# Anekant Education Society's
# Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati
# Autonomous

## Course Structure for M.Sc. Statistics (2022 Pattern)
## (With effect from Academic Year 2022-2023)

**Name of the Programme : M.Sc. Statistics**

**Program Code : PSST**

**Class : M.Sc. Part – I**

**Semester : I**

| Paper Code | Title of Paper | No. of Credits |
|---|---|---|
| PSST111 | Mathematical Analysis | 4 |
| PSST112 | Linear Algebra | 4 |
| PSST113 | Probability Distributions | 4 |
| PSST114 | Sampling Theory | 4 |
| PSST115 | Statistics Practical – I | 4 |
| PSST116 | Statistics Practical – II | 4 |

**Name of the Programme : M.Sc. Statistics**

**Program Code : PSST**

**Class : M.Sc. Part – I**

**Semester : II**

| Paper Code | Title of Paper | No. of Credits |
|---|---|---|
| PSST121 | Modern Probability Theory | 4 |
| PSST122 | Statistical Inference | 4 |
| PSST123 | Applied Multivariate Analysis | 4 |
| PSST124 | Regression Models | 4 |
| PSST125 | Statistics Practical – III | 4 |
| PSST126 | Statistics Practical – IV | 4 |

**SYLLABUS (CBCS) FOR M.Sc. Statistics**
**(With effect from Academic Year 2022-2023)**

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|---|---|
| **Name of the Programme** | **:** M.Sc. Statistics |
| **Program Code** | **:** PSST |
| **Class** | **:** M.Sc. Part – I |
| **Semester** | **:** II |
| **Course Name** | **:** Modern Probability Theory |
| **Course Code** | **:** PSST121 |
| **No. of lectures** | **:** 60 |
| **Credit** | **:** 4 credits |

## Course Outcomes:

Students will be able to

1) understand the concepts of random variables, sigma-fields generated by random variables
2) solve the problems based on probability measure, distribution function and expectation
3) understand the concepts of independence of events, random variables
4) understand different modes of convergences and their interrelationships
5) apply WLLN and CLT related to sequence of random variables

**TOPICS/CONTENTS:**

## Unit-1

Review of algebra of sets, sequence of sets, limsup, liminf and limit of a sequence of sets, Classes of sets, field, sigma field, minimal sigma field, Borel fields, measurable space, monotone classes, Measurable function, Real and Vector valued random variables, simple r.v., r.v. as a limit of sequence of simple r.v.s, Probability measure on a measurable space, probability space, properties of probability measure: continuity, mixture of probability measures. **(18L)**

## Unit 2

Distribution function, decomposition of a distribution function, discrete and continuous type r.v., Expectation of simple r.v, non-negative r.v. and arbitrary r.v., properties of expectation, moments, moment inequalities **(12L)**

## Unit 3

Convergence of a sequence of r.v.s, convergence in probability, convergence in distribution, convergence in $r^{th}$ mean, almost sure convergence, their inter-relations, Slutsky's theorem, convergence theorem for expectations, characteristic function and properties, conjugate pairs of distributions, **(15L)**

## Unit 4

Independence of events, class of independent events, independence of classes, independence of r.v's, expectation of the product of independent r.v.'s, equivalent definitions of independence, Kolmogorov 0-1 Law, Borel 0-1 criterion, Borel Cantelli Lemma, Khintchin's WLLN, Strong Law of Large Numbers (SLLN) (Statement only), Central Limit Theorem (CLT), Levy continuity theorem, CLT for i.i.d. r.v.s, Liaponove's form, Lindeberg Feller form and their applications. **(15L)**

## References:


1) Bhat, B.R. (2007) Modern Probability Theory, Third Edition. New Age Inter-national
2) Billingsley, P. (1995) Probability and Measure, Wiley Publication.
3) Chung, K. L. (2001) A Course in Probability Theory, Third Edition, Academic Press, London
4) Basu, A. K. (1999) Measure Theory and Probability (Prentice Hall of India)
5) Ash, Robert. (1972) Real Analysis and Probability, (Academic Press)
6) Feller, W. (1969) Introduction to Probability and its applications Vol.II, (Wiley Easter Ltd.)
7) Gut A. (2005), Probability: A Graduate Course, Spinger-Verlag, New York.
8) Dasgupta A. (2008), Asymptotic Theory of Statistics and Probability, Spinger-Verlag, New York.

