Name _____ Student ID _____

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

Mid Term Examination: Semester 1 — Academic Year: 2004
Date: 5 August 2006 — Time: 9.00 – 12.00
Subject: 225-502 Experimental Designs — Room: A 203

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)
1	5	-	-	-
2	5	-	-	-
3	15	-	-	-
4	15	-	-	-
5	20	10	5	5
6	20	-	-	-
7	20	-	-	-

Tests are prepared by
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Problem 1: (5 points) Five times Olympic Champion Tracy Bonner said "if you want to be a better swimmer, then swim". Then, "How should one practice?" would be the obvious next question. The objective is to find out what factors affect the performance of a particular swimmer. From the previous statement, define the factors, their levels and ranges and selected the response variable that should be in your experiment.

Problem 2: (5 points) Explain the three basic principles of experimental designs.

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Problem 3: (15 points) An automobile manufacturer wants to test the claim of a supplier that new equipment can increase gas mileage by 5 milliliter. For each trial, the technician mounts a new set of either "the standard equipment" or "the new equipment" in an engine, and runs the engine for a certain simulated distance. The trials are run in random order, and yield the following data for gasoline consumed (measured in milliliter). Analyze this experiment. Is the difference between the two equipments significant at the 0.05 level? And calculate the $P-value$ for this test

Equipment	Gasoline Consumption
Standard	548
New	502
New	530
Standard	552
New	515
New	515
Standard	553
New	518
Standard	545
New	527
Standard	535
Standard	553

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Problem 4: (15 points) A distance runner keeps track of the time it takes to run a fixed course, but he has noticed that his timings vary by season. He wants to try to assess the effect of three different brands of running shoe, so he looked at the following timings which were taken over a period of 6 months. Analyze this experiment. Is the difference between these shoes significant at the 0.05 level?

Month	Shoe	Timings
1	1	22.90
1	2	24.15
1	3	22.35
2	1	21.45
2	2	21.40
2	3	20.40
3	1	19.55
3	2	21.95
3	3	19.30
4	1	18.85
4	2	19.25
4	3	18.20

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Problem 5: (20 points) Three brands of batteries are under study. It is suspected that the lives of the three brands are different. Randomly selected batteries of each brand are tested with the following results:

Weeks of Life		
Brand 1	**Brand 2**	**Brand 3**
100	76	108
96	80	100
92	75	96
96	84	98
	82	100

(a) Are the lives of these brands of batteries different? Use $\alpha = 0.05$ (Analyze data only, just ignore model adequacy checking step)

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(b) Use the Fisher least significant difference (LSD) method to compare pairs of treatment means. Use $\alpha = 0.05$.

(c) If we wish to detect a maximum difference in battery life of 10 weeks with a probability of at least 0.90, what sample size should be used?

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Problem 6: (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	2.70	2.45	2.60
	2.78	2.49	2.72
200	2.83	2.85	2.86
	2.86	2.80	2.87

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Problem 7: (20 points) Consider the three-factor model

$$y_{ijk} = \mu + \tau_i + \beta_j + \gamma_k + (\tau\beta)_{ij} + (\beta\gamma)_{jk} + \varepsilon_{ijk} \quad \begin{cases} i = 1,2,\ldots,a \\ j = 1,2,\ldots,b \\ k = 1,2,\ldots,c \end{cases}$$

Notice that there is only one replicate. Assuming the factors are fixed, write down the analysis of variance table, only sources of variation and degrees of freedom. What would you use as the "experimental error" in order to test hypotheses?