## FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING
Masters in Engineering: Manufacturing Systems and Operations Management
Design, Analysis and Control of Manufacturing Systems - TIE 6111

## SUPPLEMENTARY EXAMINATIONS OCTOBER 2009

Time allowed: 3 hours
Instructions: Answer Total of Five (5), FOUR (4) questions, from each section A and Compulsory section B.

## SECTION A

## QUESTION 1

a) Given that NIM has eight jobs with the following information given in Table 1.1

Table 1.1: Orders in NIM

| Job | Processing <br> Times | Due dates |
| :--- | :--- | :--- |
| 1 | 13.4 | 24 |
| 2 | 2.4 | 24 |
| 3 | 1.8 | 48 |
| 4 | 7.9 | 48 |
| 5 | 12.3 | 48 |
| 6 | 10.5 | 72 |
| 7 | 2.4 | 72 |
| 8 | 8.1 | 72 |

i. Schedule the jobs to minimise average flowtime
ii. Find the average flowtime for schedule obtained in (i)
iii. Schedule the jobs to minimise maximum lateness.
iv. $\quad$ Find the maximum lateness for the schedule in (iii)
b) $\quad$ Schedule to minimise makespan the jobs given in Table 1.2

Table 1.2

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

c) For the jobs given in Table 1.3, find the lowerbound of makespan.

Table 1.3 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 |

c) Write a brief concise VB program that can be used to calculate the average Flowtime general sequencing rules like EDD.

## QUESTION 2

a) Tailwind produces high-quality but expensive training shoes for runners. The Tailwind shoe which sells for $\$ 110$, contains both gas- and liquid-filled compartments to provide more stability and better protection against knee, foot and back injuries. Manufacturing the shoes requires 10 separate tasks. How should these tasks be grouped into workstations? There are 400 minutes available for manufacturing the shoe in the plant each day. Daily demand is 60 .

Table 2.1: Element assembly time and their precedence

| Task | Performance <br> Time | Immediate <br> Predecessor |
| :---: | :---: | :---: |
| $\mathbf{1}$ | 1 | - |
| $\mathbf{2}$ | 3 | 1 |
| $\mathbf{3}$ | 2 | 2 |
| $\mathbf{4}$ | 4 | 2 |
| $\mathbf{5}$ | 1 | 3,4 |
| $\mathbf{6}$ | 3 | 1 |
| $\mathbf{7}$ | 2 | 6 |
| $\mathbf{8}$ | 5 | 7 |
| $\mathbf{9}$ | 1 | 5,8 |
| $\mathbf{1 0}$ | 3 | 9 |

b) Discuss two principles of material handling and give examples as applicable to company of your choice.
c) Discuss two categories of Conveyor belts.

## QUESTION 3

a) Explain briefly one type of tool allocation policy in flexible manufacturing system and how applicable to is to a Zimbabwe situation. types to be produced in the cell. All parts are currently purchased. The cell will perform only boring and turning operations. Tools will be kept at the machines. A robot will be used for changing tools and loading and unloading of parts. Machine operations are time consuming compared with tool changes and part moves; hence the changing of tools and utilization of the robot should not be a problem. All units of a part must be acquired by the same alternative. The set of potential part types is shown in Table 3.1.
i) Suppose boring machines are inexpensive and we can buy as many as we need. The turning centre however is expensive and only 600 time units are available per period. Order parts based on their savings per unit of resource consumed and using a greedy heuristic, recommend a set of parts to manufacture in the cell

Table 3.1: Parts Data

| Part | Demand/Period | Tuning <br> (time/part) | Boring <br> (time/part) | Purchase <br> (cost/part) | Variable <br> Machining <br> (cost/part) |
| :---: | :---: | :--- | :--- | :--- | :--- |
| A | 4 | 20 | 15 | 100 | 35 |
| B | 3 | 35 | 10 | 125 | 45 |
| C | 2 | 40 | 50 | 250 | 90 |
| D | 5 | 10 | 60 | 165 | 70 |
| E | 2 | 55 | 25 | 110 | 80 |
| F | 5 | 75 | 65 | 300 | 140 |
| G | 8 | 15 | 55 | 215 | 70 |

