

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

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

Mid Term Examination: Semester 1  
Date: 4 August 2007  
Subject: 225-502 Experimental Designs

Academic Year: 2007  
Time: 9:00 – 12:00  
Room: ห้องหัตถ์

ทฤษฎีในการสอบ โทษขั้นต่ำ คือ ปรับตกในรายวิชาที่ทฤษฎี และพักการเรียนหนึ่งภาคการศึกษา

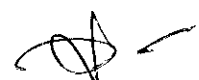
**Instructions: Read carefully**

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	-	-
2	20	12	8
3	20	-	-
4	15	-	-
5	5	-	-
6	20	-	-

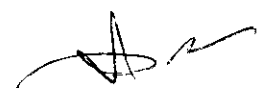
Tests are prepared by  
Nikorn Sirivongpaisal



**Problem 1: (20 points)** A company has five buses. The manager wants to compare three brands of tires. The tires are randomly assigned to the buses and run for 15,000 miles and the wear in millimeters is measured. The data are given as follows.

Tire	Bus				
	1	2	3	4	5
1	17	19	15	14	10
2	29	22	30	27	25
3	29	19	27	25	22

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



**Problem 2: (20 points)** Given the two-factor factorial design for the fixed model.

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

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

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



**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		
Total	7.3922		

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 percentage of hardwood concentration in raw pulp, the pressure, and the cooking time of the pulp are being investigated for their effects on the strength of paper. Two levels of hardwood concentration, two levels of pressure, and two cooking times are selected. A factorial experiment with two replicates is conducted, and the following data are obtained.

Percentage of Hardwood Concentration	Cooking Time 3.0 Hours	
	Pressure	
	400	650
2	196.6	199.8
	196.0	199.4
4	198.5	198.4
	197.2	197.6

Percentage of Hardwood Concentration	Cooking Time 4.0 Hours	
	Pressure	
	400	650
2	198.4	200.6
	198.6	200.9
4	197.5	199.6
	198.1	199.0

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)

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

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**Problem 6: (20 points)** The factors that influence the breaking strength 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  $\alpha = 0.05$ .

