UNIVERSITY OF MUMBAI
No. UG/127 of 2018-19

CIRCULAR:-

Attention of the Principals of the affiliated Colleges, the Head University Departments and Directors of the recognized Institutions in Humanities and Science & Technology Faculties is invited to this office Circular No. UG/107 of 2013-14, dated 26th March, 2014, relating to syllabus as per CBSGS for First Year (Semester I & II) of M.A./M.Sc. Programme in course of Statistics.

They are hereby informed that the recommendations made by the Board of Studies in Statistics at its meeting held on 1st August, 2018 have been accepted by the Academic Council at its meeting held on 8th September, 2018 **vide** item No. 4.8 and that in accordance therewith, the revised syllabus as per the (CBCS) for the M.A./M.Sc. in Statistics (Sem. I & II) has been brought into force with effect from the academic year 2018-19, accordingly. (The same is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
12th December, 2018
To

(Prof. Sunil Bhirud)
I/c REGISTRAR

The Principals of the affiliated Colleges, the Head University Departments and Directors of the recognized Institutions in Humanities and Science & Technology Faculties. (Circular No. UG/334of 2017-18 dated 9th January, 2018.)

A.C/4.8/08/09/2018

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No. UG/127 -A of 2018 MUMBAI-400 032 12th December, 2018

Copy forwarded with Compliments for information to:-

1) The I/c Dean, Faculties of Humanities and Science & Technology,
2) The Chairman, Board of Studies in Statistics,
3) The Director, Board of Examinations and Evaluation,
4) The Professor-cum-Director, Institute of Distance & Open Learning (IDOL)
5) The Director, Board of Students Development,
6) The Co-ordinator, University Computerization Centre,

(Prof. Sunil Bhirud)
I/c REGISTRAR

M.A./ M.Sc. Part - I <Statistics> Syllabus
Revised for Credit Based and Choice System
Implemented from the Academic year 2018-19.

Table showing the proposed twelve papers to be covered in the first year in two semesters.

SEMESTER I	COURSE PSST 101	COURSE PSST 102	COURSE PSST 103	COURSE PSST 104	PSST P1A & PSST P1B
	PROBABILITY THEORY	LINEAR MODELS	THEORY OF ESTIMATION	SAMPLING TECHNIQUES	STATISTICS PRACTICAL – I
					STATISTICS PRACTICAL - II
SEMESTER II	COURSE PSST 201	COURSE PSST 202	COURSE PSST 203	COURSE PSST 204	PSST P2A & PSST P2B
	DISTRIBUTION THEORY	REGRESSION ANALYSIS	PLANNING AND ANALYSIS OF EXPERIMENTS - I	MULTIVARIATE ANALYSIS – I	STATISTICS PRACTICAL-III
					STATISTICS PRACTICAL -IV

SEMESTER-I

Total No. of Classroom Teaching 60 hours +60 notional Hours =120 hours= 4 credits

Course Code	UNIT	PROBABILITY THEORY	Number of Lectures
PSST101	I	Mathematical Analysis (Proof is not expected) Sequence and series, limit, limit inferior, limit superior, monotone sequence, convergence of sequence, infinite series, Power series. Function, limit of a function, left and right hand limit, continuity, uniform continuity, derivative, mean values theorems, Taylor series expansion, intermediate forms, partial derivatives, extreme values, implicit, explicit function. Introduction to Riemann integration, integrable functions, integration under differentiation, fundamental theorem on calculus, mean value theorems of integral calculus, integration by parts. Change of limits of integration. Improper integrals: limit of integration, convergence, absolute convergence, uniform convergence,	15
	II	Sets, classes of sets, algebra of sets, limits of sequence of sets, field, sigma-field, Borel field, minimal field, definitions: random experiment, sample space, event. Measure, measureable sets, non-measurable sets, Probability space, probability definitions, Bonferroni's inequality, Booles' inequality, continuity theorem.	15
	III	Conditional probability, independence, Borel zero-one law, Borel-Cantelli lemma, Kolmogorov zero-one law. Random variable, Expectation and moments, some moment inequalities, Convolution. Characteristic function, continuity theorem of characteristic function.	15
	IV	Convergence of sequence of random variables, various types of convergence and their interrelations, Monotone convergence theorem, dominated convergence theorem. Law of large numbers: weak, strong. Central limit theorem: Lindberg's central limit theorem, Liapounov's central limit theorem.	15

