

Name \_\_\_\_\_ Student ID \_\_\_\_\_

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

Mid Term Examination: Semester 1  
Date: 29 July 2008  
Subject: 225-502 Experimental Designs

Academic Year: 2008  
Time: 13:30 – 16:30  
Room: A 401

ทฤษฎีในการสอบ โทษขั้นต่ำ คือ ปรับตกในรายวิชาที่ทฤษฎี และพักการเรียนหนึ่งภาคการศึกษา

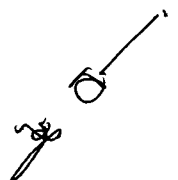
**Instructions: Read carefully**

1. All materials are allowed.
2. There are 6 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	12	8
2	20	-	-
3	20	-	-
4	15	-	-
5	5	-	-
6	20	-	-

Tests are prepared by  
Nikorn Sirivongpaisal



**Problem 1: (20 points)** Given the two-factor factorial design for the fixed model.

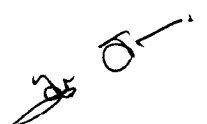
$$y_{ijk} = \mu + \tau_i + \beta_j + (\tau\beta)_{ij} + \varepsilon_{ijk}$$

$$i = 1,2,3; j = 1,2,\dots,4; k = 1,2$$

ANOVA Table			
Source of Variation	SS	df	MS
Factor A	160.33		
Factor B			4.153
Interaction	44.667		
Error			
<b>Total</b>	<b>262.958</b>		

(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 0.95 if the difference between any two means for factor B is as great as 10, how many replicates should be run?



**Problem 2: (20 points)** The factor that influence the breaking strength ( $\text{psi}^2$ ) of a synthetic fiber is being studied. The R&D engineer wants to compare four brands of production machines. The machines are randomly assigned to the operator and a synthetic fiber are produced and measured for its breaking strength. The data are given as follows.

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

Obtain a statistical model for this experiment and determine whether there is any difference in breaking strength among the brands of machines. If there is a difference, use Fisher LSD test to find the difference. Use  $\alpha = 0.01$ .

**Problem 3: (20 points)** Given the two-factor factorial design for the fixed model.

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

$$i = 1, 2, \dots, 4; j = 1, 2, \dots, 3; k = 1$$

ANOVA Table			
Source of Variation	SS	df	MS
Factor A	0.5807		
Factor B			2.3288
Residual or AB	2.1539		
<b>Total</b>	<b>7.3922</b>		

Complete the ANOVA table and perform the appropriate statistical tests for factor A effect, factor B effect, and interaction. Use  $\alpha = 0.05$ . Also provide the data from this experiment has been shown in the following table.

Pressure(lb/in <sup>2</sup> )	Temperature (°F)		
	250	260	270
120	9.60	11.28	9.00
130	9.69	10.10	9.57
140	8.43	11.01	9.03
150	9.98	10.44	9.80

**Problem 4: (15 points)** The quality control department is studying the effect of several factors on the dyeing of cotton-synthetic cloth used to manufacture men's shirts. Three small specimens of cloth were dyed under each set of conditions as shown in the following table. The finished cloth was compared to a standard, and a numerical score was assigned. Also, the results follow in the table.

Cycle Time	Temperature 300°	
	Operator	
	1	2
40	23	31
	24	32
	25	29
60	28	26
	24	27
	27	25

Cycle Time	Temperature 350°	
	Operator	
	1	2
40	24	34
	23	36
	28	39
60	26	28
	29	26
	25	24

Analyze the data and draw conclusions. Use  $\alpha = 0.05$ . What are the *P*-value of these main effects tests? (Neglect the model adequacy checking)

Name \_\_\_\_\_ Student ID \_\_\_\_\_

**Problem 5: (5 points)** From problem 4, illustrate the regression model from the experiment.

20

**Problem 6: (20 points)** The factors that influence the breaking strength ( $\text{psi}^2$ ) 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  $\alpha = 0.05$ .