University of Mumbai

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Academic Authorities,
Meetings &Services (AAMS)
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Re- accredited with A ++ Grade (CGPA 3.65) by NAAC
Category- I University Status awarded by UGC

No. AAMS_UGS/ICC/2024-25/246 Date: 06th March, 2025

CIRCULAR:-

All the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Departments is invited to this office Circular No.UG/112 of 2019-20 dated 18th September, 2019 relating to the revised syllabus of M.Phil/Ph.D. course work in Statistics.

They are hereby informed that the recommendations made by the **Board of Studies in** Statistics at its meeting held on 07th December, 2024 and subsequently passed by the Board of Deans at its meeting held on 27th January, 2025 **vide** Item No. 6.1 (R) have been accepted by the Academic Council at its meeting held on 27th January, 2025 **vide** item No. 6.1 (R) and that in accordance therewith syllabus for Pre-Ph.D. course work in Statistics was revised as per appendix with effect from the academic year 2024-25.

(The Circular is available on the University's website www.mu.ac.in).

(Dr. Prasad Karande)
REGISTRAR

MUMBAI – 400 032
06th March, 2025

To

All the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Departments.

AC./6.1(R) 27/01/2025

Copy forwarded with Compliments for information to:-

1) The Chairman, Board of Deans,
2) The Dean, Faculty of Science & Technology,
3) The Chairman, **Board of Studies in Statistics**
4) The Director, Board of Examinations and Evaluation,
5) The Director, Department of Students Development,
6) The Director, Department of Information & Communication Technology,
7) The Director, Centre for Distance and Online Education (CDOE) Vidyanagari,
8) The Deputy Registrar, Admission, Enrolment, Eligibility & Migration Department (AEM),

Copy forwarded for information and necessary action to :-	
1	The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Dept)(AEM), dr@eligi.mu.ac.in
2	The Deputy Registrar, Result unit, Vidyanagari drresults@exam.mu.ac.in
3	The Deputy Registrar, Marks and Certificate Unit,. Vidyanagari dr.verification@mu.ac.in
4	The Deputy Registrar, Appointment Unit, Vidyanagari dr.appointment@exam.mu.ac.in
5	The Deputy Registrar, CAP Unit, Vidyanagari cap.exam@mu.ac.in
6	The Deputy Registrar, College Affiliations & Development Department (CAD), deputyregistrar.uni@gmail.com
7	The Deputy Registrar, PRO, Fort, (Publication Section), Pro@mu.ac.in
8	The Deputy Registrar, Executive Authorities Section (EA) eau120@fort.mu.ac.in He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
9	The Deputy Registrar, Research Administration & Promotion Cell (RAPC), rapc@mu.ac.in
10	The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA) dy.registrar.tau.fort.mu.ac.in ar.tau@fort.mu.ac.in
11	The Deputy Registrar, College Teachers Approval Unit (CTA), concolsection@gmail.com
12	The Deputy Registrars, Finance & Accounts Section, fort draccounts@fort.mu.ac.in
13	The Deputy Registrar, Election Section, Fort drelection@election.mu.ac.in
14	The Assistant Registrar, Administrative Sub-Campus Thane, thanesubcampus@mu.ac.in
15	The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan, ar.seask@mu.ac.in
16	The Assistant Registrar, Ratnagiri Sub-centre, Ratnagiri, ratnagirisubcentar@gmail.com
17	The Director, Centre for Distance and Online Education (CDOE), Vidyanagari, director@idol.mu.ac.in
18	Director, Innovation, Incubation and Linkages, Dr. Sachin Laddha pinkumanno@gmail.com
19	Director, Department of Lifelong Learning and Extension (DLLE), dlleuniversityofmumbai@gmail.com

Copy for information :-	
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2	P.A to Pro-Vice-Chancellor pvc@fort.mu.ac.in
3	P.A to Registrar, registrar@fort.mu.ac.in
4	P.A to all Deans of all Faculties
5	P.A to Finance & Account Officers, (F & A.O), camu@accounts.mu.ac.in

To,

1	The Chairman, Board of Deans pvc@fort.mu.ac.in
2	**Faculty of Humanities,** **Dean** 1. Prof.Anil Singh Dranilsingh129@gmail.com **Associate Dean** 2. Dr.Suchitra Naik Naiksuchitra27@gmail.com 3.Prof.Manisha Karne mkarne@economics.mu.ac.in
	Faculty of Commerce & Management, **Dean** 1. Dr.Kavita Laghate kavitalaghate@jbims.mu.ac.in **Associate Dean** 2. Dr.Ravikant Balkrishna Sangurde Ravikant.s.@somaiya.edu 3. Prin.Kishori Bhagat kishoribhagat@rediffmail.com