References Books:

01 Apostol, T. M. (1974): Mathematical Analysis. 2nd edition, Narosa Publishing house.

02 Bartle G. and Sherbet, D. R. (2000): Introduction to Real Analysis. 3rd edition. Wiley.

03 Bhat B.R. (1999): Modern Probability Theory: An Introductory test book. 3rd edition. New Age International.

04 Chandra, T. and Gangopadhyay, S. (2017): Fundamentals of Probability Theory. Narosa Publishing House.

05 Gut, A. (2005): Probability: A Graduate Course. Springer.

06 Kumar, A and Kumaresan S. (2015): A Basic course in Real analysis. CRC Press.

07 Malik, S. C. and Arora, S. (2017): Mathematical Analysis. 5th edition. New age International Publishers.

08 Rohatgi V.K. & Saleh A.K. Md. Ehasanes (2001) - An Introduction to Probability and Statistics. Wiley.

09 Rudin, W. (1976): Principles of Mathematical Analysis. 3rd edition. McGraw-Hill.

Course Code	UNIT	LINEAR MODELS I	Number of Lectures
PSST 102	**I**	Basic operations ,Vector Spaces, Linear dependence and independence, Determinants of Matrices: Definition, Properties and applications of determinants for 3rd and Higher order, Inverse of matrix ,Trace of matrix, Partition of matrix, Rank of matrix, echelon forms, canonical form, generalized inverse, Solving linear equations, Characteristic roots and characteristic vectors, properties of characteristics roots , Idempotent matrix, Quadratic forms, positive and Positive semi definite matrix,	15
	II	Linear parametric function and its estimability, Gauss markoff theorem, Interval estimates and test of hypothesis, fundamental theorems on conditional error ss, Test of $\Lambda\beta=d$, generalized least squares	**15**

	III	Analysis of variance, fixed effect models : i. One –way classification model ii. Checking assumptions of ANOVA Model. iii. Simultaneous Confidence Intervals: Scheffe's, Bonferroni and Turkey's interval, iv . Two – way classification model with and without interaction effect, one observation per cell and r observations per cell. Tukey's test for non additivity. v . Two – way classification model with and without interaction effect with unequal number of observations per cell.	15
	IV	i) Analysis of variance with random and Mixed effect models: Estimation and testing of variance components in one-way, two-way and multiway classification models. ANOVA method. ii) Analysis of Covariance: Model, BLUE, ANOCOVA table, testing of hypothesis, use of ANOCOVA for missing observation.	15

References Books:

References Books : Linear Models

1. Hohn Franz E : Elementary Matrix Algebra
2. Searle S.R. : Matrix Algebra useful for Statistics
3. Kshirsagar A.M. : A course in Linear Models
4. Wang S. GUI and Chow S.C. : Advanced Linear Models.
5. Healy M. J. R. : Matrices for Statistics
6. Shantinarayan : Textbook of Matrices
7. Bishop: discrete data analysis.
8. Finney D, J :- Statistical methods in biological assays.
9. Graybill F.A :- An introduction to linear statistical models Vol. I.
10. Rao C.R :- Linear statistical inference and its applications.
11. Searle S.R :- Linear models.
12. Sen A & Srivastava M. :- Regression analysis. Springer.
13. Scheffe H :- Analysis of variance.

Course Code	UNIT	ESTIMATION THEORY	Number of Lectures
PSST103	I	Problem of point Estimation, sufficiency, Neymann factorization theorem, minimal sufficiency, completeness, Ancillarity. Unbiasedness, Uniformly minimum Variance Unbiased Estimator, Rao-Blackwell theorem, Lehmann-Scheffe theorem	15
	II	Methods of estimation: Method of moments, method of maximum Likelihood estimation (M.L.E.), properties of M.L.E, Scoring method, Large sample properties of MLE.	15
	III	Bounds for the variance: Cramer-Rao lower bound, Bhattacharya bound, Chapman-Robbins-Keifer bound for the variance of an Estimator. Consistency, properties of consistent estimators.	15
	IV	Bayes estimator, Loss function, risk functions, Minimaxity and Admissibility, Non-parametric Estimation, Jacknife and Bootstrap Estimator.	15

