UNIVERSITY
OF
JOHANNESBURG

PROGRAM	:	BACHELOR OF TECHNOLOGY *ENGINEERING : INDUSTRIAL*
SUBJECT	:	**PRODUCTION TECHNOLOGY IV**
CODE	:	**IPT411**
DATE	:	WINTER EXAMINATION 7 JUNE 2016
DURATION	:	(SESSION 2) 12:30 - 15:30
WEIGHT	:	40 : 60
TOTAL MARKS	:	100

ASSESSOR	:	F CHIROMO
MODERATOR	:	K SITHOLE
NUMBER OF PAGES	:	6 PAGES + ANNEXURE

INSTRUCTIONS TO STUDENTS:

- ANSWER ALL QUESTIONS.
- A STUDENT IS EXPECTED TO MAKE REASONABLE ASSUMPTIONS FOR DATA NOT SUPPLIED.
- NUMBER YOUR QUESTIONS CLEARLY AND UNDERLINE THE FINAL ANSWER.
- ANSWERS WITHOUT UNITS WILL BE IGNORED.

QUESTION 1

1.1   Discuss the benefits associated with the appliaction of automated
       production lines.   (10)

1.2   Discuss the common system configurations for automated production
       lines.   (6)

1.3   A transfer machine has six stations that function as given in Table Q1:

       Table Q1

Station	Operation	Process Time	p_i
1	Load part	0.78 min	0
2	Drill three holes	1.25 min	0.02
3	Ream two holes	0.90 min	0.01
4	Tap two holes	0.85 min	0.04
5	Mill flats	1.32 min	0.01
6	Unload parts	0.45 min	0

       In addition, transfer time is 0.18 min, and the average downtime per
       occurrence is 8 min. A total of 20 000 parts must be processed through
       the transfer machine. Determine:

1.3.1 ideal cycle time;   (2)
1.3.2 proportion downtime;   (2)
1.3.3 average actual production time; and   (2)
1.3.4 number of hours of operation that are required to produce the 20 000
       parts.   (2)
                                                                              [24]

QUESTION 2

2.1   Discuss the characteristics of:
2.1.1 multi-station automated assembly line;   (8)
2.1.2 single-station automated assembly line.   (4)
2.2   A manual assembly line has six stations. The assembly time at each
       manual station is 60 seconds. Parts are transferred by hand from one
       station to the next, and the lack of discipline in this method adds 12
       seconds (T_r = 12 seconds) to the cycle time. Hence, the current cycle
       time is 72 seconds. The folloring two proposals have been made: (1)
       install a mechanized transfer system to pace the line ; and (2)
       automate one or more of the manual stations using robots that would
       perform the same tasks as humans only faster. The second proposal
       requires the mechanized transfer system of the first proposal and
       would result in a partially or fully automated assembly line. The
       transfer system would have a transfer time of 6 seconds, thus reducing
       the cycle time on the manual line to 66 seconds. Regarding the second
       proposal, all six stations are candidates for automation. Each

(Question 2 – continued)

automated station would have an assembly time of 30 seconds. Thus if all six stations were automated the cycle time for the line would be 36 seconds. There are differences in the quality of parts added at the stations; these data are given in Table Q2. For each station (q = fraction defect rate, m = probability that a defect will jam the station). Average downtime per station jam at the automated stations is 3.0 min. Assume that the manual stations do not experience line stops due to defective components. Cost data: C_{at} = R0.10/min; C_w = R0.20/min ; and C_{as} = R0.15/min.

2.2.1   Determine if either or both of the proposals should be accepted.   (2)

2.2.2   If the second proposal is accepted, how many stations should be automated and which ones?   (4)

Use cost per piece as the criterion of your decision. Assume for all cases considered that the line operates without storage buffers. So when an automated station stops, the whole line stops, including the manual stations.

Table Q2

Station	q_i	m_i	Station	q_i	m_i
1	0.005	1.0	4	0.020	1.0
2	0.010	1.0	5	0.025	1.0
3	0.015	1.0	6	0.030	1.0

[18]

QUESTION 3

3.1   Explain how non-constant inspection would benefit a manufacturing company.   (6)

3.2   A solid state camera has 512 x 512 picture elements. All pixels are converted sequentially by an analog to digital converter (ADC) and read into the frame buffer for processing. The machine vision system will operate at the rate of 30 frames per second. However, in order to allow time for data processing of the contents of the frame buffer, analog-to-digital conversion of all pixels by the ADC must be completed in 1/80 seconds. Assuming that 10 nanoseconds (10×10^{-9} seconds) are lost in switching from one pixel to the next, determine the time required to carry out the analog-to digital conversion process for each pixel, in nanoseconds.   (6)

[12]

QUESTION 4

4.1   The manufacture of products consists of four types of processes or operations which include; basic processes, secondary processes, property enhancing and finishing operations. Explain the four processes and use a real life example to describe a typical sequence for a manufactured product which undergoes the four processes.   (8)