	Faculty of Science & Technology **Dean** 1. Prof. Shivram Garje ssgarje@chem.mu.ac.in **Associate Dean** 2. Dr. Madhav R. Rajwade Madhavr64@gmail.com 3. Prin. Deven Shah sir.deven@gmail.com
	Faculty of Inter-Disciplinary Studies, **Dean** 1.Dr. Anil K. Singh aksingh@trcl.org.in **Associate Dean** 2.Prin.Chadrashekhar Ashok Chakradeo cachakradeo@gmail.com
3	Chairman, Board of Studies,
4	The Director, Board of Examinations and Evaluation, dboee@exam.mu.ac.in
5	The Director, Board of Students Development, dsd@mu.ac.in DSW direcotr@dsw.mu.ac.in
6	The Director, Department of Information & Communication Technology, director.dict@mu.ac.in

AC – 27/01/2025
Item No.- 6.1 (R)

University of Mumbai

Title of the program

Pre-Ph.D course work in Statistics

(With effect from the academic year 2024-25)

University of Mumbai

(As per NEP 2020)

Sr. No.	Heading	Particulars
1	Title of program O:_____	Pre-Ph.D course work in Statistics
2	Eligibility for Admission O: _____	As per University Ordinance
3	Standards of Passing R: _____	50%
4	Years	
5	Program Academic Level	P.G.
6	Pattern	Yearly / Semester
7	Status	New/Revised
8	To be implemented from Academic Year	With effect from Academic Year 2024-25

Sign of the BOS
Chairman
Dr. Santosh Gite
BOS in Statistics

Sign of the
Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science &
Technology

Offg. Dean
Prof. Shivram S. Garje
Faculty of Science and
Technology
University of Mumbai

Syllabus

Pre-PhD Course work for Ph.D. in Statistics

To be implemented from academic year 2024-25.

Pre- Ph.D. course in Statistics is a two semester program. The program consists of 12 credits. Research Methodology and Essential Advanced statistical methods are mandatory courses for 8 credits. Seven elective courses are introduced each for 4 credits. Student has to choose one elective course from seven elective courses which is related to interest area of research.

Program: Pre-Ph.D. course work

Course Code: PHST01

Course Title: Research Methodology.

Duration of course: Classroom Teaching 60 hours

Credits of the course: 04 credits.

Objectives of the Course: To understand the research process and ethics in research.

Outcomes of the Course: Course outcomes: After completion of the course learners will,

CO 1) Understand meaning of research.

CO 2) Able to define research problem.

CO 3) Know methods of collecting data statistically.

CO 4) Know how to handle missing observations statistically in data.

CO 5) Able to use open access journals and databases.

CO 6) Know research ethics and ethical practices for future research.

Course contents:

Meaning of research, objectives of research, types of research, research process, research design, measurement and scaling, scaling techniques, types of data, Statistics in scientific Research: research design, types of statistical research: empirical, field experiments, laboratory experiments.

Data collection methods: population, sample, sampling frame, sampling unit, determination of sample size, review of probability and non-probability sampling.

Data analysis: data editing, coding, imputation of missing values, report writing,

Publication Ethics: Philosophy and ethics, scientific misconducts, plagiarism, duplicate and overlapping publications, best practices, conflicts of interest,

violation of publication ethics, authorship and contributor ship.

Open access publications, research databases: Web of Science, Scopus etc. different research Metrics: impact factor, h-index, g index, i10 index, cite score etc.

Random variable generation, Accept-reject method, Monte carlo integration, Monte carlo optimization , Markov chain Monte carlo methods: Metropolis Hasting algorithms and Gibbs sampling algorithms, convergence, applications

Use of computers in statistical research: Statistical packages like SAS, SPSS, MINITAB and other packages like MATLAB, GAUSS, Mathematica, and Maple. R statistical computing environment. LATEX type setting, writing research paper in LATEX.

Refrences.