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| **Name of the Programme** | **:** M.Sc. Statistics |
| **Program Code** | **:** PSST |
| **Class** | **:** M.Sc. Part – I |
| **Semester** | **:** II |
| **Course Name** | **:** Statistical Inference |
| **Course Code** | **:** PSST122 |
| **No. of lectures** | **:** 60 |
| **Credit** | **:** 4 credits |

## Course Outcomes:

Students will be able to understand the concept of

1) estimation and testing procedures to deal with real life problems.
2) Fisher Information matrix, Lower bounds to variance of estimators, MVUE.
3) prior and posterior data based modeling and analysis.
4) data reduction and different family of distributions
5) most powerful test, Neyman-Pearson fundamental lemma, UMP test, UMPU test.

**TOPICS/CONTENTS:**

## Unit 1

Sufficiency, Fisher's concept of sufficiency, Sufficient statistic, Factorization theorem, Joint Sufficiency, Likelihood Equivalence, Minimal Sufficiency, construction of Minimal Sufficient Statistic, Completeness, Exponential family and Pitman family admitting Minimal Sufficient Statistic.

**(15L)**

## Unit 2

Fisher information and information matrix, Estimable function, Best Linear Unbiased Estimator, Gauss-Markov theorem, Cramer Rao inequality and its application, Rao-Blackwell theorem, Lehman-Scheffee theorem and its application, necessary sufficient condition of MVUE,necessary and sufficient condition for MVUE and their applications, Ancillary statistic.

**(15L)**

## Unit 3

Critical region and test function, Neyman Pearson lemma and most powerful test, Uniformly Most Powerful (UMP) test for one sided alternative for one parameter exponential family and Pitman family, Monotone Likelihood Ratio property, statement of UMPU test, nonexistence of UMP tests. **(15L)**

## Unit 4

Confidence Interval (C.I.), Shortest Expected Length C.I. Uniformly Most Accurate C.I., introduction to Bayesian estimation: Prior and Posterior distribution, Loss function, Bayes estimation under squared error and absolute error loss functions, Conjugate family of Prior distribution and its example, Principal of Minimum Expected Posterior Loss. **(15L)**

## References:


1. Casella G. and Beregar R.L. (2002) Statistical Inference, 2nd Edition (Duxbury Advanced Series)
2. Dudewitz E.J. & Mishra S.N.(1988) Modern Mathematical Statistics (John Wiley)
3. Kale B.K. (1999) A First course on Parametric Inference (Narosa)
4. Lehman E.L (1988) Theory of point estimation (John Wiley)
5. Lehman E.L(1986) Testing of Statistical hypotheses (John Wiley)
6. Rohatagi V.K. (1976) Introduction to theory of probability & mathematical statistics (John Wiley & sons)
7. Dasgupta A. (2008), Asymptotic Theory of Statistics and Probability, Spinger-Verlag, New York.
8. Ulhas Jayram Dixit (2016) ISBN 978-981-10-0888-7 Examples in Parametric Inference with R

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**Name of the Programme** **:** M.Sc. Statistics
**Program Code** **:** PSST
**Class** **:** M.Sc. Part – I
**Semester** **:** II
**Course Name** **:** Applied Multivariate Analysis
**Course Code** : PSST123
**No. of lectures** **:** 60
**Credit** **:** 4 credits

## Course Outcomes:

After completion of this course the students will be able to

1) carry out an extensive exploratory multivariate analysis for a given multivariate data
2) carry out cluster analysis of given multivariate data
3) solve problems involving multivariate normal distribution Evaluate
4) carry out statistical inference procedures using the data from a multivariate normal distribution.
5) carry out classification of given multivariate data

**TOPICS/CONTENTS:**

## Unit-1

Exploratory multivariate data analysis, sample mean vector, sample dispersion matrix, correlation matrix, graphical representation, linear transformation and its mean, variance covariance, correlation between linear transformations, principal component analysis, factor analysis, canonical correlation with applications, cluster analysis with applications. **(20L)**

