Name _____ Student ID _____

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

Mid Term Examination: Semester 1 — Academic Year: 2009
Date: 25 July 2009 — Time: 09:00 - 12:00
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)
1	20	15	5
2	10	3	7
3	20	-	-
4	20	-	-
5	10	6	4
6	20	-	-

Tests are prepared by
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Problem 1: (20 points) An experiment to determine the effect of air gaps on percentage retained strength of asphalt. For purposes of the experiment, air gaps are controlled at three levels: low (2-4%), medium (4-6%), and high (6-8%). The data are shown in the following table.

Air Gaps	Retained Strength (%)							
Low	106	90	103	90	79	88	92	95
Medium	80	69	94	91	70	83	87	83
High	78	80	62	69	76	85	69	85

(a) Do the different levels of air gaps significantly affect mean retained strength? Use $\alpha = 0.01$. (Ignore model adequacy checking steps)

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Problem 2: (10 points) From problem 1, do the following problems.

(a) Use Tukey's test to compare pairs of treatment mean. Use $\alpha = 0.01$.

(b) Construct a set of orthogonal contrasts and test, assuming that at the outset of the experiment you suspected the percentage retained strength of air gaps at low level to be different from the other two.

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Problem 3: (20 points) An experiment was performed to determine the effect of four different chemicals on the strength of a fabric. These chemicals are used as part of the permanent press finishing process. Five fabric samples were selected. The data are shown in the following table.

	Fabric Sample				
Chemical type	1	2	3	4	5
1	2.3	2.6	1.5	2.2	2.1
2	3.2	3.4	1.4	3.0	2.8
3	2.8	2.7	1.6	2.5	2.3
4	4.9	5.4	3.0	5.1	4.4

Would you suggest what design that an experimenter should use between "completely randomized design" and "randomized complete block design"? **You have to show the reason to support your suggestion why you choose what design.**

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Problem 4: (20 points) A mechanical engineer is studying the thrust force developed by a drill press. He suspects that the drilling speed and the feed rate of the material rate are the most important factors. He selects three feed rates and use a high and low drill speed chosen to represent the extreme operating conditions. He obtains the following results. Analyze the data and draw conclusions. Use $\alpha = 0.05$ (Ignore model adequacy checking step)

Drill Speed	**Feed Rate**		
	0.015	**0.030**	**0.045**
125	3.70	3.45	3.60
	3.78	3.49	3.72
200	3.83	3.85	3.86
	3.86	3.80	3.87

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Problem 5: (10 points) Given the two-factor factorial design for the fixed model.

$$y_{ijk} = \mu + \tau_i + \beta_j + (\tau\beta)_{ij} + \varepsilon_{ijk}$$

$$i = 1,2,...,5; j = 1,2,...,4; k = 1,2,3$$

ANOVA Table			
Source of Variation	**SS**	**df**	**MS**
Factor A	615		
Factor B			34
Interaction	183		
Error			
Total	1796		

(a) Complete the ANOVA table and perform the appropriate statistical tests for factor A effect, factor B effect, and interaction. Use $\alpha = 0.05$.

(b) In a future design, suppose we wish to reject the null hypothesis with probability at least 0.85 if the difference between any two means for factor A is as great as 10, how many replicates should be run?

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Problem 6: (20 points) The factors that influence the breaking strength (psi^2) of a synthetic fiber are being studied. Four production machines and three operators are chosen and a factorial experiment is run using fiber from different production batch since there is not enough fiber to run all treatments. However, a batch contains enough material for twelve treatments only. The results from experiment are as follows.

Operator	**Machine**							
	1		**2**		**3**		**4**	
1	109	110	110	115	108	109	110	108
2	110	112	110	111	111	109	114	112
3	116	114	112	115	114	119	120	117

State the appropriate hypothesis and analyze the data and draw conclusions. Use $\alpha = 0.05$.