

M.E. Production Engineering 1st Year 2nd Semester Examination
Ex/PRD/PE/T/124C

APPLIED MULTIVARIATE STATISTICAL ANALYSIS

Time : Three hours

Full marks: 100

- 1 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 the same production batch. The results are as follows: (20)

Operator	Machine			
	1	2	3	4
1	119, 120	114, 118	118, 111	121, 118
2	115, 118	120, 121	113, 119	124, 122
3	117, 112	122, 125	112, 120	121, 127

Analyze the data and draw conclusions at 5% level of significance along with the optimal settings of the considered parameters. (Given $F_{0.05} = 9.41$ for (2, 12) df, $F_{0.05} = 5.22$ for (3, 12) and $F_{0.05} = 2.90$ for (6, 12))

- 2.(a) Write a short note on multi-dimensional scatter plot. (4)
- (b) A 3D-printing operation is carried out on carbon fiber reinforced nylon 12 material with printing speed (in mm/s) and extrusion temperature (in °C) as the input parameters, and surface roughness (in μm) as the sole tribological property. The following table records the observations. Calculate the correlation coefficient values among the considered printing parameters and response. (16)

Experiment No.	Printing speed	Extrusion temperature	Surface roughness
1	30	210	5.65
2	32	215	6.47
3	33	218	5.21
4	31	220	5.58
5	29	225	6.01
6	32	214	5.91
7	35	217	5.75
8	34	220	6.05
9	36	212	5.90
10	38	214	6.05

- 3.(a) Write a short note on factor analysis. (5)
- (b) During a tuning operation on EN31 stainless steel, a production engineer wants to examine the relationships between spindle speed (in rpm) and depth of cut (in mm), and material removal rate (in cm^3/min). Develop the corresponding multivariate regression equation. (15)

Experiment No.	Spindle speed	Depth of cut	Material removal rate
1	240	0.1	0.205
2	245	0.12	0.682
3	248	0.15	1.306
4	250	0.18	0.620
5	300	0.25	2.086
6	375	0.30	4.757
7	275	0.22	1.725
8	390	0.32	4.975

4. A production engineer attempts to minimize the cutting force (in N) during a real-time turning operation on Ti-6Al-4V alloy. He has run a 2^3 experiment using the cutting speed (A), depth of cut (B) and feed rate (C) as the factors. The data from two replicates are shown in the following table. (20)

[Turn over

Run	Replicate	
	I	II
(1)	150.70	152.47
a	213.35	220.12
b	191.73	198.35
c	322.39	320.74
ab	286.01	288.85
ac	231.73	240.23
bc	319.99	323.52
abc	299.16	302.25

Conduct an ANOVA to study the effects of the considering turning parameters on the cutting force. Also develop the corresponding residual plot. (Given $F_{0.05} = 5.59$ for (1, 7) df)

5. An electrical discharge machining operation is conducted in the Production Engineering Department with gap voltage (V), peak current (A) and duty cycle (%) as the input variables, and material removal rate (mg/min) as the sole response. All the input parameters are set at two distinct levels (low and high), and the corresponding values of material removal rate are recorded in the following table. Develop the decision tree using ID3 algorithm to investigate the effects of those parameters on material removal rate. The material removal values are also classified as low and high. (20)

Run No.	Gap voltage	Peak current	Duty cycle	Material removal rate
1	Low	Low	Low	Low
2	Low	Low	High	High
3	High	High	High	High
4	High	Low	Low	Low
5	Low	Low	High	High
6	High	Low	High	Low
7	High	High	Low	High
8	High	Low	High	High

6. There are three datasets as given below: (20)

A1(2,5), A1(3,4), A1(5,6), A1(7,5)

B1(6,6), B2(7,8), B3(2,9), B4(7,7)

C1(4,2), C2(5,9), C3(1,8)

Apply K-meaning algorithm to cluster the given datasets.

7. Five experiments are conducted on a drilling machine, and two surface roughness parameters, i.e. average surface roughness (Ra) and ten-point average surface roughness (Rz) are measured as shown below: (20)

Ra	1.1	1.2	1.5	1.3	1.8
Rz	6.0	6.8	8.0	7.8	9.0

Use principal component analysis to reduce the two-dimensional data into single dimensional data.

- 8.(a) Apply hierarchical clustering and develop the corresponding dendrogram using the given single-dimensional dataset: {2, 3, 9, 6, 7}. (12)
- (b) Describe in detail about logistic regression. (10)