NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

Bachelor of Engineering Honours Degree Industrial and Manufacturing Engineering

2nd Semester Main Examination

COURSE	**:**	**Concurrent Engineering II**
CODE	**:**	**TIE 3219**
DATE	**:**	**April/May 2014**
DURATION	**:**	**3 Hours**

INSTRUCTIONS AND INFORMATION FOR THE CANDIDATE

1. Answer any **five (5) questions**.
2. All questions carry **20 marks** each.
3. This paper contains **seven (7)** questions.
4. There are s**even (7)** printed pages.

Question 1

An experiment identifies three controllable factors for heat treatment of mild steel. Each factor can be applied at two levels as shown in Table Q1. Four trials were done (two tests for each condition) and the quality characteristic, Y1was found to be 50, 45, 40, and 55 respectively and Y2 to be 55,50, 40 and 50 respectively. Note higher values of Y are more favourable.

Table Q1 – Factors

Factor	Level 1	Level 2
A: Holding time in furnace	6 hours	5 hours
B: Holding Temperature	700^0C	800^0C
C: Cooling time	1 hour	2 hours

Apply Taguchi methods to determine the following:

(i) Determine the Taguchi experimental design orthogonal array for the process. Use the conditions provided in the table above to fill in the array. [2]

(ii) Factor averages. [3]

(iii) The S/N ratios. [6

(iv) Factorial effects for the S/N ratios. [6]

(v) Optimum condition [1]

(vi) The result at the optimum condition [2]

Question 2

(a) Define, making use of appropriate equations, Value Engineering. [2]

(b) There are four types of value considered in Value Engineering. Distinguish these four types of value. [12]

(c) Outline the steps involved in value analysis. [6]

Question 3

(a) By use of an appropriate diagram, illustrate and explain how the three major types of assembly methods differ by type and production volume. [6]

(b) A product is made from 25 parts and is to be manufactured in five (5) different styles obtained by having one alternative for each of the five parts in the assembly. Ten major design changes will probably take place during the first five (5) years of the product life. The expected annual production volume is 1 500 000 units – 500 000 units per shift. As a company policy, the amount to be spent on an item of automation equipment that will do the work of one operator per shift is $50000 and the annual cost of one assembly operator is estimated to be $10000 (including overheads). Use this information and Table Q3 in the Appendix to select the appropriate assembly method for this product. [14]

Question 4

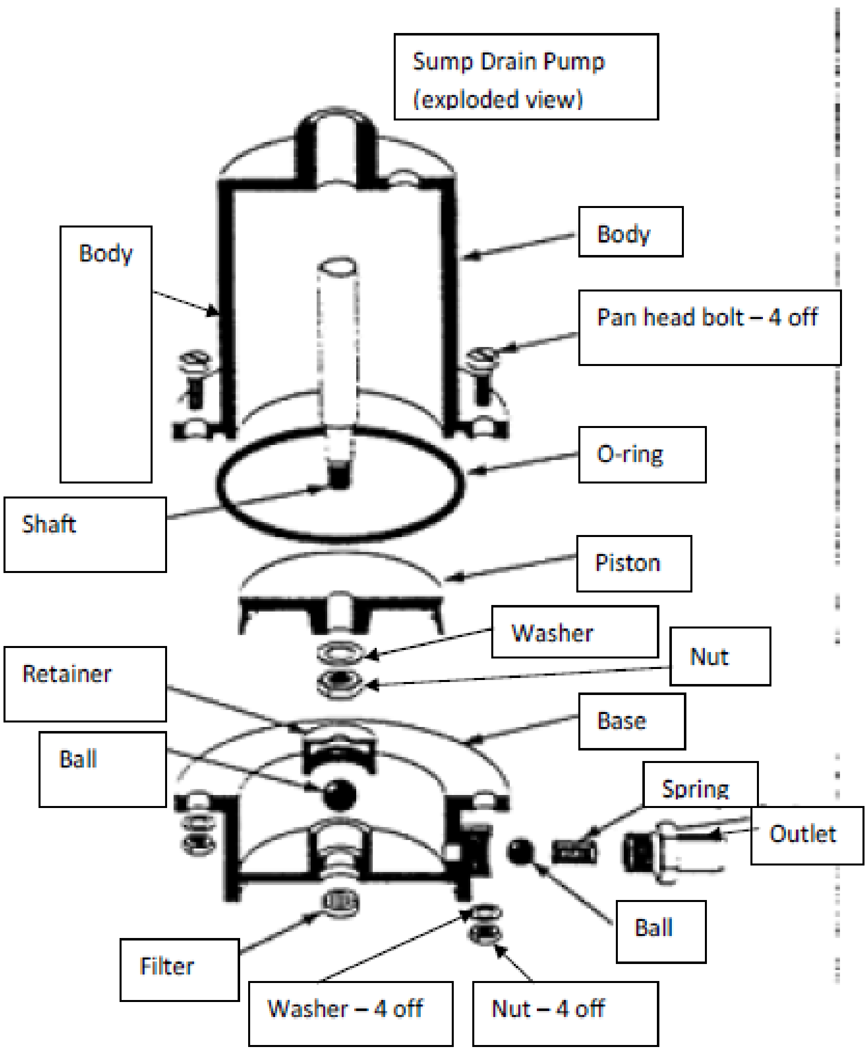
(a) The Lucas DFA method is one of the three major assembly evaluation method (AEM) used. Using an appropriate diagram illustrate the Lucas Assembly-sequence flowchart diagram. [5]

