Name _____ Student ID _____

Prince of Songkla University
Department of Industrial Engineering, Faculty of Engineering

Final Examination: Semester 1 Academic Year: 2009
Date: 29 September 2009 Time: 0900-1200
Subject: 225-502 Experimental Designs Room: หัวหุ่นยนต์

ทุจริตในการสอบ โทษขั้นต่ำ คือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียนหนึ่งภาคการศึกษา

Instructions: Read carefully

1. All materials are allowed.
2. There are 5 problems, do all of them. Also show your work clearly and legibly.
3. Answer the questions in this test paper, only.
4. You must write your name and your student ID in every page of the test.
5. Total score is 100 points.

Distribution of Score

Problem	Points	(a)	(b)	(c)	(d)
1	10	-	-	-	-
2	20	-	-	-	-
3	30	5	10	5	10
4	25	-	-	-	-
5	15	-	-	-	-

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Problem 1: (10 points) The data from an experiment that studies a variation of the bottle filling are shown in the following table. Analyze the data from experiments and make the conclusions. Use $\alpha = 0.05$. (Ignore model adequacy checking steps)

	Coded Factors			Fill Height Deviation	
Run	*A*	*B*	*C*	Replicate 1	Replicate 2
1	-	-	-	-3	-1
2	+	-	-	0	1
3	-	+	-	-1	0
4	+	+	-	2	3
5	-	-	+	-1	0
6	+	-	+	2	1
7	-	+	+	1	1
8	+	+	+	6	5

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Problem 2: (20 points) From Problem 1, suppose that only four runs could be made on each shift. Set up a design with ABC confounded in replicate 1 and replicate 2. And analyze the data from experiments, also make the conclusions. Use $\alpha = 0.05$. (Ignore model adequacy checking steps).

	Coded Factors			Fill Height Deviation	
Run	A	B	C	Replicate 1	Replicate 2
1	-	-	-	-3	-1
2	+	-	-	0	1
3	-	+	-	-1	0
4	+	+	-	2	3
5	-	-	+	-1	0
6	+	-	+	2	1
7	-	+	+	1	1
8	+	+	+	6	5

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Problem 3: (30 points) Consider the following data from a specific experiment uses a 2^{5-2} design to investigate these factors A, B, C, D, E. The results obtained are in the following.

$e = 23.2$	$ad = 16.9$	$cd = 23.8$	$bde = 16.8$	$ab = 15.5$	$bc = 16.2$	$ace = 23.4$	$abcde = 18.1$

(a) Verify that the design generators used were $I = ACE$ and $I = BDE$.

(b) Write down the complete defining relation and the aliases for this design.

(c) Estimate the main effects.

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(d) Complete the ANOVA table below by assuming all two-factor and three-factor interactions are negligible. Also make the conclusions. Use $\alpha = 0.05$. (Ignore model adequacy checking steps).

Source	**SS**	**DF**	**MS**	**F**
A				
B				
C				
D				
E				
Error				
Total				

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Problem 4: (25 points) It has been concluded after a factor screening experiment that the yield (y, in %) of a chemical process is mainly affected by the temperature (ξ_1, in $^\circ C$) and by the reaction time (ξ_2, in minutes). Due to the safety reasons, the region of operation is limited to $50 \le \xi_1 \le 250$ and $150 \le \xi_2 \le 500$. A process engineer decides to run 2^2 full factorial experiment with factor levels at

Factor	Low	Center	High
X_1	170	200	230
X_2	150	200	250

The experiment results are shown in the following table.

x_1	x_2	ξ_1,	ξ_2,	y (yield)
-1	-1	170	150	32.79
1	-1	230	150	24.07
-1	1	170	250	48.94
1	1	230	250	52.49
0	0	200	200	38.89
0	0	200	200	48.29
0	0	200	200	29.68
0	0	200	200	46.50
0	0	200	200	44.15

From the above experiment results, complete the ANOVA table below. And find the step size of the path of steepest ascent, in term of natural variables.

Source	SS	DF	MS	F
Temperature				
Time				
Residual				
(Interaction)				
(Pure Quadratic)				
(Pure Error)				
Total				

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Problem 5: (15 points) An experiment was investigated by an engineer. The response y is filtration time, x_1 is temperature, and x_2 is pressure. A second-model in coded units was already given in the following.

$$\hat{y} = 41.200 - 1.970x_1 + 1.457x_2 + 3.712x_1^2 + 2.463x_2^2 + 6.000x_1x_2$$

If you are this engineer, what operating conditions would you recommend if the objective is to minimize the filtration time?