

Reg. No. :

**Question Paper Code : 30913**

M.E./M.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2022.

First Semester

Computer Integrated Manufacturing

MA 4155 – APPLIED PROBABILITY AND STATISTICS FOR MANUFACTURING  
ENGINEERING

(Common to M.E. Manufacturing Engineering)

(Regulations 2021)

(Use of Statistical Tables may be permitted)

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. If  $P(A) = 0.4$ ,  $P(B) = 0.7$ ,  $P(A \cap B) = 0.3$ , find  $P(\overline{A \cap B})$ .
2. What is memoryless property? Give example?
3. The joint probability density function of  $(X, Y)$  is given by  $f(x, y) = 2$ ,  $0 \leq x < y \leq 1$ , find the marginal density function of  $X$ .
4. Give the significance of least squares while fitting a linear regression equation.
5. What is Type I and Type II error?
6. What is the test statistic used to compare the variances of two population?
7. How is point estimation different from interval estimation?
8. What does it mean to find 95% confidence interval?
9. What is  $2^2$  factorial design in ANOVA?
10. What are the principal components in designing an experiment?

PART B — (5 × 13 = 65 marks)

11. (a) (i) In a particular production run, 20% of the chips are subject to high levels of contamination, 30% to medium level and 50% to low level contamination. It is known that chips with high level of contamination has 0.10 probability of failure, chips with medium level and low level has 0.01 and 0.001 probability of failure respectively. What is the probability that a product using one of these chips fails? What is the probability of a failure due to high contamination? (6)
- (ii) The number of telephone calls that arrive at a phone exchange is often modelled as a Poisson random variable. Assume that on the average there are 10 calls per hour. What is the probability that there are exactly 5 calls in one hour? What is the probability that there are 3 or less calls in one hour? What is the probability that there are exactly 15 calls in two hours? (7)

Or

- (b) (i) Each sample of water has a 10% chance of containing a particular organic pollutant. Assume that the samples are independent with regard to the presence of the pollutant. Find the probability that in the next 18 samples, exactly 2 contains the pollutant. Find the probability that atleast 4 samples contains the pollutant. (7)
- (ii) The time between the arrivals of electronic messages at your computer is exponentially distributed with a mean of two hours. What is the probability that you do not receive a message during a two-hour period? If you have not had a message in the last four hours, what is the probability that you do not receive a message in the next two hours? What is the expected time between your fifth and sixth messages? (6)

12. (a) Given a joint probability density function  
 $f(x, y) = \frac{1}{16}xy, 0 < x < 2, 0 < y < 4$ . Find  $E(X)$ ,  $E(Y)$ ,  $E(XY)$  and  $Cov(X, Y)$ . (13)

Or

(b) Determine the value of  $c$  that makes the function  $f(x, y) = c(x + y)$ , a joint probability mass function over the nine points with  $x = 1, 2, 3$  and  $y = 1, 2, 3$ . (13)

(i) What is the marginal probability distribution of random variable  $X$  and  $Y$ ?

(ii) What is the conditional probability distribution of  $Y$  given  $X = 1$ ?

(iii) Find  $P(X < 2, Y < 2)$ ,  $P(X = 1, Y < 2)$ .

13. (a) (i) Air crew escape system are powered by a solid propellant. The burning rate of this propellant is an important product characteristic. Specifications require that the mean burning rate must be 50 centimetres per second. We know that the standard deviation of burning rate is 2 centimetres per second. The experimenter decides to specify a significance level of  $\alpha = 0.05$  and select a random sample of  $n = 25$  and obtains a sample average burning rate of 51.3 centimetres per second. What conclusion must be drawn? (6)

(ii) A random sample of 60 printed boards has been collected, and the following number of defects observed.

Number of defects :	0	1	2	3
Observed frequency :	32	15	9	4

Does the assumption of a Poisson distribution seem appropriate as a probability model for this data? Use  $\alpha = 0.05$  level of significance. (7)

Or

(b) (i) Two different types of injection moulding machines are used to form plastic parts. A part is considered defective if it has excessive shrinkage or is discoloured. Two random samples, each of size 300, are selected and 15 defective parts are found in the sample from machine 1 while 8 defective parts are found in the sample from machine 2. Is it reasonable to conclude that both machines produce the same fraction of defective parts using  $\alpha = 0.05$ ? (6)

- (ii) A company has to choose among three health insurance plans. Management wishes to know whether the preference or plans is independent of job classification and wants to use  $\alpha = 0.05$ . The opinions of a random sample of 500 employees are given in the table.