(b) Use the Lucas DFA method on Figure Q4 to determine the:

i. Design Efficiency, [3]

ii. Feeding Ratio, [6]

iii. Fitting Ratio. [6]



Component description	Component number	Functional analysis
Base	1	A
Filter	2	B
Ball	3	A
Retainer	4	B
Ball	5	A
Outlet	6	B
Spring	7	B
Shaft	8	B
Piston	9	A
Washer	10	B
Nut	10	B
Body	12	B
O-ring	12	B
Bolt	14abc	B
Bolt	14d	B
Washer	15abc	B
Nut	16abc	B
Washer	15d	B
Nut	16d	B

Fig Q4

Question 5

(a) What does the acronym "*DFX"* stand for? State six (6) different techniques that the "X" can stand for. [8]

(b) Choose any four Xs that you specified above and explain, highlighting the design guidelines, how they are used. [12]

Question 6

(a) Explain the robust design problem. [5]

(b) Use an example to illustrate the robust design problem. [5]

(c) Using Taguchi quality control method, explain the various stages of quality control that can deliver a robust product. [10]

Question 7

(a) On a FAST (Function Analysis Systematic Technique) diagram, use appropriate illustrations to explain what you understand by the following terms:

   i) High order function. [3]

   ii) Low order function. [3]

(b) Develop a detailed fast diagram for a product of your choice. [14]

End of Exam

Appendix Q1

Array Selector

Number of Levels	Number of Parameters (P)																													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
2	L4	L4	L8	L8	L8	L8	L12	L12	L12	L12	L16	L16	L16	L16	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32
3	L9	L9	L9	L18	L18	L18	L18	L27	L27	L27	L27	L27	L36	L36	L36	L36	L36	L36	L36	L36	L36	L36								
4	L'16	L'16	L'16	L'16	L'32	L'32	L'32	L'32	L'32																					
5	L25	L25	L25	L25	L25	L50	L50	L50	L50	L50	L50																			

L4 Array

Experiment	P1	P2	P3
1	1	1	1
2	1	2	2
3	2	1	2
4	2	2	1

L8 Array

Experiment	P1	P2	P3	P4	P5	P6	P7
1	1	1	1	1	1	1	1
2	1	1	1	2	2	2	2
3	1	2	2	1	1	2	2
4	1	2	2	2	2	1	1
5	2	1	2	1	2	1	2
6	2	1	2	2	1	2	1
7	2	2	1	1	2	2	1
8	2	2	1	2	1	1	2

