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

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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.

2/...
QUESTION 1

1.1 Discuss the benefits associated with the application of automated production lines.

1.2 Discuss the common system configurations for automated production lines.

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

<table>
<thead>
<tr>
<th>Station</th>
<th>Operation</th>
<th>Process Time</th>
<th>( p_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Load part</td>
<td>0.78 min</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Drill three holes</td>
<td>1.25 min</td>
<td>0.02</td>
</tr>
<tr>
<td>3</td>
<td>Ream two holes</td>
<td>0.90 min</td>
<td>0.01</td>
</tr>
<tr>
<td>4</td>
<td>Tap two holes</td>
<td>0.85 min</td>
<td>0.04</td>
</tr>
<tr>
<td>5</td>
<td>Mill flats</td>
<td>1.32 min</td>
<td>0.01</td>
</tr>
<tr>
<td>6</td>
<td>Unload parts</td>
<td>0.45 min</td>
<td>0</td>
</tr>
</tbody>
</table>

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;
1.3.2 proportion downtime;
1.3.3 average actual production time; and
1.3.4 number of hours of operation that are required to produce the 20 000 parts.

QUESTION 2

2.1 Discuss the characteristics of:

2.1.1 multi-station automated assembly line;

2.1.2 single-station automated assembly line.

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 \( (T_r = 12 \text{ seconds}) \) to the cycle time. Hence, the current cycle time is 72 seconds. The following 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 \(q = \text{fraction defect rate, } m = \text{probability that a defect will jam the station}\). 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: \(C_{at} = \text{R0.10/min}; C_w = \text{R0.20/min}; \) and \(C_{as} = \text{R0.15/min}\.\)

\[ \begin{align*}
2.2.1 & \text{ Determine if either or both of the proposals should be accepted.} \\
2.2.2 & \text{ If the second proposal is accepted, how many stations should be automated and which ones?}
\end{align*} \]

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.

\[
\begin{array}{|c|c|c|c|c|c|}
\hline
\text{Station} & q_i & m_i & \text{Station} & q_i & m_i \\
\hline
1 & 0.005 & 1.0 & 4 & 0.020 & 1.0 \\
2 & 0.010 & 1.0 & 5 & 0.025 & 1.0 \\
3 & 0.015 & 1.0 & 6 & 0.030 & 1.0 \\
\hline
\end{array}
\]

[18]

QUESTION 3

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

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 \(10 \times 10^{-9}\) 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.

[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)

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 casting 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.

6.2 The monthly demand for a part produced for an automotive final assembly plant is 16,000 units. There are 20 working days in February and the effective operating time of 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.

TOTAL = 100
ANNEXURE

FORMULA SHEET

\[ T_p = T_c + FT_d; \]
\[ F = \sum_{i=1}^{n} P_i; \quad F = np \]
\[ R_p = \frac{1}{T_p}; \quad R_c = \frac{1}{T_c}; \quad E = \frac{T_c}{T_p} = \frac{T_c}{T_c + FT_d}; \quad T_r = \frac{(180 - \theta)}{360N} \]
\[ C_{pc} = C_m + C_o T_p + C_i; \quad \theta = \frac{360}{n_s}; \quad T_c = \frac{1}{N}; \quad T_s = \frac{(180 + \theta)}{360N} \]
\[ T_c = \text{Max}\{T_{sl}\} + T_r; \quad D = \frac{FT_d}{T_p} = \frac{FT_d}{T_c + FT_d}; \quad E + D = 1.0 \]
\[ E_k = \frac{T_c}{T_c + F_k T_{dk}}; \quad E_b = E_o + D_1 h(b) E_2; \quad E_o = \frac{T_c}{T_c + (F_1 + F_2) T_d} \]
\[ D_1 = \frac{F_1 T_d}{T_c + (F_1 + F_2) T_d}; \quad r = \frac{F_1}{F_2}; \quad b = B \frac{T_d}{T_c} + L \]
\[ E_o = \text{Minimum}\{E_k\} \text{ for } k = 1, 2, \ldots, K; \quad E_0 < E_b < E_o \]

Constant Downtime:

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

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

Geometric Downtime:

When \( r = 1.0 \), then \( h(b) = \frac{b - 1}{2 + (b - 1) \frac{T_c}{T_d}} \)
When \( r \neq 1.0 \) Define \( K = \frac{1 + r - \frac{T_c}{T_d}}{1 + r - \frac{T_c}{T_d}} \) then \( h(b) = \frac{r(1 - K^b)}{1 - rK^b} \)

\[
T_c = T_h + \sum_{j=1}^{n_r} T_{cj}; \quad T_p = T_c + \sum_{j=1}^{n_r} q_j m_j T_d; \quad T_p = T_c + n mq T_d
\]

\[
m q_i + (1 - m_i) q_i + (1 - q_i) = 1; \quad mq + (1 - m) q + (1 - q) = 1
\]

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

\[
T_p = T_c + \sum_{i \in n_s} p_i T_d; \quad p_i = m_i q_i; \quad T_p = T_c + n_a p T_d
\]

\[
C_o = C_{at} + \sum_{i \in n_a} C_{ati} + \sum_{i \in n_w} C_{wi}; \quad C_o = C_{at} + n_a C_{ati} + n_w C_{wi}
\]

\[
C_{pc} = \frac{C_m + C_o T_p + C_t}{P_{ap}}; \quad P_{ap} = \prod_{i=1}^{a} (1 - q_i + m_i q_i);
\]

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

\[
R_{ap} = P_{ap} R_p = \frac{P_{ap}}{T_p} = \frac{(1 - q + mq)^n}{T_p}; \quad C_{pc} = \frac{C_m + C_o T_p + C_t}{P_{ap}}
\]
\[ T_c = T_h + \sum_{j=1}^{n_u} T_{q_j}; \quad T_p + T_c + \sum_{j=1}^{n_u} q_j m_j T_d; \quad T_p = T_c + nmqT_d; \]

\[ T_p = T_c + \sum_{i \in n_u} r_i T_d; \quad T_p = T_c + n_p T_d; \quad C_o = C_{at} + \sum_{i \in n_u} C_{ai} + \sum_{i \in n_u} C_{wi}; \]

\[ C_o = C_{at} + n_q C_{as} + n_a C_{w}; \quad C_{pc} = \frac{C_{as} + C_{sT_p} + C_t}{P_{cp}}; \]

\[ Q = Q_o (1 - q); \quad D = Q_o q; \quad Q_f = Q_o \prod_{i=1}^{n} (1 - q_i) \]

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

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

\[ C_b = Q_o \left( C_{pr1} + C_{s1} \right) + Q_o (1 - q_1) (C_{pr2} + C_{s2}) + Q_o (1 - q_1) (1 - q_2) (C_{pr3} + C_{s3}) + \ldots + Q_o \prod_{i=1}^{n} (1 - q_i) (C_{prn} + C_{sn}) \]

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

\[ C_{sf} = \sum_{i=1}^{n} C_{si}; \quad C_{sf} = nC_s \]

\[ C_b \text{ (100\% inspection)} = QC_s; \quad C_b \text{ (no inspection)} = QqC_d \]

\[ C_b \text{(sampling)} = C_s Q_s + (Q - Q_s) q C_d P_a + (Q - Q_s) C_s (1 - P_a) \]

\[ q_c = \frac{C_s}{C_d} \]

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

\[ C_b = Q_o \left( nC_{pr} + C_{s(n)} \right) + Q_o (1 - q)^n (5C_{pr} + C_{s(2n)}) + \ldots \]
\[ n_o = 2^b; \quad MR = \frac{L}{n_o - 1} = \frac{L}{2^b - 1} \]

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

\[ (x - a)^2 + (y - b)^2 = R^2; \quad (x - a)^2 + (y - b)^2 + (z - c)^2 = R^2 \]

\[ x + Ay + B = 0; \quad y = mx + b \]

\[ x + Ay + Bz + C = 0 \]

\[ R_a = \int_0^1 \frac{|y|}{L} dx; \quad R_a = \frac{\sum_{i=1}^n |y_i|}{n}; \]

\[ R = L \cot A \]

\[ TIC = \frac{C_m Q}{2} + \frac{C_{m0} D_a}{Q}; \quad C_h = hC_{pc}; \quad C_{zu} = T_{zu} C_{dt} \]

\[ TC = D_a C_{pc} + \frac{C_m Q}{2} + \frac{C_{m0} D_a}{Q}; \quad Q = EOQ = \sqrt{\frac{2D_a C_{zu}}{C_h}} \]

\[ C_{pc} = C_m + n_o(C_{oT_p} + C_{no}) \quad C_p = n_o(C_{oT_p} + C_{no}) \]

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

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

\[ Y = 1 - q; \quad OEE = AUYr_{os}; \quad T_{mtl} = \frac{EOT}{Q_{dl}} \]