References Books

01 Casella, G. and Berger, R. L. (2002): Statistical Inference. Duxbury.

02 Cox, D. R. and Hinkley, D. V. (1996): Theoretical Statistics. Chapman and Hall.

03 Dixit, U. J. (2016): Examples in Parametric Inference with R. Springer.

04 Jun Shao (2005): Mathematical Statistics. Springer.

05 Kale, B. K. (2005): A First Course on Parametric Inference. Narosa Publishing.

06 Lehmann, E.L.and George Casella(1998) :- Theory of point estimation. Springer.

07 Rohatgi V.K. & Saleh A.K. Md. Ehasanes (2001) - An Introduction to Probability and Statistics. Wiley.

Course Code	UNIT	SAMPLING TECHNIQUES	Number of Lectures
PSST104	**I**	Complete enumeration, need of sampling, types of sampling: probability sampling and non probability sampling. Some concepts: unit, population, population parameter, sampling unit, sampling frame, sample. Simple random sampling, stratified random sampling, need for stratification, allocation requiring more than 100% sampling, effects of deviations from optimum allocation, Post stratification, method of collapsed strata, allocation of more than one unit. Determination of sample size Ratio estimator, Unbiased type ratio estimator. Ratio method for stratified random sampling, combined and separate ratio, regression estimators. Regression estimator, Regression method for stratified random sampling, combined and separate regression estimators.	15
	II	Systematic sampling when $N = nk$ and $N \neq nk$, estimation of variance of estimated mean, Comparison of systematic random sampling with simple random sampling and without replacement and stratified random sampling. Varying Probability Sampling: Probability Proportional to Size sampling with replacement (PPSWR): Methods of obtaining a sample i. Cumulative Total Method. ii. Lahiri's method Properties of the estimator Hansen-Hurwitz estimator. Comparison of PPSWR with simple random sampling with replacement. Probability Proportional to Size sampling without replacement: Sen-Midzuno method, Des Raj's ordered estimator, Horvitz-Thompson estimator, Yates Grundy form of variance.	15

	III	Cluster Sampling: Cluster sampling of uniform cluster size, efficiency of cluster sampling with respect to simple random sampling. Optimum cluster size, Cluster sampling of unequal cluster size Two-stage sampling: with equal first-stage units, optimum values of n and m, with unequal first-stage units. Two-phase sampling (Double sampling): Double sampling for stratification, optimum allocation.	15
	IV	Network sampling: multiplicity estimator, Horvitz-Thompson estimator, stratification in network sampling. Adaptive sampling: adaptive cluster sampling, systematic and strip adaptive cluster sampling, stratified adaptive cluster sampling. Non-sampling errors: response and non-response error, methods of imputation.	15

References Books

01 Bansal A, (2017): survey Sampling. Narosa.

02 Chaudhari, A and Stenger, H (1992): Survey Sampling, Marcel Dekker.

03 Chaudhari, A (2014): Modern Survey Sampling, CRC Press.

04 Cochran W.G. (1999): Sampling techniques. Wiley series.

05 Singh Daroga and Chaudhary, F. S. (1986): Theory and Analysis of Sample Survey Designs. New Age International Publishers.

06 Mukhopadhyay, P. (2009): Theory and Methods of Survey Sampling. Eastern Economy Edition, 2nd Edition.

07 Murthy M.N.(1967): Sampling theory and Methods. Statistical Publishing Society, Calcutta.

08 Sukhatme,P.V.and Sukhatme B.V.(1970) : Sampling theory of Surveys with applications. Food and Agriculture organization.

