



Institute of Actuaries of India

Statutory body established under an Act of Parliament

Unit No. F-206, 2nd Floor, F Wing, Tower II, Seawoods Grand Central,
Plot no R-1, Sector 40, Nerul Road, Navi Mumbai - 400706
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Subject

A1 - Fundamentals of Mathematical Statistics



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COURSE STRUCTURE

SECTION	TOPIC	WEIGHTING
I	Data analysis and research	0-5%
II	Random Variable and Probability distributions	25-30%
III	Confirmatory data analysis - Parameter estimation and Statistical tests	25-30%
IV	Exploratory data analysis - Correlation and Regression methods	25-30%
V	Bayesian methods for data analysis	10-20%

TENTATIVE CHAPTER NAMES UNDER EACH SECTION:

Section I: Data analysis and research

1. Data analysis and research

Section II: Random Variable and Probability distributions

2. Probability theory and Random Variables
3. Discrete Probability distributions
4. Continuous Probability distributions
5. Special distributions for statistical tests
6. Moments and Cumulants
7. Joint distributions, Conditional expectation and convolutions
8. Simulation tools - random number generation and bootstrapping

Section III: Confirmatory data analysis - Parameter estimation and Statistical tests

9. Sampling, the Central limit theorem and asymptotic convergence
10. Point estimation
11. Interval estimation
12. Tests of Hypotheses

Section IV: Exploratory data analysis - Correlation and Regression methods

13. Correlation
14. Singular Value Decomposition and Principal Component Analysis
15. Regression analysis
16. Generalised linear models

Section V: Bayesian methods for data analysis

17. Bayes' theorem and Bayesian inference
18. Credibility theory
19. Empirical Bayes credibility models



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Detailed syllabus and learning outcomes of this course:

SR. NO.	EXPECTED LEARNING OUTCOME	SECTION
A	Define/ Explain/Describe, as required	
1	Data analysis:	I
	▪ Sources of data	
	▪ Steps	
	▪ Types	
	▪ Uses	
	▪ Reproducibility	
	▪ Limitations	
2	Elements of Probability theory:	II
	▪ Sample space, random experiment, event	
	▪ Axioms and ruled of probability	
	▪ Independence of events	
3	Conditional probability and Bayes theorem	II
	Random variable - distribution function, mean variance, covariance,	
	▪ Probability density and cumulative distribution function	
	▪ Expected value, Variance, Covariance, Correlation coefficient	
4	Univariate, bivariate, multivariate distributions	II
	Characteristics and key uses of following probability distributions:	
4a	Discrete distributions:	II
	▪ Binomial	
	▪ Negative Binomial	
	▪ Geometric	
	▪ Hypergeometric	
	▪ Poisson	
	▪ Uniform	
4b	Continuous distributions:	II
	▪ Normal	
	▪ Lognormal	
	▪ Exponential	
	▪ Gamma	
	▪ Beta	
	▪ Weibull	
	▪ Burr	
	▪ Pareto	
	▪ Uniform	
4c	Special distributions:	II
	▪ Chi-squared	
	▪ Student's t	
	▪ F-distribution	



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SR. NO.	EXPECTED LEARNING OUTCOME	SECTION
5	Characteristics of Poisson process and its uses in real world	II
6	Independence property and its conditions	II
7	Joint distributions:	II
	▪ Marginal distributions	
	▪ Conditional distributions	
	▪ Convolutions	
	▪ Conditional expectation	
8	Central limit theorem and its statistical uses	III
9	Sampling and types of sampling	III
10	Measures of Sample data & degrees of freedom	III
11	Process of estimation of parameters and estimation methods	III
	▪ Method of moments	
	▪ Maximum likelihood	
12	Following properties of estimators:	III
	▪ Efficiency	
	▪ Sufficiency	
	▪ Bias	
	▪ Consistency	
	▪ Mean squared error	
13	Cramer-Rao lower bound for asymptotic distribution of maximum likelihood estimates	III
14	Response variable and explanatory variable	IV
15	Process of fitting a:	IV
	▪ Simple linear regression model	
	▪ Multivariate linear regression model	
16	Null and Alternate hypotheses	III
17	Type I Type II errors	III
18	Contingency table, chi square test and degrees of freedom	III
19	Bayesian statistics:	V
	▪ Posterior distribution	
	▪ Prior distribution	
	▪ Loss function	
20	Credibility theory and its actuarial application	V
B	Calculate	
21	Probabilities associated with various distributions using tables / density & distribution functions	II
22	Confidence intervals:	III
	▪ using central limit theorem for normal and normal approximations of other distributions	
	▪ for two sample data	
	▪ for paired data difference of means	
	▪ for unknown parameter using assumed distribution of sample	



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SR. NO.	EXPECTED LEARNING OUTCOME	SECTION
23	Correlation coefficients using Pearson, Spearman and Kendall methods	IV
24	Conditional probabilities under Bayes theorem	V
C	Derive	
25	Mean and variance for two or more random variables using linear transformation	II
26	Mean and variance of sample mean and mean of sample variance using population statistics	II
27	Least square estimates of parameters in regression model	IV
28	Posterior distribution of a parameter using Bayesian approach	V
29	Bayesian parameter estimates and credibility weights in: - Poisson/gamma model - Normal/normal model	V
30	Empirical Bayesian estimates and credibility weights in: - Claim count or amounts - Claim frequency or loss ratios	V
D	Generate	
31	Generate simulated random variables using the Monte Carlo/inverse transform method	II
32	Generate simulated samples of a distribution and compare with properties of Normal	II
E	Use	
33	R statistical software for generating random variables	II
34	Generating functions to determine moments and cumulants	II
35	PCA for dimensionality reduction	IV
36	Bootstrap methods to obtain confidence intervals and estimator characteristics in R software	II
37	Normal, Chi-squared, F, t distributions, as appropriate, to apply basic tests of hypothesis in various situations	III
38	R statistical software to apply the permutation approach to non-parametric hypothesis tests.	III
39	Regression method to fit linear regression model and analyse the goodness of fit	IV
40	R statistical software to fit: - Suitable simple linear regression model to a data set - Suitable multiple linear regression model to a data set	IV