4.2   Discuss what you understand by the term 'computer integrated manufacturing'.   (4)

[12]

QUESTION 5

5.1   Discuss activities associated with production planning.   (10)

5.2   A batch of large castings is processed through a machine shop. The batch size is 20. Each raw castings costs R175. There are 22 machining operations performed on each casting at an average operation time of 0.5 hour per operation. Setup time per operation averages 5 hours. The cost rate for the machine and labour is R40 per hour. Nonoperation costs (inspection, handling between operations, etc.) average R5 per operation per part. The corresponding nonoperation time between each operation averages two working days. The shop works five 8-hour days per week, 52 weeks per year. Interest rate used by the company is 25% for investing in work in progress (WIP) inventory, and storage cost rate is 14% of the value of the item held. Both of these rates are annual rates. Determine the following:

5.2.1   manufacturing lead time for the batch of casting;   (2)

5.2.2   total cost to the shop of each casting when it is completed, including the holding cost; and   (4)

5.2.3   total holding cost of the batch for the time it spends as work-in-progress.   (2)

[18]

QUESTION 6

6.1   Discuss how worker involvement assists in eliminating waste.   (12)

6.2   The monthly demand for a part produced for an automaotive final assembly plant is 16 000 units. There are 20 working days in February and the effective operating time o the plant is 900 min per day (two shifts). The fraction defect rate for the component is 0.017, and the automated machine that produces the part has an availability of 96%. Determine the takt time for this part.   (4)

[16]

TOTAL = 100

ANNEXURE

FORMULA SHEET

$$T_p = T_c + FT_d; \qquad F = \sum_{i=1}^{n} p_i; \qquad F = np$$

$$R_p = \frac{1}{T_p}; \qquad R_c = \frac{1}{T_c}; \qquad E = \frac{T_c}{T_p} = \frac{T_c}{T_c + FT_d}; \qquad T_r = \frac{(180-\theta)}{360N}$$

$$C_{pc} = C_m + C_o T_p + C_t; \qquad \theta = \frac{360}{n_s}; \qquad T_c = \frac{1}{N}; \qquad T_s = \frac{(180+\theta)}{360N}$$

$$T_c = Max\{T_{si}\} + T_r; \qquad D = \frac{FT_d}{T_p} = \frac{FT_d}{T_c + FT_d}; \quad E + D = 1.0$$

$$E_k = \frac{T_c}{T_c + F_k T_{dk}}; \qquad E_b = E_o + D_1' h(b) E_2; \qquad E_o = \frac{T_c}{T_c + (F_1 + F_2)T_d}$$

$$D_1' = \frac{F_1 T_d}{T_c + (F_1 + F_2)T_d}; \qquad r = \frac{F_1}{F_2}; \qquad b = B\frac{T_d}{T_c} + L$$

$$E_\infty = Minimum\{E_k\} for \ k = 1, 2, \ldots\ldots\ldots\ldots, K; \qquad E_0 \langle \ E_b \ \langle \ E_\infty$$

Constant Downtime:

$$When \ r = 1.0, \ then \ h(b) = \frac{B}{B+1} + L\frac{T_c}{T_d}\frac{1}{(B+1)(B+2)}$$

$$When \ r \neq 1.0, \ then \ h(b) = r\frac{1-r^B}{1-r^{B+1}} + L\frac{T_c}{T_d}\frac{r^{B+1}(1-r)^2}{(1-r^{B+1})(1-r^{B+2})}$$

Geometric Downtime:

$$When \ r = 1.0, \ then \ h(b) \quad \frac{b\dfrac{T_c}{T_d}}{2 + (b-1)\dfrac{T_c}{T_d}};$$

$$\text{When } r \neq 1.0 \text{ Define } K = \frac{1 + r - \dfrac{T_c}{T_d}}{1 + r - r\dfrac{T_c}{T_d}} \quad \text{then } h(b) = \frac{r(1 - K^b)}{1 - rK^b}$$

$$T_c = T_h + \sum_{j=1}^{n_e} T_{ej}; \qquad T_p = T_c + \sum_{j=1}^{n_e} q_j m_j T_d; \qquad T_p = T_c + nmqT_d$$

$$m_i q_i + (1 - m_i)q_i + (1 - q_i) = 1; \qquad mq + (1 - m)q + (1 - q) = 1$$

$$\prod_{i=1}^{n} [m_i q_i + (1 - m_i)q_i + (1 - q_i)] = 1; \qquad [mq + (1 - m)q + (1 - q)]^n = 1$$

$$T_p = T_c + \sum_{i \in n_a} p_i T_d; \qquad p_i = m_i q_i; \qquad T_p = T_c + n_a p T_d$$

$$C_o = C_{at} + \sum_{i \in n_a} C_{asi} + \sum_{i \in n_w} C_{wi}; \quad C_o = C_{at} + n_a C_{as} + n_w C_w$$

$$C_{pc} = \frac{C_m + C_o T_p + C_t}{P_{ap}}; \qquad P_{ap} = \prod_{i=1}^{n} (1 - q_i + m_i q_i);$$