09 Thompson, S. K. (2002): Sampling. Willey. 2nd edition.

<table>
<tr><th>Course Code</th><th>STATISTICS PRACTICALS - I</th></tr>
<tr><td>PSST P1A</td><td>
<table>
<tr><td>Sr. No.</td><td>Title of Practical</td></tr>
<tr><td colspan="2">Practicals based on Estimation Theory & Matrix theory</td></tr>
<tr><td>01</td><td>Matrix Theory-I(Determinant, Rank of Matrix , Inverse of matrix)</td></tr>
<tr><td>02</td><td>Matrix Theory-II-(Generalized Inverse, Simultaneous Linear Equations ,Characteristics roots & Characteristics Vectors)</td></tr>
<tr><td>03</td><td>Methods of estimation.</td></tr>
<tr><td>03</td><td>Uniform Minimum variance unbiased estimation – II</td></tr>
<tr><td>04</td><td>Lower bounds for variance</td></tr>
<tr><td>05</td><td>Consistency</td></tr>
<tr><td>06</td><td>Bayes’ Estimation</td></tr>
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<tr><td></td><td>
<table>
<tr><td>Sr. No.</td><td>Title of Practical</td></tr>
<tr><td colspan="2">Practicals based on SamplingTechniques</td></tr>
<tr><td>07</td><td>Simple random sampling and Stratified random sampling.</td></tr>
<tr><td>08</td><td>Ratio and Regression methods of Estimation.</td></tr>
<tr><td>09</td><td>Systematic random sampling and Varying Probability Sampling</td></tr>
<tr><td>10</td><td>Cluster sampling.</td></tr>
<tr><td>11</td><td>Two-stage and Two-phase sampling.</td></tr>
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<tr><th>Course Code</th><th>STATISTICS PRACTICAL - II</th></tr>
<tr><td rowspan="2">PSST P1B</td><td>
<table>
<tr><td>Sr. No.</td><td></td></tr>
<tr><td>01</td><td>Introduction to R Language, SAS and SPSS softwares..</td></tr>
<tr><td>02</td><td>Elementary calculation</td></tr>
<tr><td>03</td><td>Data processing and Manipulation</td></tr>
<tr><td>04</td><td>Matrix operations using R language & SAS language</td></tr>
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</td></tr>
<tr><td>Practical’s based on Linear Models.
<table>
<tr><td>Sr. No.</td><td></td></tr>
<tr><td>01</td><td>Matrix Theory-I (Determinant, Rank of Matrix , Inverse of matrix)</td></tr>
<tr><td>02</td><td>Matrix Theory-II(Generalized Inverse, Simultaneous Linear Equations, Characteristics roots & Characteristics Vectors)</td></tr>
<tr><td>03</td><td>Linear Model-I</td></tr>
<tr><td>04</td><td>Linear Model-II</td></tr>
<tr><td>05</td><td>Techniques for Checking Assumptions of ANOVA</td></tr>
<tr><td>06</td><td>One way classification model</td></tr>
<tr><td>07</td><td>Two way classification model -I</td></tr>
<tr><td>08</td><td>Two way Classification Model-II</td></tr>
<tr><td>09</td><td>Random Effect Models</td></tr>
<tr><td>10</td><td>Analysis of Covariance</td></tr>
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Content of Statistical practical PSSTP1A and PSSTP1B to be covered with the help software’s like SAS , SPSS and R.

8 hours practical per week
Therefore Practicals with Software = 8 hours per week
Hence 120 Teaching hours + 120 Notional hours
= 240 hours
= 8 credits
PSSTP1A for 4 credits and PSSTP1B for 4 credits.

Reference Books : **Statistical Software**

1. Carver R.H. & others Data analysis with SPSS.
2. Cody R.P. & Smith J.H. Applied Statistics and the SAS programming language.
3. Darren Georage and Paul Mallery SPSS for windows.
4. Spencer N.H.(2004) SAS Programming, the one day course.
5. Random A and Everitt R.S. : A handbook of statistical analysis using R
6. Nom o' Rowke, Larry Hatcher, Edward J. Stepansk : A Step by step approach using SAS for univariate and multivariate Statistics (2nd Edition)
7. A step by step Approach using SAS for unvariate and multivariate Statistics-2nd Edition by Nom O' Rourke, Larry Hatcher Edward J. Stepansk. SAS Institution. Inc. Wily.
8. Data. Statistics and Decision Models with Excel Donald L. Harmell, James F.Horrell.
9. Cornillon, P.et.al. (2015): R for statistics, CRC Press.