	Plan 1	Plan 2	Plan 3
Salaried workers	160	140	40
Hourly workers	40	60	60

Check if there is significant relation between workers and plans. (7)

14. (a) (i) The CVN technique measures impact energy and is often used to determine whether or not a material experiences a ductile-to-brittle transitions with decreasing temperature. Ten measurements of impact energy on specimens of A238 steel cut at  $0^{\circ}\text{C}$  shows a mean of 64.46. Assume that the impact energy is normally distributed with standard deviation 1. Construct a 95% confidence interval for  $\mu$ , the mean impact energy. (6)

- (ii) An automated filling machine is used to fill bottles with liquid detergent. A random sample of 20 bottles results in a sample variance of fill volume of 0.0153 ounces<sup>2</sup>. If the variance of fill volume is too large, an unacceptable proportion of bottles will be underfilled or overfilled. Assume that fill volume is approximately normally distributed. Find 95% upper confidence bound for the population variance of fill volume. (7)

Or

- (b) (i) In a random sample of 85 automobile engine crankshaft bearings, 10 have a surface finish that is rougher than the specifications allowed. A point estimate of the proportion of bearings in the population that exceeds the roughness specification is 0.12. Find a 95% two sided confidence interval for population proportion. (6)

- (ii) Tensile strength tests were performed on two different grades of aluminium spars used in manufacturing the wing of a commercial transport aircraft. From past experience with the spars manufacturing process and the testing procedure, the standard deviations of the tensile strengths are assumed to be known. The data obtained are :  $n_1 = 10$ ,  $\bar{x}_1 = 87.6$ ,  $\sigma_1 = 1$ ,  $n_2 = 12$ ,  $\bar{x}_2 = 74.5$  and  $\sigma_2 = 1.5$ . If  $\mu_1$  and  $\mu_2$  denote the true mean tensile strengths for the two grades of spars, construct a 90% confidence interval for the difference in mean strength  $\mu_1 - \mu_2$ . (7)

15. (a) A manufacturer of paper used for making grocery bags is interested in improving the product's tensile strength. A team of engineers decides to investigate four levels of hardwood concentration in the pulp. The measurements from six test specimens at each concentration levels are given in the table. (13)

	Specimen					
	1	2	3	4	5	6
Concentration 1	7	8	15	11	9	10
Concentration 2	12	17	13	18	19	15
Concentration 3	14	18	19	17	16	18
Concentration 4	19	25	22	23	18	20

Conduct an analysis of variance test to check if there is significant difference between the hardwood concentration levels using  $\alpha = 0.01$ .

Or

- (b) An experiment was performed to determine the effect of four different chemicals on the strength of a fabric. These chemicals are used as part of the permanent press finishing process. Five fabric samples were selected, and a RCBD was run by testing each chemical type once in random order on each fabric sample. For the data given in the table, conduct a two way analysis to check whether the difference between chemicals and fabric samples are significant at  $\alpha = 0.01$ . (13)

	Fabric 1	Fabric 2	Fabric 3	Fabric 4	Fabric 5
Chemical 1	1.3	1.6	0.5	1.2	1.1
Chemical 2	2.2	2.4	0.4	2.0	1.8
Chemical 3	1.8	1.7	0.6	1.5	1.3
Chemical 4	3.9	4.4	2.0	4.1	3.4

PART C — (1 × 15 = 15 marks)

16. (a) A study on the deflection (mm) of particle board from stress levels of relative humidity gave the result in the table.

X : Stress level (%) : 10 15 18 11 20

Y : Deflection (mm) : 25 35 20 31 28

Fit a simple linear regression equation, for the given data. Estimate the value of deflection when stress level is 19%, using the fitted equation. What is the estimate of  $\sigma^2$ ? Estimate the correlation coefficient of the given data. (15)

Or

- (b) Suppose the current measurement in a strip of wire is assumed to follow a normal distribution with a mean of 10 milliamperes and a variance of four milliamperes<sup>2</sup>. What is the probability that (15)

(i) a measurement exceeds 13 milliamperes.

(ii) a current measurement is between 9 and 11 milliamperes.

(iii) Determine the value for which the probability that a current measurement is less than this value is 0.98.

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