## Unit- 2

Multivariate normal distribution, singular and non-singular normal distribution. m.g.f., characteristic function, moments, distribution of a linear form and quadratic form of normal variables, Cochran theorem, marginal and conditional distribution. Test for multivariate normality. **(12L)**

## Unit- 3

M.L.E's of parameters of multivariate normal distribution and their sampling distribution, Wishart matrix, Wishart distribution and its properties, Tests of hypothesis about mean vector of a multivariate normal population, Hotelling T2 statistic and its distribution, its applications. Likelihood ratio test, confidence region for mean vector of multivariate normal distribution. **(15L)**

## Unit- 4

Test for equality of dispersion matrices, discriminant analysis, Mahalanobis D2 statistic, test for significance of the coefficients in discriminant function, misclassification error, methods and applications of MANOVA (without derivation of the distribution of Wilk's lambda). **(13L)**

**REFERENCES**


1) Anderson T.W. (1984) Introduction to multivariate analysis (John Wiley)
2) C. R. Rao (1985) Linear Statistical inference and its applications (Wiley Eastern Ltd)
3) Hardle, W. K. & Simar, L. (2012), Applied Multivariate Statistical analysis (Springer, New York)
4) Johnson R.A. and Wichern D.W. (1988) Applied multivariate statistical analysis (Prentice Hall Inc.)
5) Johnson R.A. & Wichern, D.W. (1988). Applied Multivariate Statistical analysis (Prentice Hall Inc.)
6) Kshirsagar A.M. (1983) Multivariate Analysis (Marcel Dekker.)
7) K.C. Bhuyan (2005) Multivariate Analysis and its application, New Central book agency, LTD. Kolkatta
8) Morrison, D.F. (1990). Multivariate Statistical Methods (McGraw Hill Co.) (3rd ed.)
9) Bryan F. J., Manly, Jorge A. Navarro Alberto, Multivariate Statistical Methods, Fourth Edition, A Primer.

**SYLLABUS (CBCS) FOR M.Sc. Statistics**
**(With effect from Academic Year 2022-2023)**

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|---|---|
| **Name of the Programme** | **:** M.Sc. Statistics |
| **Program Code** | **:** PSST |
| **Class** | **:** M.Sc. Part – I |
| **Semester** | **:** II |
| **Course Name** | **:** Regression Models |
| **Course Code** | **:** PSST124 |
| **No. of lectures** | **:** 60 |
| **Credit** | **:** 4 credits |

## Course Outcomes:

Students will be able to

1) Excellent familiarity with both linear and nonlinear regression models.
2) Understanding of model selection and regression modelling techniques should be demonstrated.
3) The relation between dependent and independent variables should be examined.
4) Estimate the parameters and fit a model.
5) Investigate possible diagnostics in regression modeling and analysis.
6) Use confidence intervals and hypothesis testing to validate the model.

**TOPICS/CONTENTS:**

### Unit-1

Simple linear regression, assumptions, least square (LS) estimators of parameters, standard error of estimators, testing of hypothesis for coefficient of regression, S.E. of prediction, testing of hypothesis about parallelism (slopes), equality of intercepts, generalized and weighted least squares, congruence, extrapolation, optimal choice of independent variables diagnostics checks and correction: graphical technique, tests for normality, uncorrelatedness, homoscedasticity, lack of fit, transformation on of dependent or independent variables. **(15L)**

### Unit 2

Multiple regression: Standard Gauss-Markov setup, least square estimation, error and estimation spaces, variance and covariance of LS estimators, properties of LS estimators, estimation of error variance, case with correlated observation, LS estimation with restriction on parameters, simultaneous

estimation of linear parametric functions, testing of hypothesis for one and more than one linear parametric functions, confidence intervals and regions, generalized and weighted least squares, Mallows Cp, stepwise regression methods – forward, backward, stepwise. **(15L)**