Data Site :

http://www.cmie.com/ - time series data (paid site)
www.mospi.nic.in / websitensso.htm (national sample survey site)
www.mospi.nic.in /cso_test.htm (central statistical organization)
www.cenrusindia.net (cenrus of India)
www.indiastat.com (paid site on India statistics)
www.maharashtra.gov.in /index.php (Maharashtra govt.site)
www.mospi.gov.in (government of India)

Case studies :

1. A.C Rosander : Case Studies in Sample Design
2. Business research methods – Zikund (http://website, swlearning.com)
3. C. Ralph Buncher 21 and Jia-Yeong Tsay : Statistical in the Pharmaceutical Industry
4. Contempory Marketing research – carl McDaniel, Roges Gates. (McDaniel, swcollege.com)
5. Edward J Wegmes g. Smith : Statistical Methods for Cancer Studies
6. Eugene K. Harris and Adelin Albert : Survivorship Analysis for Clinical Studies
7. Marketing research – Zikmund (http://website.swlearing.com)
8. Marketing research – Naresh Malhotra (http://www.prenhall.com /malhotra)
9. http://des.maharashtra.gov.in (government of maharashtra data)
10. Richard G. Cornell :Statistical Methods for Cancer Studies
11. Stanley H. Shapiro and Thomas H.Louis Clinical Trials
12. William J. Kennedy, Jr. and James E. Gentle. Statistical Completing

13. Case Studies in Bayesion Statistics vol. VI
Lecture notes in Bayesion Statistics number 167 (2002)
Constantine, Gatsonis Alicia, Carriquary Andrew, Gelman

14. Wardlow A.C (2005) Practical Statistical for Experimental bilogoists
(2^{nd} Edition)

Seminar : Case Studies listed in the paper to be discussed and brief summary should be prepared.

2 hours per week : (30 Teaching hours+ 30 Notional hours)
= 60 hours
= 2 credits

Total number of Credits for First Semester
Theory 16 + Practicals 8 = 24

Exam Pattern For Theory

Internal Exam	40 Marks
Semester End Exam	60 Marks of 3 hours duration

At the end of First Semester there will be a practical examination based on practical's listed in practical papers PSSTP1A and PSSTP1B using statistical software's like R, SAS and SPSS where necessary.

Exam Pattern For Practical

Practicals papers	Practical examination	Viva	Journal	Total
PSSTP1A	80 marks	10 marks	10 marks	100
PSSTP1B	80 marks	10 marks	10 marks	100

SEMESTER II

Total No. of Classroom Teaching 60 hours +60 notional Hours =120 hours= 4 credits

Course Code	UNIT	DISTRIBUTION THEORY	Number of Lectures
PSST201	I	Distribution function, quantile function, empirical distribution function, Properties of distributions, Jordan decomposition theorem, functions of random variables. Generating functions: probability generating function, moment generating function.	15
	II	Multiple random variables, joint cumulative distribution function, joint probability function, joint moment generating function, conditional probability distribution, conditional expectation, functions of several random variables. Moments, covariance, correlation. Truncated distributions. Mixture of distributions.	15
	III	Some special statistical univariate discrete distributions: degenerate distribution, two-point distribution, discrete uniform distribution, hypergeometric distribution, negative hypergeometric distribution, negative binomial distribution. Special properties of binomial distribution, Poisson distribution, geometric distribution. Compound distributions. Some special statistical bivariate distributions: negative binomial distribution, hypergeometric distribution, Multinomial distribution.	15
	IV	Some special statistical univariate continuous distributions: uniform distribution, Probability integral transform, gamma distribution, beta distribution, Cauchy distribution, Pareto distribution, Order statistics.	15

References Books

01 Bhat B.R. (1999): Modern Probability Theory: An Introductory test book. 3rd edition. New Age International.

02 David, H.A and Nagaraja, H. N. (2005): Order Statistics. Wiley.

03 Johnson, N. L., Kotz S. and Balakrishnan, N (2005): Univariate Discrete Distributions. Wiley.

04 Johnson, N. L., Kotz S. and Balakrishnan, N (2004): Continuous

Univariate Distributions. Volume-I. Wiley.