## QUESTION 4

a) Explain with examples one question that have to be kept in mind through the design process of a material handling system.
b) An existing FMS has 20 hrs per week of unused capacity. Six part types are being considered for FMS production. These parts are currently purchased at costs of (100, $50,75,84,95,165$ ) dollars respectively. Each product is expected to be in production two more years with annual demand rate of ( $100,300,1000,500,500,250$ ). Horizontal machining centers are the most limited resources on the FMS. HMC hours per unit for the contemplated part type are (2.0, 3.5, $2.5,1.0,1.4,2.2$ ) respectively. If produced on the FMS parts are expected to cost $(95,40,60$, $70,75,1250$ ) dollars
i) Suppose the FMS is to be fully utilized. Parts may be partially made in-house and remaining units purchased. Which parts should be added to the FMS?
ii) What is the cost savings?

## QUESTION 5

a) A job shop has three types of machines: two mills, two drilling presses and one surface grinder. Orders arrive at the shop at a rate of 2 per day. About $60 \%$ of these go to milling first and $40 \%$ start at drilling. Half of the drilling jobs go to milling next, $30 \%$ go to grinding next and the rest leave the system. $30 \%$ of jobs being milled go to grinding and the other leave the shop. Jobs always leave the shop after grinding. Operation times are exponential distributed, averaging one day per job for each of milling, drilling and grinding. Find the average number of jobs in the system.
b) NUST Barber shop has four barbers who spend an average of 15 minutes on each customer. Customer arrive all day at an average of 12 per hour. Arrivals tend to follow the Poisson distribution and service times are exponential distributed.
i) What is the probability that the shop is empty?
ii) What is the average number of customers in the barber shop?
iii) What is the average time spent in the shop?
iv) What is the average number waiting to be served?
v) What is the average time in the queue?

## QUESTION 6

a) Describe the unit load concept in material handling.
b) Discuss briefly any two main questions to be considered in a specific checklist for material handling systems.
c) Discuss the cost issues to be considered I material handling.

## SECTION B

QUESTION 7
The pre-induction physical examination given by the Army involves the following seven activities as shown in Table 7.1.

Table 7.1 Activity and average times

| Activity | Average Time (min) |
| :--- | :--- |
| Medical history | 10 |
| Blood tests | 8 |
| Eye examination (weight, height, blood | 5 |
| Measurements <br> pressure) | 7 |
| Medical Examination | 16 |
| Psychological interview | 12 |
| Exit Medical evaluation | 10 |

These activities can be performed in any order, with two exceptions: The medical history must be taken first and the exit medial evaluation is the final step. At present three paramedics and two physicians are on duty during each shift. Only a physician can perform the exist evaluation or conduct the psychological interview. Other activities can be carried out by either physicians or paramedics.
a) Develop a line balance of the line.
b) Develop a layout.
c) How many people can be processed per hour?
d) What activity is the current bottleneck?

| Table A.1: M/M/C Queueing Results |  |  |
| :--- | :--- | :--- |
|  | $\mathrm{M} / \mathrm{M} / 1$ | $\mathrm{M} / \mathrm{M} / \mathrm{C}$ |
| L | $L_{s}=\frac{\lambda}{\mu-\lambda}$ | $L_{q}+\frac{\lambda}{\mu}$ |
| $\mathrm{L}_{\mathrm{q}}$ | $L_{q}=\frac{\lambda^{2}}{\mu(\mu-\lambda)}$ | $\frac{\rho(c \rho)^{c} p(o)}{c!(1-\rho)^{2}}$ |
| $\mathrm{~W}_{\mathrm{q}}$ | $\mathrm{W}_{q}=\frac{\lambda}{\mu(\mu-\lambda)}$ | $\frac{(c \rho)^{c} p(o)}{c!c \mu(1-\rho)^{2}}$ |
| W | $W_{s}=\frac{1}{\mu-\lambda}$ | $W_{q}+\mu^{-1}$ |
| $\mathrm{P}(\mathrm{o})$ | $P_{o}=1-\frac{\lambda}{\mu}$ | $\left[\frac{(c \rho)^{c}}{c!(1-\rho)}+\sum_{n-o}^{c-1} \frac{(c \rho)^{n}}{n!}\right]^{-1}$ |
|  | $\rho=\frac{\lambda}{\mu}$ |  |

End of Exam