- Beall, J. (2012): Predatory publishers and corrupting open access. Nature. 489,(7415), 179
- Bird, A. (2006) Philosophy of Science. Routledge.
- Buren, Stef van (2012): Flexible imputation of missing data. Chapman and Hall
- Kothari, C. R. (2014): Research Methodology. Third edition, Wiley Eastern limited
- Patten, M. L. and Newhart, M. (2017): Understanding research methods: An overview of essentials. 10th edition. Routledge.
- Chaddah, P. (2018): Ethics in competitive research: Do not get scooped: do not get plagiarize.
- Muralidhar, K. Ghosh, A. and Singhvi, A. K. (2019): Ethics in science education. Research and Governance, Indian national science academy, New Delhi
- MATLAB online manual.
- MINITAB online manual.
- Mathematica online manual.
- SAS online manual.
- GAUSS online manual.
- LATEX Manual
- R manual

Program: Pre-Ph.D. course work

Course Code: PHST02

Course Title: Essential Advanced Statistical Methods.

Duration of course: Classroom Teaching 60 hours

Credits of the course: 04 credits.

Objectives of the Course: To understand the basic statistical methods useful in research to solve research problem.

Outcomes of the Course: After completion of the course learners will,

CO 1) Understand to solve differential linear and non-linear equations.

CO 2) understand fuzzy concept.

CO 3) understand how to estimate the parameters by EM algorithm.

CO 4) understands resampling methods and data validation methods.

CO 5) Able to understand smoothing techniques.

Course contents:

Differential equations: Linear and nonlinear, ordinary and partial differential equations. Separable method, integrating factor method. Boundary and initial conditions. Maxima, minima, Taylor series expansions, concavity and convexity ,Newton raphson methods.

Basics of Fuzzy Set theory, membership functions, Operations on fuzzy sets (union, intersection, complement), Fuzzy relations and their properties. Overview of Classical Optimization Techniques. Uncertainty and imprecision in real world problems. Role of fuzzy sets in optimization model.

EM algorithm: Incomplete data problems, E and M steps, convergence of EM algorithm, standard errors in the context of EM algorithm, application of EM algorithm.

Maximum likelihood estimation (MLE) under restricted parameter space, inconsistent MLE, MLE in discrete case, iterative procedure for MLE. Confidence sets, Uniformly Most Accurate (UMA), Uniformly Most Accurate Unbiased (UMAU) confidence sets.

Bootstrap methods, estimation of sampling distribution, confidence intervals, failure of bootstrap, variance stabilizing transformation, Jackknife and cross-validation, applications.

Smoothing techniques: Kernel estimators, nearest neighbor estimators, orthogonal and local polynomial estimators, wavelets estimators, splines, choice of bandwidth and other smoothing parameters.

References.

- Lehman, E.L. and Caseela, G (1998): Theory of Point Estimation, Springer 2nd Edition
- S.S. Sastry (1977): Introductory Methods of Numerical Analysis. PHI Learning.
- Earl A. Coddington (1961): An Introduction to Ordinary Differential Equations. PHI Learning.
- T. Amaranath(1996) : An Elementary Course in Partial Diffreantial Equations, Narosa.
- SILVERMAN, B. W. (1986). Density Estimation for Statistics and Data Analysis. Chapman and Hall, Londo
- McLachlan, GJ. And Krishnan, T (2008): The EM Algorithms and Extensions, Wiley.
- Rajgopalan ,M and Dhanvanthan,P(2012): Statistical Inference, PHI Learning.
- Srivastava,M.K. and Srivastava, M(2014): Statistical Inference, PHI Learning Private Limited.
- Bradley Efron and Robert J. Tibshirani (1998): An Introduction to the Bootstrap, Chapman and Hall/CRC.
- Shaha Nita H, Soni Hardik, Gor Ravi M (2007) Operation Research, PHI Learning
- Taha, H. A. (2010): Operations Research: An introduction. Pearson. 9th Edition.
- Winston, W. L. (2003): Operations Research: Applications and Algorithms. Cengage Learning. 4th Edition.
- Swarup, K., Gupta, P. K. and Mohan, M. (1992): Operations Research. Sultan Chand and Sons.SAS online manual.
- Bhargava A.K. (2013), Fuzzy set Theory Fuzzy Logic and their applications , Sultan S Chand
- H.J. Zimmerman (2001), Fuzzy Set Theory- and its applications , Springer.

Elective Papers

Ph.D. student will choose one course from following seven courses which is related to interest of his/her research topic. Elective papers will be taught by concerned supervisor.

Program: Pre-Ph.D. course work

Course Code: E-PHST03

Course Title: Optimization Techniques.