05 Johnson, N. L., Kotz S. and Balakrishnan, N (2004): Continuous Univariate Distributions. Volume-II. Wiley.

06 Rao, C. R. (2002): Linear statistical Inference and its Applications. Wiley.

07 Rohatgi V.K. & Saleh A.K. Md. Ehasanes (2001) - An Introduction to Probability and Statistics. Wiley.

08 Ross, S. M. (2014): Introduction to Probability Models. 11th edition. Elsevier.

Course Code	UNIT	Regression Analysis	Number of Lectures
PSST 202	I	Multiple Linear regression models: Assumptions of Linear regression model and checking their assumptions, Box-Cox Power transformation, Diagnostics of Multicollinearity, Regression on Dummy variable, Variable Selection methods: Subset selection, Forward selection, backward elimination and stepwise.	15
	II	Regression diagnostics: Analysis of residuals, definition of ordinary and Studentized residuals, their properties and use in regression diagnostics, Autocorrelation, Influence Analysis, Cook's distance, PRESS Statistics, covariance ratio , Orthogonal polynomials.	15
	III	Generalized Linear regression models: Logistic regression: Example, model, MLE of parameters, Iterative procedure to solve likelihood equations, multiple regressors. Multinomial and Ordinal Logistic Regression. Poisson Regression. Analysis of Categorical data: Log linear models, Contingency tables.	15
	IV	Ridge regression: Ill conditioned matrix, need of ridge regression, biased estimator, Mean square error. Bias and MSE of ridge estimator, ridge trace method. Sensitivity Analysis: Properties of Hat matrix, Role of variables in regression model.	15

References Books

1. Kshirsagar A.M. : A course in Linear Models
2. Draper N.R & Smith H : Applied Regression Analysis.
3. Song GUI Wang and S.C Chow: Advanced Linear Models.
4. Agresthi: Categorical data analysis.
5. Chattterjee and Haddi: Sensitivity Analysis
6. David W Hosmer and Stanley Lemeshow: Applied Logistic regression.
7. Healy M. J. R. : Matrices for Statistics
8. Shantinarayan : Textbook of Matrices
9. Bishop: discrete data analysis.
10. Cox, D. R. : Analysis of binary data.
11. Chaterjee and Price: Regression Analysis with examples
12. Finney D, J :- Statistical methods in biological assays.
13. Graybill F.A :- An introduction to linear statistical models Vol. I.
14. Montgomery D.C. & Peck B.A. :- Introduction to linear regression analysis.
15. Rao C.R :- Linear statistical inference and its applications.
16. Searle S.R :- Linear models.
17. Seber G.A.F :- Linear regression analysis.
18. Sen A & Srivastava M. :- Regression analysis. Springer.
19. Scheffe H :- Analysis of variance.

Course Code	UNIT	PLANNING AND ANALYSIS OF EXPERIMENTS - I	Number of Lectures
PSST203	I	Brief History of Statistical Design. Basic principles of design. Contrast, orthogonal contrast and mutual orthogonality of contrasts. General block design (GBD) - an example. C- matrix and its properties. Properties of design – Connectedness, Balance and orthogonal. Statistical analysis of GBD. Randomized Block Design as a particular case of GBD.	15
	II	Balanced incomplete block design (BIBD). C-matrix, properties, statistical analysis of BIBD. Resolvable BIBD, Affine resolvable BIBD Optimality of block design. : A,D,E – optimality.	15

	III	Factorial design – an example. Basic definitions and principles . The advantage of factorial designs. The 2^2 factorial design. The general 2^k factorial design. Fitting response curves and response surfaces. A single replicate of 2^k design. NPP method, half NPP method, hidden replication method, Lenth's method and Bisgaard's conditional inference chart method for detecting significant effects. The addition of centre points to the design.	15
	IV	Blocking and confounding of a replicated 2^k factorial design. Das method, contrast method and sign method to obtain principal block. Total and partial confounding. Two level fractional factorial designs . The one half fraction and one quarter fraction of the 2^k design. General $2^{(k-p)}$ fractional factorial design. Alias structure. Complete defining relation. Resolution – III designs. Resolution -IV and Resolution - V designs. Statistical analysis of all these designs.	15

