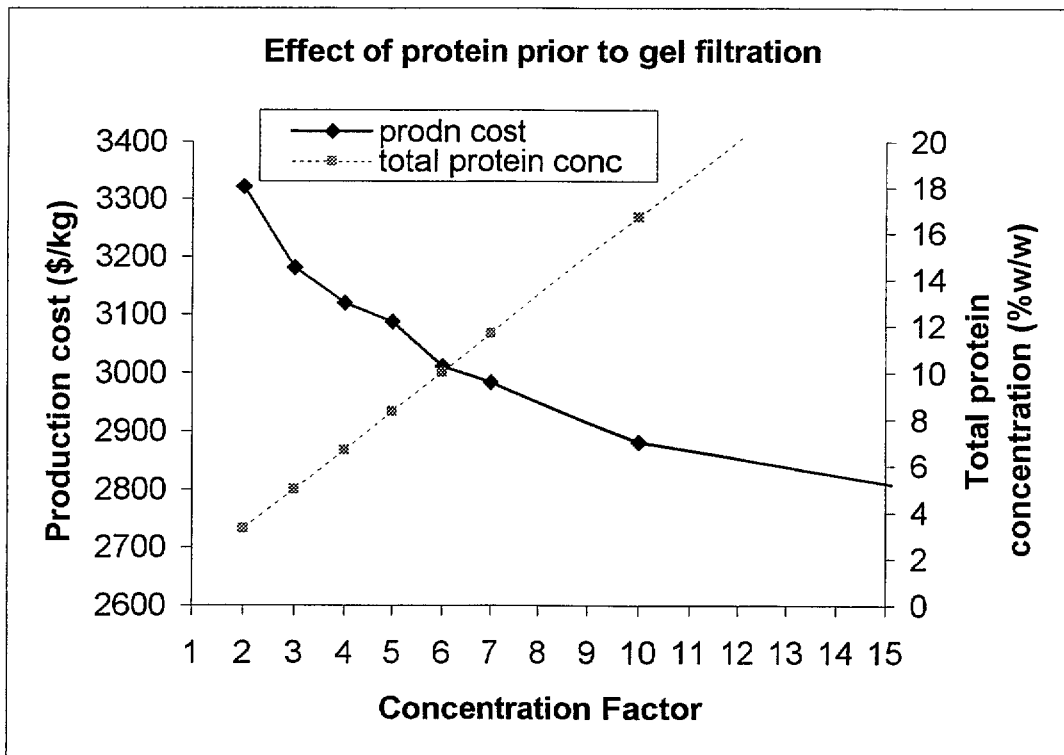| Equipment Tag	Procedure Name	Capacity Utilization (%)	Equipment Uptime (%)	Combined Utilization (%)
Air Filter-101	P-4	100	78.57	78.57
Fermenter-102	P-5	91.11	86.37	78.7
Diafilter-101	P-7	100	3.33	3.33
Tank -103	P-8	85.04	2.62	2.23
Ultrafilter-101	P-9	100	2.42	2.42
Affinity Column-101	P-10	50.04	9.32	4.66
Diafilter -102	P-11	100	2.6	2.6
Ion Exchange Column -102	P-12	52.93	7.65	4.05
Tank -104	P-14	20.55	3.84	0.79
HIC Column -103	P-15	47.64	8	3.81
Diafilter -103	P-17	100	2.36	2.36
Dead-End -102	P-19	100	2.38	2.38
Air Filter-102	P-6	100	78.57	78.57

CONTINUED

c) The Gantt chart below shows the schedules for a manufacturing process. Identify the scheduling bottleneck and suggest a strategy for debottlenecking. Discuss the advantage and disadvantages of the strategy. [5]

Equipment Utilization Chart / Multiple [3] Batches

LEGEND   Batch # Color Code

#1 ■   #2 ▨   #3 ▨
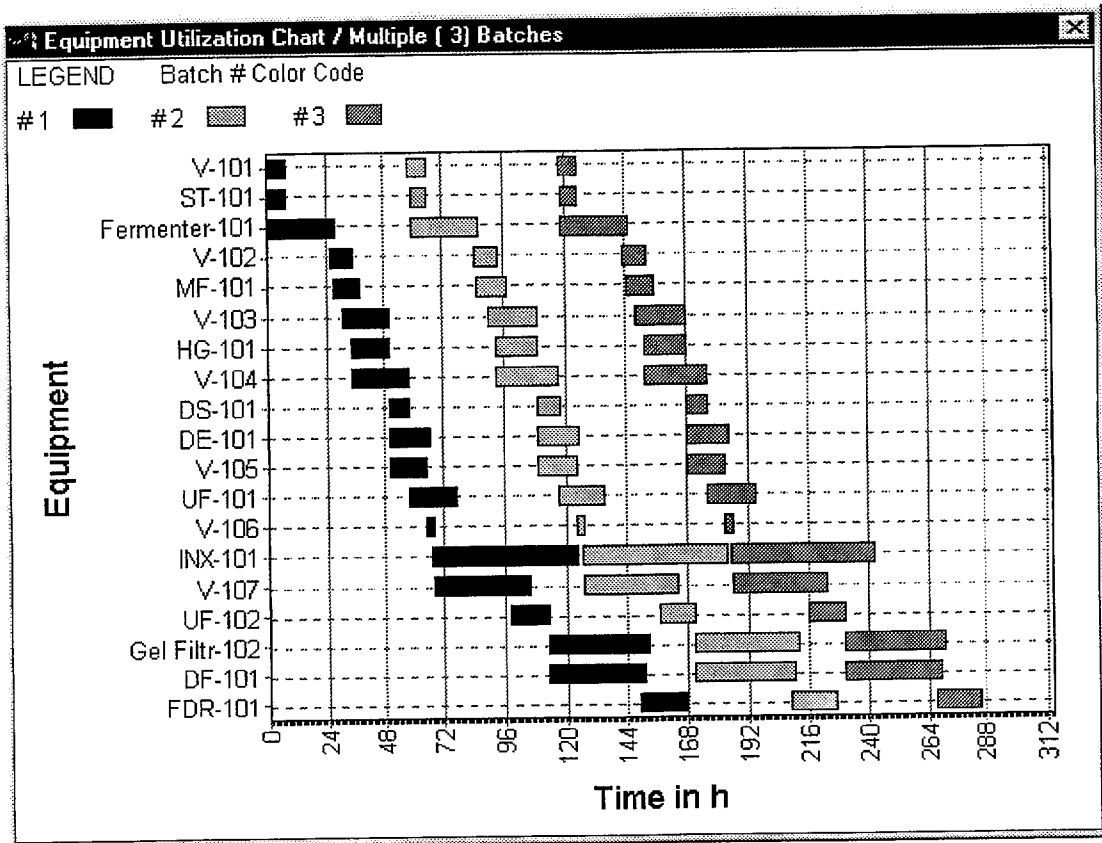
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d) Simulation is very useful for what-if analysis. The following figure was generated to investigate the impact of an ultrafiltration operation prior to gel filtration upon the production cost and the protein concentration of the outlet stream for a design case in SuperPro Designer. Discuss the response of production cost and protein concentration to the changes in the concentration factor and give possible reasons for this response. If the protein loading on the gel filtration column should be limited to 6~8%, what concentration factor (CF) should you use? [5]

END OF PAPER