

National Institute of Technology Hamirpur

Department of Mechanical Engineering

End Semester Examination (Dec-2020)

M. Tech. (Manufacturing) I Semester + PhD Time: 02 Hours Max. Marks: 50

Sub.: Design and Analysis of Experiments (ME - 722)

Instructions: 1) All questions, weightage of marks as mentioned, are compulsory

2) Assume suitable data wherever necessary

1. (a) What do you understand by the designing of experiments? Discuss the basic principles for the statistically design of experiments. [5 M].

(b) How are the responses variables selected? Discuss the method of selection of factors, levels and range. [5 M].

2. (a) What are the residuals? Discuss about the normal probability plot of residuals and outlier. [5 M].

(b) A pharmaceutical manufacturer wants to investigate the bioactivity of a new drug. A completely randomized single-factor experiment was conducted with three dosage levels, and the following results were obtained.

| Dosage | Observations |    |    |    |    |
|--------|--------------|----|----|----|----|
| 20 g   | 24           | 28 | 37 | 30 | 31 |
| 30 g   | 37           | 44 | 31 | 35 | 36 |
| 40 g   | 42           | 47 | 52 | 38 | 44 |

Is there evidence to indicate that dosage level affects bioactivity? Use  $\alpha = 0.05$ . [5].

3. (a) What are the  $2^k$  factorial designs? Discuss the  $2^2$  design in details with a suitable example. [5 M].

(b) The yield of a chemical process is being studied. The two most important variables are thought to be pressure and the temperature. Three levels of each factor are selected, and a factorial experiment with two replicates is performed. The yield data are as follow:

| Temperature<br>(°C) | Pressure (psig) |      |      |
|---------------------|-----------------|------|------|
|                     | 200             | 215  | 230  |
| 150                 | 90.4            | 90.7 | 90.2 |
|                     | 90.2            | 90.6 | 90.4 |
| 160                 | 90.1            | 90.5 | 89.9 |
|                     | 90.3            | 90.6 | 90.1 |
| 170                 | 90.5            | 90.8 | 90.4 |
|                     | 90.7            | 90.9 | 90.1 |

Analyze the data and draw conclusions. Use  $\alpha = 0.05$ . [5 M].

4. (a) What are the linear regression models? Discuss the method of estimation of the parameters in linear regression models? [5].

(b) The tensile strength of a paper product is related to the amount of hardwood in the pulp. Ten samples are produced in the pilot plant, and the data obtained are shown in the following table.

| <b>Strength</b> | <b>Percent Hardwood</b> | <b>Strength</b> | <b>Percent Hardwood</b> |
|-----------------|-------------------------|-----------------|-------------------------|
| 160             | 10                      | 181             | 20                      |
| 171             | 15                      | 188             | 25                      |
| 175             | 15                      | 193             | 25                      |
| 182             | 20                      | 195             | 28                      |
| 184             | 20                      | 200             | 30                      |

Fit a linear regression model relating strength to percent hardwood. [5].

5. (a) What do you know about the response surface methodology? Discuss the method of steepest ascent. [5].

(b) What are the different aspects in selecting of appropriate designs for fitting response surface? Discuss about the Central Composite design (CCD) and Box-Behnken design (BBD). [5].

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