L9 Array

Experiment	P1	P2	P3	P4
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

L12 Array

Experiment	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	2	2	2	2	2	2
3	1	1	2	2	2	1	1	1	2	2	2
4	1	2	1	2	2	1	2	2	1	1	2
5	1	2	2	1	2	2	1	2	1	2	1
6	1	2	2	1	2	2	1	2	1	2	1
7	1	2	2	2	1	2	2	1	2	1	1
8	2	1	2	1	2	2	2	1	1	1	2
9	2	1	1	2	2	2	1	2	2	1	1
10	2	2	2	1	1	1	1	2	2	1	2
11	2	2	1	2	1	2	1	1	1	2	2
12	2	2	1	1	2	1	2	1	2	2	1

L16 Array

Experiment	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2
3	1	1	1	2	2	2	2	1	1	1	1	2	2	2	2
4	1	1	1	2	2	2	2	2	2	2	2	1	1	1	1
5	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2
6	1	2	2	1	1	2	2	2	2	1	1	2	2	1	1
7	1	2	2	1	1	2	2	2	2	1	1	2	2	1	1
8	1	2	2	2	2	1	1	2	2	1	1	1	1	2	2
9	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
10	2	1	2	1	2	1	2	2	1	2	1	2	1	2	1
11	2	1	2	2	1	2	1	1	2	1	2	2	1	2	1
12	2	1	2	2	1	2	1	2	1	2	1	1	2	1	2
13	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1
14	2	2	1	1	2	2	1	2	1	1	2	2	1	1	2
15	2	2	1	2	1	1	2	1	2	2	1	2	1	1	2
16	2	2	1	2	1	1	2	2	1	1	2	1	2	2	1

L18 Array

Experiment	P1	P2	P3	P4	P5	P6	P7	P8
1	1	1	1	1	1	1	1	1
2	1	1	2	2	2	2	2	2
3	1	1	3	3	3	3	3	3
4	1	2	1	1	2	2	3	3
5	1	2	2	2	3	3	1	1
6	1	2	3	3	1	1	2	2
7	1	3	1	2	1	3	2	3
8	1	3	2	3	2	1	3	1
9	1	3	3	1	3	2	1	2
10	2	1	1	3	3	2	2	1
11	2	1	2	1	1	3	3	2
12	2	1	3	2	2	1	1	3
13	2	2	1	2	3	1	3	2
14	2	2	2	3	1	2	1	3
15	2	2	3	1	2	3	2	1
16	2	3	1	3	2	3	1	2
17	2	3	2	1	3	1	2	3
18	2	3	3	2	1	2	3	1

L25 Array

Experiment	P1	P2	P3	P4	P5	P6
1	1	1	1	1	1	1
2	1	2	2	2	2	2
3	1	3	3	3	3	3
4	1	4	4	4	4	4
5	1	5	5	5	5	5
6	2	1	2	3	4	5
7	2	2	3	4	5	1
8	2	3	4	5	1	2
9	2	4	5	1	2	3
10	2	5	1	2	3	4
11	3	1	3	5	2	4
12	3	2	4	1	3	5
13	3	3	5	2	4	1
14	3	4	1	3	5	2
15	3	5	2	4	1	3
16	4	1	4	2	5	3
17	4	2	5	3	1	4
18	4	3	1	4	2	5
19	4	4	2	5	3	1
20	4	5	3	1	4	2
21	5	1	5	4	3	2
22	5	2	1	5	4	3
23	5	3	2	1	5	4
24	5	4	3	2	1	5
25	5	5	4	3	2	1