## Unit 3

**a)** Multicollinearity: consequences, detection and remedies: (Principal component regression, ridge regression), autocorrelation consequences, Durbin Watson test, estimation of parameters in autocorrelation. **(10L)**

**b)** Test for significance of simple, multiple and partial correlation coefficients. Residual and residual diagnostics, transformation of variables: Box-Cox power Transformation. **(5L)**

## Unit 4

**a)** Polynomial regression, inverse regression, Non-linear regression: Non-linear least squares transformation to a linear model, their uses and limitations, examination of non-linearity, initial estimates, iterative procedure, and Newton-Raphson method. **(5L)**

**b)** Generalized linear model: Link function: normal, binomial, Poisson, exponential, gamma. Logit transform, ML estimation of Logistic regression, tests of hypothesis, Wald test, LR test, score test, test for overall regression. **(10L)**

## References


1) Draper, N. R. and Smith H. (1998) Applied regression analysis 3rd edition ( John Wiley)
2) Hosmer, D. W. and Lemeshow, S. (1989) Applied logistic regression (John Wiley)
3) Mc Cullagh, P. and Nelder, J. A.(1989) Generalized linear models (Chapman and Hall)
4) Montogomery D.C., Elizabeth a. Peck, G. Geoffrey.(2003) Introduction to linear regression analysis (Wiley Eastern)
5) Neter, J.; Wasserman, W. and Kutner, M.H.(1985) Applied linear statistical models
6) Ratkowsky, D. A. (1983) Nonlinear regression modeling (Marcel Dekker)

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**Name of the Programme** : M.Sc. Statistics
**Program Code** : PSST
**Class** : M.Sc. Part – I
**Semester** : II
**Course Name** : Statistics Practical – III
**Course Code** : PSST125
**No. of lectures** : 60
**Credit** : 4 credits

## Course Outcomes:

Students should be able to:

1) understand the link between multivariate techniques and corresponding univariate techniques,
2) analyze multivariate data and the dependence structure of variates to extract the useful information from a massive dataset,
3) apply suitable tools for exploratory data analysis, dimension reduction, and classification to formulate and solve real-life problems,
4) analyze multivariate data using data reduction techniques like principal component analysis, factor analysis,

| Sr. No. | Title of Experiments |
|---|---|
| 1. | Exploratory multivariate data analysis |
| 2. | Testing Multivariate Normality |
| 3. | Model sampling from multivariate normal distribution and computation of M.L.E.'s of parameters |
| 4. | Principal component analysis |
| 5. | Factor Analysis |
| 6. | Cluster Analysis |
| 7. | Canonical correlation analysis |
| 8. | Application of Hotelling $T^2$ statistics- I |
| 9. | Application of Hotelling $T^2$ statistics- II |
| 10. | Likelihood ratio tests (Multivariate Test) |
| 11. | Discriminant analysis |
| 12. | Multivariate Analysis of Variance |

**SYLLABUS (CBCS) FOR M.Sc. Statistics**
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**Name of the Programme** : M.Sc. Statistics
**Program Code** : PSST
**Class** : M.Sc. Part – I
**Semester** : II
**Course Name** : Statistics Practical – IV
**Course Code** : PSST126
**No. of lectures** : 60
**Credit** : 4 credits

## Course Outcomes:

Students should be able to:

1) Excellent familiarity with both linear and nonlinear regression models.
2) Understanding of model selection and regression modelling techniques should be demonstrated.
3) Estimate the parameters and fit a model.
4) Investigate possible diagnostics in regression modeling and analysis.
5) Use confidence intervals and hypothesis testing to validate the model.

| Sr. No. | Title of Experiments |
|---|---|
| 1. | Simple regression and regression diagnostic |
| 2. | Multiple regression |
| 3. | Lack of fit of the regression model |
| 4. | Multiple regression (selection of variable) |
| 5. | Multicollinearity and diagnosis I |
| 6. | Multicollinearity and diagnosis II |
| 7. | Polynomial regression |
| 8. | Nonlinear regression |
| 9. | Poisson regression |
| 10. | Logistic regression |
| 11. | Computation of confidence coefficient for given confidence interval. |
| 12. | Comparison of lengths of CI |