# NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

**FACULTY OF INDUSTRIAL TECHNOLOGY**

**DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING**

**MEng - Manufacturing Systems and Operations Management**

**Main Examination**

| | | |
|---|---|---|
| **COURSE** | **:** | **DESIGN ANALYSIS AND CONTROL OF MANUFACTURING SYSTEMS** |
| **CODE** | **:** | **TIE 6111** |
| **DATE** | **:** | **JANUARY 2013** |
| **DURATION** | **:** | **3 HOURS** |

**INSTRUCTIONS AND INFORMATION TO CANDIDATE**

1. Answer **Four (4)** questions.
2. This paper contains seven **(7)** questions.
3. There are Eight **(8)** printed pages.

**QUESTION 1**

a) Briefly discuss two aspects on the business implication as applied to a manufacturing company of your interest. Support answer with tangible facts. [10]

b) Discuss five issues that should be obtained from marketing that can be used by facilities planner. [15]

**QUESTION 2**

a) The paper flow to be expected through one section of the city hall consists of the following:

- 10 medical records from records to marriage licenses per day
- 7 Certificates from printing to marriage license per day
- 4 Blood samples from marriage licenses to lab per day
- 4 Blood sample reports from labs to marriage licenses per day
- 1 Box of medical records from marriage license to records per week

The following load equivalent conversions can be used

- One medical record is equivalent to one certificate
- One medical record is equivalent to one-half of a blood sample
- One medical record is equivalent to one blood sample report
- One medical record is equivalent to one-tenth of a box of medical records

i) Develop a from-to chart [5]
ii) Develop a relationship chart [5]
iii) Suggest using pairwise switch the best arrangement of the layout. [5]

b) The Colour World Paint Company stores all its metal compressed gas containers in a warehouse. These long cylindrical metal tanks contain various gases used in manufacturing cans of spray paint. The gas tanks are delivered to the warehouse by truck. Two receiving dock workers unload the containers from the delivery trucks and place them on four wheel trucks. Two materials handlers are responsible for pushing the loaded trucks into the warehouse, unloading the tanks and setting them up on end. The two materials handlers spend a major portion of their day moving loads of the gas tanks into the warehouse and placing them into the proper storage locations. In total, there are five different types of gases that in equal proportion make up 98% of all gas handled.

Question: Management would like to identify a better way to handle these gas tanks. How can the handling operation be improved? [10]

**QUESTION 3**

a) Given that Limpopo Company has eight jobs with the following information given in Table 3.1

Table 3.1: Orders in Limpopo Company

| Job | Processing Times | Due dates |
|---|---|---|
| 1 | 13.2 | 4 |
| 2 | 1.8 | 4 |
| 3 | 1.6 | 8 |
| 4 | 7.7 | 8 |
| 5 | 12.1 | 8 |
| 6 | 10.2 | 12 |
| 7 | 2.2 | 12 |
| 8 | 8.0 | 12 |

i. Schedule the jobs to minimise average flowtime [2]
ii. Find the average flowtime for schedule obtained in (i) [4]
iii. Schedule the jobs to minimise maximum lateness. [2]
iv. Find the maximum lateness for the schedule in (iii) [2]

b) Schedule to minimise makespan the jobs given in Table 3.2 [2]

Table 3.2

| Job | Welding | Painting |
|---|---|---|
| 1 | 2 | 4 |
| 2 | 3 | 5 |
| 3 | 1 | 12 |
| 4 | 7 | 8 |
| 5 | 5 | 6 |
| 6 | 1 | 4 |
| 7 | 4 | 8 |

c) For the jobs given in Table 3.3, find the lowerbound of makespan. [3]

Table 3.3 Flowshop Processing times

| | Machine | | | |
|---|---|---|---|---|
| Job | 1 | 2 | 3 | 4 |
| 1 | 2.0 | 1.5 | 2.0 | 3.5 |
| 2 | 4.5 | 2.5 | 1.0 | 3.0 |
| 3 | 1.5 | 5.0 | 0.5 | 1.5 |
| 4 | 4.0 | 2.5 | 0.5 | 1.0 |

d) The scheduling method to get makespan may not give the best solution. Demonstrate, by writing an algorithm, how the scheduling algorithm in (b) can be integrated with the *simulated annealing* algorithm [10]

**QUESTION 4**

a) A Manufacturer of electric appliances desires an output of 367 units per 8 hours day. The line is stopped for a 20-minutes break in the middle of the afternoon. Manufacturing operations and their sequence for assembly are shown in Table 4.1. Group the assembly line activities into appropriate work stations and compute the balance delay using rank position weight method. [10]