$$R_{ap} = P_{ap} R_p = \frac{P_{ap}}{T_p} = \frac{\displaystyle\prod_{i=1}^{n} (1 - q_i + m_i q_i)}{T_p};$$

$$R_{ap} = P_{ap} R_p = \frac{P_{ap}}{T_p} = \frac{(1 - q + mq)^n}{T_p}; \qquad C_{pc} = \frac{C_m + C_o T_p + C_t}{P_{ap}}$$

$$T_c = T_h + \sum_{j=1}^{n_e} T_{ej};$$

$$T_p + T_c + \sum_{j=1}^{n_e} q_i m_j T_d;$$

$$T_p = T_c + nmq T_d;$$

$$T_p = T_c + \sum_{i \in n_a} p_i T_d;$$

$$T_p = T_c + n_a p T_d;$$

$$C_o = C_{at} + \sum_{i \in n_a} C_{asi} + \sum_{i \in n_w} C_{wi};$$

$$C_o = C_{at} + n_a C_{as} + n_w C_w;$$

$$C_{pc} = \frac{C_m + C_o T_p + C_t}{P_{ap}};$$

$$Q = Q_o(1-q);$$

$$D = Q_o q;$$

$$Q_f = Q_o \prod_{i=1}^{n}(1-q)$$

$$Q_f = Q_o(1-q)^n;$$

$$D_f \ Q_o \ Q_f;$$

$$\prod_{i=1}^{n}(p_i + q_i) = 1;$$

$$C_b = Q_o \sum_{i=1}^{n} C_{pri} + Q_o C_{sf} = Q_o\left(\sum_{i=1}^{n} C_{pri} + C_{sf}\right);$$

$$C_b = Q_o(nC_{pr} + C_{sf})$$

$$C_b = Q_o(C_{pr1} + C_{s1}) + Q_o(1-q_1)(C_{pr2} + C_{s2}) + Q_o(1-q_1)(1-q_2)(C_{pr3} + C_{s3}) + \ldots\ldots + Q_o \prod_{i=1}^{n-1}(1-q)(C_{prn} + C_{si})$$

$$C_b = Q_o\left(1 + (1-q) + (1-q)^2 + \ldots\ldots\ldots + (1-q)^{n-1}\right)(C_{pr} + C_s)$$

$$C_{sf} = \sum_{i=1}^{n} C_{si};$$

$$C_{sf} = nC_s$$

$$C_b(100\% \, inspection) = QC_s;$$

$$C_b(no \ inspection) = QqC_d$$

$$C_b(sampling) = C_s Q_s + (Q - Q_s)qC_d P_a + (Q - Q_s)C_s(1 - P_a)$$

$$q_c = \frac{C_s}{C_d}$$

$$C_b = Q_o\left(\sum_{i=1}^{n} C_{pri} + C_{sn}\right) + Q_o \prod_{i=1}^{n}(1-q_i)\left(\sum_{i=1+n}^{2n} C_{pri} C_{s(2n)}\right) + \ldots\ldots\ldots\ldots$$

$$C_b = Q_o(nC_{pr} + C_{s(n)}) + Q_o(1-q)^n(5C_{pr} + C_{s(2n)}) + \ldots\ldots\ldots\ldots$$

$$n_o = 2^B; \qquad MR = \frac{L}{n_o - 1} = \frac{L}{2^B - 1}$$

$$L = \pm\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}; \qquad L = \pm\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$$

$$(x - a)^2 + (y - b)^2 = R^2; \qquad (x - a)^2 + (y - b)^2 + (z - c)^2 = R^2$$

$$x + Ay + B = 0; \qquad y = mx + b$$

$$x + Ay + Bz + C = 0$$

$$R_a = \int_0^L \frac{|y|}{L}dx; \qquad R_a = \frac{\sum_{i=1}^n |y_i|}{n};$$

$$R = L\cot A$$

$$TIC = \frac{C_h Q}{2} + \frac{C_{su} D_a}{Q}; \qquad C_h = hC_{pc}; \qquad C_{su} = T_{su}C_{dt}$$

$$TC = D_a C_{pc} + \frac{C_h Q}{2} + \frac{C_{su} D_a}{Q}; \qquad Q = EOQ = \sqrt{\frac{2D_a C_{su}}{C_h}}$$

$$C_{pc} = C_m + n_o(C_o T_p + C_{no}); \qquad C_p = n_o(C_o T_p + C_{no})$$

$$TC_{pc} = C_m + C_p + \int_0^{MLT}\left(C_m + \frac{C_p t}{MLT}\right)hdt; \qquad TC_{pc} = C_m + C_p + \left(C_m + \frac{C_p}{2}\right)h(MLT)$$

$$Holding\ cost/pc = \left(C_m + \frac{C_p}{2}\right)h(MLT)$$

$$Y = 1 - q; \qquad OEE = AUYr_{os}; \qquad T_{takt} = \frac{EOT}{Q_{dd}}$$