NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

Master of Engineering in Manufacturing Systems and Operations Management

DESIGN, ANALYSIS AND CONTROL OF MANUFACTURING SYSTEMS

TIE 6111

First Semester Main Examination Paper

December 2014

This examination paper consists of 5 pages

Time Allowed: 3 hours

Total Marks: 100

Special Requirements: None

Examiner's Name: S Mhlanga

INSTRUCTIONS

1. Answer any **four (4)** questions**,** each carries 25 marks.
2. Use of calculators is permissible

MARK ALLOCATION

QUESTION	MARKS
1.	**25**
2.	**25**
3.	**25**
4.	**25**
5.	**25**
6.	**25**
7.	**25**
TOTAL	**100**

Question 1

a) Discuss five (5) pieces of information obtained from marketing and which can be used by the facilities planner. [15]

b) Given the following spatial schematic of departments shown in Figure 1:

i) Evaluate the flow path lengths of each of the components shown in Table 1. [10]

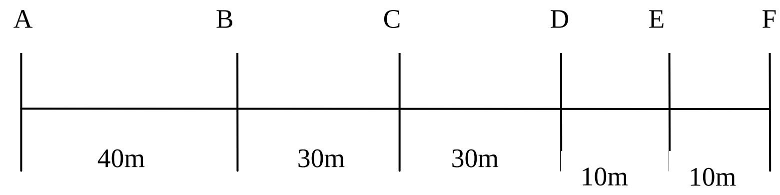

Figure 1: Spatial Arrangment of Departments A to F

Table 1: Routing Information of components

Component	Routing
1	A - B – C – D - E - F
2	A – C – B – D – E - F
3	A –F – E – D – C B – A - F

Question 2

a) Briefly discuss the factors to be considered in determining the style and size of a pallet. [10]

b) A small shop has five existing machines (M1 through M5) located at coordinate location P1 = (8,25), P2 = (10,12), P3 = (16,30), P4 = (30,10) and P5 = (40,25). Two new machines (N1 and N2) are to be located in the shop. It is anticipated that there will be four trips per day between the new machines. The number of trips per day between each machine and existing machine is shown in Table 2.

Table 2: The number of trips per day between machines

Machine	**M1**	**M2**	**M3**	**M4**	**M5**
N1	8	6	5	4	3
N2	2	3	4	6	6

i) Formulate the objective function assuming rectilinear distance is used. [5]

ii) Formulate the constraints, [8]

iii) State the variables to be considered. [2]

Question 3

Write the pseudo code of the Genetic Algorithm in solving a pairwise switch facility layout problem. Clearly explain all the terms used and support your answer with an example. [25]

Question 4

a) The following jobs shown in Table 4.1 are waiting to be processed at a machine center.

Table 4.1: Processing Times for Jobs

Job	Processing Time	Due Date	Number of Remaining operations
A	6	8	4
B	2	6	8
C	8	18	10
D	3	15	7
E	9	23	5

In what sequence would the jobs be ranked according to the following rules:

i) FCFS, [2]
ii) EDD, [2]
iii) SPT, [2]
iv) CR, [2]
v) Least Slack Rule. [2]

b) Calculate the average Flowtime and maximum tardiness for the EDD schedule. [7]

c) Four jobs are to be processed through a two step operation. The first operation involves data entry and the second involves verification. Processing times are shown in Table 4.2. Determine a sequence that will minimize the total completion time for these jobs and the makespan. [8]

Table 4.2: Process times

Job	Data Entry (hours)	Verify (hours)
A	2.5	1.7
B	3.8	2.6
C	1.9	1.0
D	1.8	3.0

Question 5

a) Explain briefly three types of flexibility [9]

b) An FMS is planned with one Turning center and two milling centers. The center will run 16 hours, 6 days a week and the machines are expected to be available 90% of the time. Machines will cost $45 per hour to operate. Applying greedy heuristic determine the set of part families to be produced on the FMS based on data shown in Table 5.1. [16]

Table 5.1: Data for Question 5

Part Family	Weekly Demand	Milling Center Time per Unit	Turning Time per Unit	Material Cost per Unit	Subcontracting Cost per Unit
1	400	0.15	0.00	10.50	25.00
2	400	0.35	0.00	12.25	35.00
3	800	0.50	0.01	21.45	62.35
4	400	0.20	0.00	6.45	24.35
5	800	0.15	0.00	15.45	21.95

Question 6

a) Consider a facility open 24 hours per day with a single machine that is used to service only one type of job. The company policy is to limit the number of jobs within the facility at any one time to 4. The mean arrival rate of jobs is 120 jobs per day, and the mean processing time for a job is 15 minutes. Both the processing and inter-arrival times are assumed to be exponentially distributed. Answer the following questions regarding the long-run behavior of the facility.

i) What is the average number of jobs that arrive at the facility (but not necessarily get in) per hour? [5]

ii) What is the average time taken by jobs in the system? [5]

b) The manager of a bank must determine how many tellers, out of a maximum number of 6, should work on Fridays. For every minute a customer is in the bank, the manager believes that a cost of $0.05 is incurred. On average 2 customers per minute arrive at the bank, and a teller takes an average of 2 minutes to complete a customer's transaction. It costs the bank $9 per hour to hire a teller. Assuming an M/M/C queuing system, how many tellers should the bank have working on Fridays in order to minimise the sum of service costs and customer waiting costs? [15]

Question 7

a) Applying binary ordering algorithm what are the natural groups that one can form using information given in Table 7.1. [10]

Table 7.1: Machine-Part Incidence Information

		Part Number'					
Machine ID		1	2	3	4	5	6
	A			1		1	
	B		1	1			
	C	1			1		
	D		1	1		1	
	E	1			1		1

b) The Belmont machine shop has a machine – part matrix shown in Table 7.1. Using the similarity coefficient Matrix, group the five machines. [10]

c) Draw the similarity coefficient dendrogram for the machines in *(b)*. [5]

Table A.1: Queuing Formulae for Question 6

Table A.1: M/M/C Queuing Results		
	M/M/1	M/M/C
L	$L_s = \frac{\lambda}{\mu - \lambda}$	$L_q + \frac{\lambda}{\mu}$
L_q	$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)}$	$\frac{\rho(c\rho)^c p(o)}{c!(1-\rho)^2}$
W_q	$W_q = \frac{\lambda}{\mu(\mu - \lambda)}$	$\frac{(c\rho)^c p(o)}{c! c\mu(1-\rho)^2}$
W	$w_s = \frac{1}{\mu - \lambda}$	$W_q + \mu^{-1}$
P(o)	$P_o = 1 - \frac{\lambda}{\mu}$	$\left[\frac{(c\rho)^c}{c!(1-\rho)} + \sum_{n-o}^{c-1} \frac{(c\rho)^n}{n!} \right]^{-1}$
	$\rho = \frac{\lambda}{\mu}$	

End of Examination