References Books

01 Chakraborti, M. C. (1962): Mathematics of Design and analysis of Experiments. Asia Publishing House.

02 Cochran, W. G. and cox, G. M. (1959): Experimental Design. 2nd Edition, Asia Publishing House

03 Davies, O. L. (1954): The Design and analysis of Industrial Experiments. Oliver and Boyd.

04 Das, M. N. and Giri, N. C. (2015): Design and analysis of Experiments. 2nd edition. New Age International Publishers.

05 Fisher, R. A. (1935): The Design of Experiments. Oliver and Boyd.

06 Montgomery, D. C. (2016): Design and analysis of Experiments. 8th edition, Wiley.

Course Code	UNIT	MULTIVARIATE ANALYSIS I	Books & Page Numbers
PSST301	I	i) Multivariate data and Multivariate graphical display. Multivariate normal distribution, Wishart distribution,	15
	II	Hotelling' s T^2 and its applications. Regression and correlation coefficients among several variables and their testing.	15
	III	Likelihood Ratio Tests, Multivariate Analysis of variance .	15
	IV	Discriminant analysis, classification of the observations into one of the two populations. Extension to more than two populations.	15

Reference Books :

1. Johnson Richard A and Wichern D.W.(1998) : Applied Multivariate Statistical Analysis (4^{th} Edition)
2. Anderson T.W.(1958) : An Introduction to Multivariate Statistical Analysis.John Wiley & Sons
3. Dillon William R & Goldstein Mathew (1984) : Multivariate Analysis : Methods and Applications.
4. Giri Narayan C. (1995) : Multivariate Statistical Analysis.
5. Kshirsagar A. M. (1979) : Multivariate Analysis ,Marcel Dekker Inc. New York.
6. Hardle Wolfgang & Hlavka : Multivarite Statistics : Exercise & Solutions
7. Parimal Mukhopadhyay: Multivariate Statistical Analysis.

<table>
<tr><th>Course Code</th><th>STATISTICS PRACTICALS - III</th></tr>
<tr><td>PSST P2A</td><td>Practicals based on Distribution Theory and Planning & Analysis of Experiments-I
<table>
<tr><td>Sr. No.</td><td>Title of Practical</td></tr>
<tr><td>01</td><td>Generating random sample from discrete distributions.</td></tr>
<tr><td>02</td><td>Generating random sample from continuous distributions.</td></tr>
<tr><td>03</td><td>Probability plotting.</td></tr>
<tr><td>04</td><td>C Matrix: Checking Connectedness, Balance and Orthogonality.</td></tr>
<tr><td>05</td><td>NPP, Half NPP and Hidden replication method for single replicate 2^k Design.</td></tr>
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<tr><td></td><td>Practicals based on Regression analysis
<table>
<tr><td>Sr. No.</td><td>Title of Practical</td></tr>
<tr><td>01</td><td>Multiple linear Regression: Assumption Checking, Multicolliearity, Selection methods.</td></tr>
<tr><td>02</td><td>Regression Diagnostics</td></tr>
<tr><td>03</td><td>Binary Logistic Regression</td></tr>
<tr><td>04</td><td>Multinomial Logistic Regression</td></tr>
<tr><td>05</td><td>Ordinal Logistic Regression.</td></tr>
<tr><td>06</td><td>Poisson Regression.</td></tr>
<tr><td>07</td><td>Orthogonal Polynomials</td></tr>
<tr><td>08</td><td>Categorical Data Analysis</td></tr>
<tr><td>09</td><td>Ridge Regression</td></tr>
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<table>
<tr><th>Course Code</th><th>STATISTICS PRACTICALS - IV</th></tr>
<tr><td>PSST P2B</td><td>Practicals based on Planning and Analysis of Experiments.
<table>
<tr><td>Sr. No.</td><td>Title of Practical</td></tr>
<tr><td>01</td><td>Completely Randomized design</td></tr>
<tr><td>02</td><td>General block design</td></tr>
<tr><td>03</td><td>Randomized block design</td></tr>
<tr><td>04</td><td>Balanced Incomplete block design</td></tr>
<tr><td>05</td><td>2^2 factorial design.</td></tr>
<tr><td>06</td><td>Single replicate 2^k design</td></tr>
<tr><td>07</td><td>Confounding in 2^k factorial design</td></tr>
<tr><td>08</td><td>Two level fractional factorial design</td></tr>
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<tr><td></td><td>Practicals based on Multivariate analysis
<table>
<tr><td>Sr. No.</td><td>Title of Practical</td></tr>
<tr><td>01</td><td>Multivariate Normal Distribution.</td></tr>
<tr><td>02</td><td>Hoteling T^2</td></tr>
<tr><td>03</td><td>Multivariate Regression</td></tr>
<tr><td>04</td><td>Likelihood Ratio Test</td></tr>
<tr><td>05</td><td>Multivariate Analysis of Variance (MANOVA)</td></tr>
<tr><td>06</td><td>Discriminant Analysis</td></tr>
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Contents of PSST P2A & PSSTP2B to be covered with the help of Statistical Software like SAS, SPSS, MINITAB, ' R' Software etc