Duration of course: Classroom Teaching 60 hours

Credits of the course: 04 credits.

Objectives of the Course: To understand the basic optimization techniques.

Outcomes of the Course: Course outcomes: After completion of the course learners will,

CO 1) Understand to solve differential linear and non-linear equations.

CO 2) understand fuzzy concept.

CO 3) Understand the different models in inventory control.

CO 4) understands the different queuing models.

CO 5) Able to understand supply chain management system.

Course contents:

Linear Programming Problem (LPP), basic solution, feasible solution, optimal solution, convexity of set of feasible solutions, optimal solution as extreme point of feasible space, simplex method, revised simplex method,

Local and global extrema of a real valued function, unconstrained and constrained extrema of differentiable non-linear real valued function, method of Lagrange multipliers, convex function and its extrema, convex programming problem.

Inventory Management: Introduction to Inventory control problem, Type of Inventory, Different cost in Inventory Problem, Selective control techniques

Techniques of Inventory models: EOQ with known demand, uniform demand, problem of EOQ with shortages, Inventory model with stochastic demand, Buffer stock, price discounts, back order inventory models, Recent trends in inventory management.

Queuing theory: Introduction of Queuing theory, Elements of a Queuing model.
Pure birth and death model, specialized poison queues, single server models: (M/M/1):(GD/∞/∞), M/M/1:(GD/M/∞), Multiserver models.

Supply Chain Management: Defining SCM, Development Trends. Global SC Operations: Global Business Environment, Strategic Challenges, Current change in Global SCM. Supply chain Design and Planning: Supply chain configuration, Extent of vertical Integrations**,** Outsourcing and offshoring, Location Decision, Capacity Planning, Bullwhip effect

References:

- Gross, D. and Harris, C. M. (2002): Fundamentals of queueing theory. John Wiley.
- Kambo, N. S. (2008): Mathematical Programming Techniques. Affiliated East West Press Pvt.
- Taha, H. A. (2010): Operations Research: An introduction. Pearson. 9th Edition.
- Winston, W. L. (2003): Operations Research: Applications and Algorithms. Cengage Learning. 4th Edition.
- Swarup, K., Gupta, P. K. and Mohan, M. (1992): Operations Research. Sultan Chand and Sons.SAS online manual.
- Dr. Dawai Lu(2011): Fundamentals of Supply Chain Management.

Program: Pre-Ph.D. course work

Course Code: E-PHST04

Course Title: Fundamentals of Mathematics.

Duration of course: Classroom Teaching 60 hours

Credits of the course: 04 credits.

Objectives of the Course: To increase fluency of research student in Mathematical foundations required for their research in Statistics.

Outcomes of the Course: Research Student will have knowledge of:

- Concepts of sequence, series and function required in Statistics.
- Differential Calculus and its applications in Statistics.
- Integral calculus and its applications in Statistics.
- Concepts of linear algebra and its applications in Statistics.

Pre-requisites for the Course:

Real system, types of intervals, absolute values and its properties, functions, sets and

operations, bounded and unbounded set, supremum, infimum, countable, uncountable sets, neighborhood of a point, limit point of a set.

Course contents:

Real sequence: limit points of sequence, limit inferior, limit superior of a sequence, convergence of a sequence, divergence of a sequence, Cauchy's principle, monotone sequence, some important sequences.

Infinite series: necessary condition, Cauchy's principle, positive term series and their tests of convergence, alternating series, absolute and conditional convergence, Leibnitz theorem, Cauchy product of two series and its convergence, power series, radius of convergence.

Function of single variable: limit of a function, left and right hand limit, continuity, uniform continuity. Sequence and series of functions, uniform convergence, pointwise convergence.

derivative, mean value theorems, Taylor series expansion, intermediate forms, extreme values.

improper integration, convergence of improper integration, Integration by parts, integration under differentiation, Change of limits of integration. Introduction to Riemann integration, Riemann-Stieltjes integration, Lebesgue integration.

Euclidean space, open set, closed set, metric spaces. functions of several variables, limit point, repeated limits, continuity, differentiability, Taylor's theorem, extreme values, implicit and explicit functions.

