UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACHELOR OF TECHNOLOGY *ENGINEERING : INDUSTRIAL*
SUBJECT	:	**PRODUCTION TECHNOLOGY IV**
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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

The uptime efficiency of a 30 station automated production line is only 50%. The ideal cycle time is 50 seconds, and the average downtime per line stop occurrence is 4.0 minutes. Assume the frequency of breakdowns for all stations is equal ($p_i = p$ for all stations) and that the downtime is constant. To improve uptime efficiency, it is proposed to install a storage with a 20-part capacity for R21 000. The present production cost is R6.00 per unit. Ignoring material and tooling costs, determine the number of units that would have to be produced in order for the R21 000 investment to pay for itself.

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QUESTION 2

A single-station assembly machine performs five work elements to assemble four components to a base part. The elements are listed in Table Q2, together with the fraction defect rate (q) and probability of a station jam (m) for each of the components added (NA means not applicable).

Table Q2

Element	Operation	Time	q	m	p
1	Add gear	4	0.02	1.0	
2	Add spacer	3	0.01	0.6	
3	Add gear	4	0.015	0.8	
4	Add gear and mesh	7	0.02	1.0	
5	Fasten	5	0	NA	0.012

Time to load the base part is 3 seconds and time to unload the completed assembly is 4 seconds, giving a total load/unload time of $T_h = 7$ seconds. When a jam occurs, it takes an average of 1.5 minutes to clear the jam and restart the machine. Determine:

2.1 production rate of all product; (5)
2.2 yield of good product; (3)
2.3 production rate of good product; and (2)
2.4 uptime efficiency of the assembly machine. (2)

[12]

QUESTION 3

A certain component is produced in three sequential opetations. Operation 1 produces defects at a rate $q_1 = 5\%$. Operation 2 produces defects at a rate $q_2 = 8\%$. Operation 3 produces defects at a rate $q_3 = 10\%$. Operations 2 and 3 can be performed on units that are already defective. If 10 000 starting parts are processed through the sequence, determine:

(Question 3 – continued)

3.1 the number of units that are expected to be defect-free; (3)

3.2 the number of units that are expected to have exactly one defect; and (4)

3.3 the number of units that are expected to have all three defects. (3)

[10]

QUESTION 4

The coordinates of the intersection of two lines are to be determined using a coordinate measuring machine (CMM) to define the equations for the two lines. The two lines are the edges of a machined part, and the intersetion represents the corner where the two edges meet. Both lines lie in the x-y plane. Measurements are in millimetres. Two points are measured on the first line to have coordinates of (5.254, 10.430) and (10.223, 6.052). The two points are measured on the second line to have coordinates of (6.101, 0.657) and (8.970, 3.824). The coordinate values have been corrected for probe radius.

4.1 Determine the equations for the two lines in the form $x + Ay + B = 0$. (14)

4.2 Determine the coordinates of the intersection of the two lines. (5)

4.3 The edges represented by the two lines are specified to be perpendicular to each other. Calculate the angle between the two lines to determine if the edges are perpendicular. (5)

[24]

QUESTION 5

An injection-moulding machine used to produce 25 different plastic moulded parts in a typical year. Annual demand for a typical part is 30 000 units. Each part is made out of a different plastic (the differences are in type of plastic and colour) Because of the differences, changeover time between parts is significant,averaging 6 hours to (1) change moulds and (2) purge the previous plastic from the injection barrel. One setup person normaly does these two activities sequentially. A proposal has been made to separate the tasks and use two setup persons working simultaneously. In that case, the mould can be changed in 1.5 hours and purging takes 4.5 hours. Thus, the total downtime per changeover will be reduced to 4.5 hours from the previous 6 hours. Downtime on the injection-moulding machine is R200/hr. Labour cost for setup time is R20/hr. Average cost of a plastic moulded part is R2.50, and holding cost is 24% annually. For the 5-hour setup, determine:

5.1 the economic batch quantity; (4)

5.2 the total number of hours per year that the injection-moulding machine is down for changeovers; and (3)

5.3 the annual inventory cost; (3)

(Question 5 – continued)
For the 3.5 hour setup, determine:

5.4 the economic batch quantity; (4)
5.5 the total number of hours per year that the injection-moulding machine is down for changeovers; and (3)
5.6 the annual inventory cost. (3)
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QUESTION 6

6.1 Explain your understanding of computer-aided design. (4)
6.2 Explain factors the influence the make-or-buy decision. (8)
[12]

TOTAL = 100

ANNEXURE

FORMULA SHEET

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

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

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

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

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

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

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

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:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$R = L \cot A$$

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

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

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

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

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

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