8 hours practical per week

Therefore Practicals with Software = 8 hours per week

Hence 120 Teaching hours + 120 Notional hours

= 240 hours

= 8 credits

PSSTP2A for 4 credits and PSSTP2B for 4 credits

Reference Books : **Statistical Software**

10. Carver R.H. & others Data analysis with SPSS.
11. Cody R.P. & Smith J.H. Applied Statistics and the SAS programming language.
12. Darren Georage and Paul Mallery SPSS for windows.
13. Spencer N.H.(2004) SAS Programming, the one day course.
14. Practical Statistical for experimental biologists.
15. Random A and Everitt R.S. : A handbook of statistical analysis using R
16. Nom o' Rowke, Larry Hatcher, Edward J. Stepansk : A Step by step approach using SAS for univariate and multivariate Statistics (2nd Edition)
17. A step by step Approach using SAS for unvariate and multivariate Statistics-2nd Edition by Nom O' Rourke, Larry Hatcher Edward J. Stepansk. SAS Institution. Inc. Wily.
18. Data. Statistics and Decision Models with Excel Donald L. Harmell, James F.Horrell.

Data Site :

http://www.cmie.com/ - time series data (paid site)
www.mospi.nic.in / websitensso.htm (national sample survey site)
www.mospi.nic.in /cso_test.htm (central statistical organization)
www.cenrusindia.net (cenrus of India)
www.indiastat.com (paid site on India statistics)
www.maharashtra.gov.in /index.php (Maharashtra govt.site)
www.mospi.gov.in (government of India)

Case studies :

1. A.C Rosander : Case Studies in Sample Design
2. Business research methods – Zikund (http://website, swlearning.com)
3. C. Ralph Buncher 21 and Jia-Yeong Tsay : Statistical in the Pharmaceutical Industry
4. Contempory Marketing research – carl McDaniel, Roges Gates. (McDaniel, swcollege.com)
5. Edward J Wegmes g. Smith : Statistical Methods for Cancer Studies
6. Eugene K. Harris and Adelin Albert : Survivorship Analysis for Clinical Studies
7. Marketing research – Zikmund (http://website.swlearing.com)
8. Marketing research – Naresh Malhotra (http://www.prenhall.com /malhotra)
9. http://des.maharashtra.gov.in (government of maharashtra data)
10. Richard G. Cornell :Statistical Methods for Cancer Studies
11. Stanley H. Shapiro and Thomas H.Louis Clinical Trials
12. William J. Kennedy, Jr. and James E. Gentle. Statistical Completing
13. Case Studies in Bayesion Statistics vol. VI
    Lecture notes in Bayesion Statistics number 167 (2002)

Constantine, Gatsonis Alicia, Carriquary Andrew, Gelman
14. Wardlow A.C (2005) Practical Statistical for Experimental bilogoists (2^{nd} Edition)

Seminar : Case Studies listed in the paper to be discussed and brief summary should be prepared.
2 hours per week : 30 Teaching hours+ 30 Notional hours
= 60 hours
= 2 credits

Total number of Credits for Second Semester
Theory 16 + Practicals 8 = 24

Exam Pattern For Theory

Internal Exam	40 Marks
Semester End Exam	60 Marks of 3 hours duration

At the end of second Semester there will be a practical examination based on practical's listed in practical papers PSSTP2A and PSSTP2B using statistical software where necessory .

Exam Pattern For Practical

Practicals papers	Practical examination	Viva	Journal	Total
PSSTP2A	80 marks	10 marks	10 marks	100
PSSTP2B	80 marks	10 marks	10 marks	100

Semester I	Theory Practicals	4 x 4=16 8 24 credits
Semester II	Theory Practicals	4 x 4=16 8 24 credits