

Mat-2.103 Design of Experiments

Examination 5 January 2006 / Mellin

Write clearly on every sheet of paper in the following order:

- Mat-2.103 DesExp 5 Jan 2006
- Your student identification number
- IN BLOCK LETTERS your family name, your first name(s)
- Your degree programme, the year of registration
- Your possible former names and degree programmes
- Signature

A function calculator plus the collection of formulae and statistical tables of Laininen and/or Mellin are allowed.

Answer shortly, but justify your answers adequately.

1. Engineers in a chemical plant installed a new type of filter to filter impurities in a chemical concentration produced by the plant. Percentages of the impurities were measured before and after the installation of the new filter. The measurements were based on two mutually independent simple random samples of the concentration. Summary of the sample information of the two samples is given below.

	Sample size	Arithmetic mean (%)	Sample variance
Before	8	13.5	10.2
After	9	9.2	9.5

- (a) Test by using the level of significance of 10 % the null hypothesis that the variances of the percentages of impurities before and after the installation of the new filter are the same against the alternative hypothesis that the variances are not the same.
- (b) Test by using the level of significance of 5 % the null hypothesis that the expectations of the percentages of the impurities before and after the installation of the new filter are the same against the alternative hypothesis that the expectation of the percentages of the impurities after the installation is lower than the expectation of the impurities before the installation.

You should choose the testing procedure in (b) according to the result in the test in (a).

You can assume that both samples are normally distributed.

2. Two devices to measure daily rainfalls were compared in a field test. Both devices were used to measure daily rainfalls during the same ten days. The results (in millimeters) are given below.

Day	1	2	3	4	5	6	7	8	9	10
Device A	1	9	0.7	1.5	0.75	5	0.6	2	3	1
Device B	0.75	10.5	0.4	2.1	0.5	8	0.4	3.5	4.5	2.5

Test by using the level of significance of 5 % the null hypothesis that the two devices give the same readings on the average against the alternative hypothesis that the readings are not the same on the average.

3. Wear of four fabrics was compared in a field test. Four pieces of each of the four fabrics were randomly picked up and the losses in weights (in grams) were measured after 10 000 times of friction applied to each piece. The results are given below.

Fabric			
A	B	C	D
1.93	2.55	2.40	2.33
2.38	2.72	2.68	2.40
2.20	2.75	2.31	2.28
2.25	2.70	2.28	2.25

Use one-way-analysis-of-variance to test the null hypothesis that average wear of the four fabrics is the same. Use the level of significance of 1 % in the test.

The sum of squares of the observed values = $\sum_{i=1}^4 \sum_{j=1}^4 y_{ji}^2 = 92.9719$

4. The average consumption of three brands of petrol (A = regular, B = extra, C = super) were compared by using three different type of cars. Nuisance factors in the test were the driver (three drivers) and the type of car (three types). The results (the mileage per 1 gallon of petrol) of test are given below.

Brand (mileage)		Car		
		4 cylinders	6 cylinders	8 cylinders
Driver	1	A (36.0)	B (33.0)	C (26.5)
	2	B (36.5)	C (33.5)	A (25.0)
	3	C (38.0)	A (32.5)	B (26.0)

Test by using the level of significance of 5 % the null hypothesis that the average mileages for the three brands are the same.

The sum of squares of the observed values = $\sum_{i=1}^3 \sum_{j=1}^3 \sum_{k=1}^3 y_{kij}^2 = 9343$

5. Vacuum valves are often used in high-class hi-fi equipment. The effects of varying two factors, E = Exhaust Index (in seconds) and V = Pump Heater Voltage (in volts), on the pressure inside a certain type of valve (in Hg-micrometers \times 1000) were compared in a test. The results are given below.

Pressure		E		
		60	90	150
V	127	48	28	7
		58	33	15
	220	62	14	9
		54	10	6

What are the conclusions of the test? Apply an appropriate analysis-of-variance model to analyze the results. Use the level of significance of 5 % in the tests.

The sum of the observed values = $\sum_{i=1}^3 \sum_{j=1}^2 \sum_{k=1}^2 y_{kij}^2 = 14988$