UNIVERSITY OF JOHANNESBURG

PROGRAM : BACHELOR OF TECHNOLOGY ENGINEERING : INDUSTRIAL

SUBJECT : **PRODUCTION TECHNOLOGY IV**

CODE : **IPT411**

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WEIGHT : 40 : 60

TOTAL MARKS : 100

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NUMBER OF PAGES : 4 PAGES + 1 ANNEXURE

INSTRUCTIONS :

- 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.

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QUESTION 1

1.1 State and explain the three types of motion that characterize workpart transfer mechanism in automated production lines. (3)

1.2 Discuss how maximum possible efficiency is achieved in the operation of multi-stage automated lines. (4)

1.3 Explain how the "law of diminishing returns" operate in multi-stage automated lines. (4)

1.4 An eight-station rotary indexing machine performs the machining operations shown in Table Q1. Details of the processing times and breakdown frequencies for each station are also included in the table. The transfer time for the machine is 0.15 minutes per cycle. A study of the system was undertaken, during which 2000 parts were completed. It was determined in this study that when breakdowns occur, it takes an average of 0.7 min to make repairs and get the system operating again.

Table Q1

Station	Process	Process Time (min)	Breakdowns
1	Load part	0.50 min	0
2	Mill top	0.85 min	22
3	Mill sides	1.10 min	31
4	Drill two holes	0.60 min	47
5	Ream two holes	0.43 min	8
6	Drill six holes	0.92 min	58
7	Tap six holes	0.75 min	84
8	Upload part	0.40 min	0

For the study period, determine:

1.4.1 the ideal cycle time; (1)

1.4.2 the actual average production time; (2)

1.4.3 the average actual production rate; (1)

1.4.4 the line uptime efficiency; (1)

1.4.5 the number of hours required to produce the 2000 parts. (2)

[18]

QUESTION 2

2.1 Discuss the conditions under which automated assembly technology should be considered for implementation. (4)

2.2 A single station robotic assembly system performs a series of five assembly elements, each of which adds a different component to a base part. Each element takes 4.5 seconds. In addition, the handling time needed to move the base part into and out of position is 4 seconds. For identification, the components, as well as the elements that assemble them, are numbered 1, 2, 3, 4, and 5. The fraction defect rate is 0.005 for all components, and the probability of a jam by a defective component is 0.7. The average downtime per occurrence is 2.5 minutes. Determine:

(Question 2 – Continued)

2.2.1 the production rate; (3)
2.2.2 the yield of good product in the output; (3)
2.2.3 the uptime efficiency; (2)
2.2.4 the proportion of the output that contains a defective type 3 component. (2)
[14]

QUESTION 3

3.1 Discuss any four characteristics of potential applications for which CMMs are most appropriate. (4)
3.2 Discuss the problems associated with 100% manual inspection. (6)
3.3 A batch of 1000 parts has been produced and a decision is needed whether to 100% inspect the batch or not. Past history with this part suggests that the fraction defect rate is around 0.02. Inspection cost per part is $0.20. If the batch is passed on for subsequent processing, the damage cost for each defective unit in the batch is $8.00. Determine:
3.3.1 the batch cost for 100% inspection; (1)
3.3.2 the batch cost if no inspection is performed; (1)
3.3.3 the critical fraction defect value for deciding whether to inspect. (2)
[14]

QUESTION 4

4.1 The manufacture of products consists of four types of processes or operations which include basic process, secondary processes, property enhancing and finishing operations. Explain the four processes and use a real life example to describe a typical process sequence for a manufactured product which undergoes the four processes. (8)
4.2 Compare and contrast retrieval CAPP and generative CAPP approaches in Computer-aided process planning (6)
4.3 A high-resolution solid state camera is to have a 1040 x 1392 pixel matrix. An image processing rate of 30 times per second must be achieved, or 0.0333 sec per frame. To allow for time lost in other data processing per frame, the total analog-to-digital time per frame must be 80% of the 0.0333 seconds or 0.0267 seconds. In order to be compatible with this speed, in what time period must the analog-to-digital conversion be accomplished per pixel? (4)
[18]

QUESTION 5

5.1 Capacity adjustments can be divided into short-term adjustments and long-term adjustments. Discuss four of the capacity adjustments for the short term. (8)

5.2 Discuss what enterprise resource planning entails. (4)

5.3 A workpart costing R80 is processed through the factory. The manufacturing lead time for the part is 12 weeks, and the total time spent in processing during the lead time is 30 hours for all operations at a rate of R35 per hour. Non-operation costs total R70 during the lead time. The holding cost rate used by the company for work-in-process is 26%. The plant operates 40 hours per week, 52 weeks per year. If this part is typical of the 200 parts per week processed through the factory, determine the following:

5.3.1 the holding cost per part during the manufacturing lead time; (1)

5.3.2 the total annual holding costs to the factory. (1)

5.4 If the manufacturing lead time were to be reduced from 12 weeks to 8 weeks, determine the new total holding costs on an annual basis. (2)

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QUESTION 6

6.1 Discuss any three reasons why people and materials are sometimes moved unnecessarily in production operations. (6)

6.2 Discuss basic approaches used to attain production levelling. (8)

6.3 The following data apply to sheet metal parts produced at a stamping plant that serves a final assembly plant in the automotive industry. The data are average values representative of the parts made at the plant. Annual demand is 150 000 pieces (for each part produced); average cost per piece = \$20; holding cost = 25%, changeover (setup) time for the presses = 5 hours; cost of downtime on any given press = \$200/hr.

6.3.1 Compute the economic batch size and the total annual inventory cost for the data. (3)

6.3.2 If the changeover time could be reduced to 30 min, compute the economic batch size and the total annual inventory cost. (3)

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TOTAL = 100

ANNEXURE

FORMULA SHEET

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

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

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

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

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

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

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

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:

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

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

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

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

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

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

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

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

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

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

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

$$T_p = T_c + \sum_{i \in n_a} p_i T_d; \qquad T_p = T_c + n_a p T_d; \qquad C_o = C_{at} + \sum_{i \in n_a} C_{asi} + \sum_{i \in n_w} C_{wi};$$

$$C_o = C_{at} + n_a C_{as} + n_w C_w; \qquad C_{pc} = \frac{C_m + C_o T_p + C_t}{P_{ap}};$$

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

$Q_f = Q_o\,(1-q)^n;$ $D_f\ Q_o\ Q_f;$ $\prod_{i=1}^{n}(p_i + q_i) = 1;$

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

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

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

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

$C_b\,(100\%\,inspection) = QC_s;$ $C_b(no\ inspection) = QqC_d$

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

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

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

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

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

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

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

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

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

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

$$R = L\cot A$$

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

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

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

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

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

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