Vector Spaces, Linear dependence and independence of vectors. Determinant of Matrices: Definition, Properties and applications of determinants for higher order. Inverse of matrix, trace of matrix, Partition of matrix, Rank of matrix, echelon forms, canonical form. Generalized inverse, Solving linear homogeneous and nonhomogeneous equations. Characteristic roots and characteristic vectors, properties of characteristics roots. Quadratic forms, positive and Positive semi definite matrix. Derivatives with respect to vectors and matrices, LU factorization, Cholesky factorization, spectral decomposition, singular value decomposition, applications.

References:

- Apostol, T. M. (1974): Mathematical Analysis. 2nd edition, Narosa Publishing house.
- Bapat, R. B. (2012): Linear Algebra and Linear models. Hindustan Book Agency. Third edition
- Bartle G. and Sherbert, D. R. (2000): Introduction to Real Analysis. 3rd edition. Wiley.
- Hohn, F. E. (1973): Elements of Matrix Algebra, Macmillan.
- Kumar, A and Kumaresan S. (2015): A Basic course in Real analysis. CRC Press.
- Malik, S. C. and Arora, S. (2017): Mathematical Analysis. 5th edition. New age International Publishers.
- Rudin, W. (1976): Principles of Mathematical Analysis. 3rd edition. McGraw-Hill.
- Rao, C. R. (2002): Linear Statistical Inference and its Applications, Wiley Eastern
- Rao, A. R. and Bhimasankaram, P. (1992): Linear Algebra. Tata McGraw-Hill, new Delhi.
- Searle, S. R. and Khuri, A. I. (2017). Matrix Algebra Useful for Statistics, 2nd Ed., John Wiley, New York.
- Shanti Narayan and Mittal, P. K. (2000): Textbook of Matrices. S. Chand and Company. New Delhi.

Program: Pre-Ph.D. course work

Course Code: E-PHST05

Course Title: Advance Probability Theory

Duration of course: Classroom Teaching 60 hours.

Credits of the course: 04 credits.

Objectives of the Course: To increase fluency of research student in Probability Theory required for their research in Statistics.

Outcomes of the Course: Research Student will have knowledge of:

- Fundamentals of Probability Theory.
- Distribution function and its properties.
- Generating functions.
- Central Limit Theorem.
- Law of large numbers.

Pre-requisites for the Course: elementary knowledge of probability, set operations.

Course contents:

Sets, classes of sets, algebra of sets, limits of sequence of sets. Field, sigma field, Borel sigma field, minimal sigma field, examples. Random experiment, sample space, event, probability measure, conditional probability measure, independence, martingales, random variable Bonferroni's inequality, Booles' inequality, examples.

Distribution function, discrete, continuous, mixed type distributions, properties of distribution function, Jordan decomposition theorem, probability integral transform.

Expectation and moments, non existence of moments, moment inequalities: Jensen's inequality, Markov inequality, basic inequality and their applications, examples. Multiple random variables, joint cumulative distribution function, joint probability function, characteristic function, Laplace transform, Univariate and multivariate transformations.

Probability distributions and their relations, characterizations and generalizations.

Stable distributions, infinite divisibility,

convergence of sequence of random variables, convergence in distribution, convergence in probability, convergence almost surely, convergence in r^{th} mean, their interrelations, Law of large numbers: weak, strong, Central limit theorem: Lindberg Levy's central limit theorem. Monotone convergence theorem, dominated convergence theorem, continuity theorem on probability, Borel zero-one law, Borel-Cantelli lemma.

References:

- Ash, R. B. (2000). Probability & Measure Theory. Academic Press.2^{nd} Edition.
- Athreya, K. B. and Lahiri S. (2006). Measure Theory and Probability Theory, Springer.
- Bhat B.R. (1999): Modern Probability Theory: An Introductory test book. 3^{rd} edition. New Age International.
- Billingsley, P. (1995). Probability and Measure, 3rdEdition, John Wiley, New York
- Chandra, T. and Gangopadhyay, S. (2017): Fundamentals of Probability Theory. Narosa Publishing House.
- Chung, K. L. (2001). A Course in Probability Theory, Third Edition, Academic Press, London
- Gut, A. (2005): Probability: A Graduate Course. Springer.

Program: Pre-Ph.D. course work

Course Code: E-PHST06

Course Title: Advanced Statistical Inference

Duration of course: Classroom Teaching 60 hours

Credits of the course: 04 credits.

Objectives of the Course: To make aware research student to the statistical inferential methods.

Outcomes of the Course: Research Student will be

- aware of basic estimation and testing of hypothesis problems.
- able to estimate the parameters in special conditions.
- able to estimate the parameters using Bayesian approach.
- able to know new emerging statistical concept, smoothing technique.