Appendix Q3

CLASSIFICATION SYSTEM FOR PRODUCTS AND ASSEMBLIES

			0	1	2	3	4	5	6	7	8	9
			single product has a market life of 3 years or more without significant fluctuations in demand, the manual fitting or adaption of parts is not required and the parts are of sufficiently high quality (See notes 1 and 2 on the reverse side)								variety of different but similar products, no manual fitting, high quality parts and investment in automation encouraged (6)	variety of products, manual fitting, low quality parts, fluctuations in demand or automation discouraged (6)
			investment in automation encouraged $SQ/W \geq 3$ (3)				investment in automation discouraged $SQ/W < 3$ (3)					
			few product styles $\gamma \leq 1.5$ (4)		several product styles $\gamma > 1.5$ (4)		few product styles $\gamma \leq 1.5$ (4)		several product styles $\gamma > 1.5$ (4)			
			few design changes $n_d \leq 0.5$ (5)	several design changes $n_d > 0.5$ (5)	few design changes $n_d \leq 0.5$ (5)	several design changes $n_d > 0.5$ (5)	few design changes $n_d \leq 0.5$ (5)	several design changes $n_d > 0.5$ (5)	few design changes $n_d \leq 0.5$ (5)	several design changes $n_d > 0.5$ (5)		
annual production volume per shift greater than 0.7 million assemblies $V_{as} > 0.7$	7 or more parts in the assembly $n \geq 7$	0	AF	AF	AP	AP	AF	AF	AP	AP	AP	MA
	less than 7 parts in the assembly $n < 7$	1	AI	AI	AI	AI	AI	AI	AI MM	MM AI	AP	MA
annual production volume per shift greater than 0.5 million assemblies $0.5 < V_{as} \leq 0.7$	25 or more parts in the assembly $n \geq 25$	2	AF	AP	AP	AP	AF AP	AP	AP	AP	AP	MA
	15 or more parts in the assembly $15 \leq n < 25$	3	AF AP	AP AF	AP	AP	AF MM	AP MM	AP MM	AP MM	AP	MA
	10 or more parts in the assembly $10 \leq n < 15$	4	AI	AI	AI	AP AI	AI	AI	MM AI	MM AP	AP	MA
	7 or more parts in the assembly $7 \leq n < 10$	5	AI	AI	AI	AI AP	AI	MM AI	MM	MM	AP MM	MA
	less than 7 parts in the assembly $n < 7$	6	AI	AI	AI	AI MM	AI	MM AI	MM	MM	MM AR	MA
annual production volume per shift greater than 0.1 million assemblies $0.1 < V_{as} \leq 0.5$	10 or more parts in the assembly $n \geq 10$	7	AI AP	AP	AP	AP	MM AI	AP MM	AP MM	AP	AP	MA
	less than 10 parts in the assembly $n < 10$	8	MM	MM	MM	MM	MM	MM	MM	MM MA	AR MA	MA
annual production volume per shift less than or equal to 0.1 million assemblies $V_{as} \leq 0.1$		9	MM	MM MA	MM MA	MA	MM MA	MA	MA	MA	MA	MA

Appendix Q4

Lucas DFA method - Manual Handling Analysis			
Handling Index = A+B+C+D			
A. Size & Weight of Part ***One* of the following**		**B. Handling difficulties** ***All* that apply**	
Very small - requires tools	1.5	Delicate	0.4
Convenient - hands only	1	Flexible	0.6
Large and/or heavy requires more than 1 hand	1.5	Sticky	0.5
Large and/or heavy requires hoist or 2 people	3	Tangible	0.8
		Severely nest	0.7
		Sharp/Abrasive	0.3
		Untouchable	0.5
		Gripping problem / slippery	0.2
		No handling difficulties	0
C. Orientation of Part ***One* of the following:**		**D. Rotational Orientation of Part** ***One* of the following**	
Symmetrical, no orientation req'd	0	Rotational Symmetry	0
End to end, easy to see	0.1	Rotational Orientation, easy to see	0.2
End to end, not visible	0.5	Rotational Orientation, hard to see	0.4

Lucas DFA method - Manual Fitting Analysis			
Fitting Index = A+B+C+D+E+F			
A. Part Placing and Fastening ***One* of the following**		**B. Process Direction** ***One* of the following**	
Self-holding orientation	1.0	Straight line from above	0
Requires holding *Plus 1 of the following*	2.0	Straight line not from above	0.1
Self-securing (i.e. snaps)	1.3	Not a straight line	1.6
Screwing	4.0		
Riveting	4.0		
Bending	4.0		
C. Insertion ***One* of the following**		**D. Access and/or Vision** ***One* of the following**	
Single	0	Direct	0
Multiple insertions	0.7	Restricted	1.5
Simultaneous multiple insertions	1.2		
E. Alignment ***One* of the following**		**F. Insertion Force** ***One* of the following**	
Easy to align	0	No resistance to insertion	0
Difficult to align	0.7	Resistance to insertion	0.6