Table 4.1: Element assembly time in minutes and their precedences

| **Task** | **Performance Time** | **Immediate Predecessor** |
|---|---|---|
| **1** | 0.17 | - |
| **2** | 0.4 | 1 |
| **3** | 0.5 | 1 |
| **4** | 1.2 | 1 |
| **5** | 0.3 | 2, 3 |
| **6** | 0.4 | 4 |
| **7** | 1.1 | 5 |
| **8** | 0.8 | 6 |
| **9** | 6.7 | 7, 8 |
| **10** | 0.3 | 9 |

b) Discuss briefly how Genetic Algorithms works and how it can be applied to line balancing. [15]

**QUESTION 5**

a) Explain briefly three types of flexibility [6]
b) Give two advantages and two disadvantages for one type of material handling systems. [4]
c) An assembly system uses kitting, assembly and inspection stations. There are three kitters, one automatic assembler and one inspector. Each worker is available 7.5hrs per day. Table 5.1 contains the set of jobs ready to be produced. To avoid leaving kits exposed, a job must be completed the same day it is started. Which kits should be made today? [15]

Table 5.1

| | | Processing Time (standard hours) | | |
|---|---|---|---|---|
| Job | Duedate | Kitting | Assembly | Inspection |
| 1 | 1 | 10.5 | 2.4 | 0.5 |
| 2 | 1 | 3.5 | 1.0 | 0.6 |
| 3 | 1 | 5.7 | 0.6 | 0.6 |
| 4 | 1 | 2.3 | 0.3 | 0.4 |
| 5 | 2 | 23.9 | 4.2 | 3.5 |
| 6 | 2 | 4.5 | 1.2 | 1.5 |
| 7 | 3 | 2.3 | 1.1 | 0.8 |
| 8 | 3 | 4.1 | 0.6 | 3.5 |
| 9 | 3 | 12.4 | 4.6 | 7.2 |
| 10 | 4 | 10.4 | 2.4 | 0.1 |
| 11 | 4 | 18.9 | 5.4 | 4.5 |

**QUESTION 6**

a) Customers arrive at an automated coffee-vending machine at a rate of four per minute, following a Poisson distribution. The coffee machine dispenses a cup of coffee at a constant rate of 10seconds.

i) What is the average number of people waiting in line? [3]

ii) What is the average number in the system? [4]

iii) How long does the average person wait in line before receiving service? [3]

b) At NUST barber shop there are four (4) barbers who work full-time and spend an average of 15 minutes on each customer. Customers arrive all day long at an average rate of 12 per hour. Arrivals tend to follow the Poisson distribution and service times are exponentially distributed.

i) What is the probability that the shop is empty? [2]
ii) What is the average number of customers in the barber shop? [3]
iii) What is the average time spent in the shop? [3]
iv) What is the average time that a customer waits to be called to the barber chair? [2]
v) What is the average number waiting to be served? [2]
vi) What is the shop's utilization factor? [3]

**QUESTION 7**

Consider the following matrix of eight parts and four machines shown in Table 7.1.

| | Components | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Machines | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| M1 | | 1 | 1 | | 1 | | 1 | 1 |
| M2 | 1 | 1 | | 1 | 1 | | | 1 |
| M3 | 1 | | | 1 | 1 | 1 | 1 | 1 |
| M4 | | 1 | | 1 | | 1 | | |

a) Determine similarity coefficients between all pairs of machines [10]
b) Use the single-linkage cluster analysis method and develop a dendrogram. [2]
c) Assuming that intercell moves cost five times intracell moves, determine the optimal cell configuration to minimize the total cost of inter and intracell material handling. [4]
d) Discuss the ways in which you can resolve the problem of exceptional elements and bottleneck machines. [2]
e) Using a single pass heuristic, group the Kango (Pvt) Ltd machines whose utilisation are shown in Table 7.2 such that there is no inter-group movement of work-parts. [5]

Table 7.2

| | Part | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| Machine | 2 | 1 | 5 | 3 | 6 | 7 | 4 | 8 | Utilization |
| A | 0.3 | 0.5 | 0.6 | | | | | | 1.4 |
| F | 0.3 | 0.4 | 0.2 | | | | | | 1.0 |
| C | 0.4 | | | 0.4 | 0.3 | 0.4 | | | 1.5 |
| E | | | | 0.9 | 0.2 | 0.4 | 0.1 | | 0.9 |
| B | | | | 0.4 | | | | 0.4 | 0.8 |
| D | | | | | | | 0.5 | 0.3 | 0.8 |

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 Exam**