Pre-requisites for the Course:

Fundamental concepts of estimation and testing of hypothesis.

Course contents:

Review of estimation theory, properties of estimator, m-parameter exponential family, Pitman family, Cramer family. Methods of estimation: Method of moments, method of maximum Likelihood, minimum chi-square. Maximum likelihood estimation (MLE) under restricted parameter space, inconsistent MLE, MLE in discrete case, iterative procedures for MLE, asymptotic properties.

Review of fundamental notions of testing of hypothesis, most powerful, uniformly most powerful tests (UMP), examples, non existence of UMP, UMP unbiased test, Monotone likelihood ratio property of family of distributions, Similar tests, Neyman-Structure tests, invariant tests. Confidence sets, Uniformly Most Accurate (UMA), Uniformly Most Accurate Unbiased (UMAU) confidence sets.

Bayesian inference: Point estimators, credible intervals, Bayesian Highest Posterior Density (HPD) confidence intervals, testing, prediction of a future observation. Model selection and hypothesis testing based on objective probabilities and Bayes' factors large sample methods: Limit of posterior distribution, consistency of posterior distribution, asymptotic normality of posterior distribution.

Quantile function, Empirical distribution function, Empirical quantile function.

Kernel, symmetric kernel, U-statistics: definition, properties, one and two sample

problems. Smoothing techniques: Kernel estimators, nearest neighbor estimators, orthogonal and local polynomial estimators, wavelet estimators, Splines, Choice of bandwidth and other smoothing parameters.

References:

- Casella, G. and Berger, R. L. (2002): Statistical Inference. Duxbury.
- Cox, D. R. and Hinkley, D. V. (1996): Theoretical Statistics. Chapman and Hall.
- Dixit, U. J. (2016): Examples in Parametric Inference with R. Springer
- Goon, A. M., Gupta, M. K. and Dasgupta, B. (1998): An outline of statistical theory. The World Press. Calcutta. Volume II.
- Shao, J. (2005): Mathematical Statistics. Springer. 2nd Edition.
- Kale, B. K. (2005): A First Course on Parametric Inference. Narosa Publishing
- Lehmann, E.L. and Casella, G. (1998): Theory of point estimation. Springer.
- Lehmann, E. L. and Romano, J. P. (2005): Testing Statistical Hypothesis, Springer. 3rd Edition.
- Mood, A. M., Graybill, F. A. and Boes, D. C. (2005): Introduction to the theory of Statistics. Tata McGraw-Hill. Third edition.
- Rajgopalan, M. and Dhanavanthan, P. (2012): Statistical Inference. PHI Learning, New Delhi.
- Rohatgi V.K. and Saleh A.K. Md. Ehasanes (2001): An Introduction to Probability and Statistics. Wiley
- Srivastava, M. K. and Srivastava, M. (2014): Statistical Inference: Testing of Hypotheses. PHI Learning private limited.

Program: Pre-Ph.D. course work

Course Code: E-PHST07

Course Title: Advance Concepts in Reliability and Survival Analysis

Duration of course: Classroom Teaching 60 hours

Credits of the course: 04 credits.

Objectives of the Course: To increase fluency of research student in reliability analysis and survival analysis.

Outcomes of the Course: Research Student will have knowledge of:

- Fundamental concepts of reliability and survival analysis

- Parametric and nonparametric estimation of survival and hazard function.
- Parametric inferential concepts
- Regression models for life experiments.
- Obtaining reliability of different systems.

Pre-requisites for the Course: Fundamental concepts in reliability and survival analysis.

Course contents:

Survival function, Hazard function, cumulative hazard function, reversed hazard function, nature of hazard function, censoring, types of censoring, Life distributions, different ageing classes and their interrelations, tests for exponentiality, one sample, two sample problems.

Kaplan-Meier estimator of survival function, properties of Kaplan-Meier estimator, Nelson-Aalen estimator of cumulative hazards function. Construction of likelihood under censoring schemes. Parametric inference.

Competing risk models, proportional hazards model, accelerated failure time model, Cox proportional hazards model, residual analysis of proportional hazards model.

Univariate frailty, shared frailty, correlated frailty, additive frailty models, cure models, cure frailty models,

Reliability of the system: structure function, standard systems: series system, parallel system, k-out-of-n system, coherent system, path sets and path vectors, minimal path sets, cut sets and cut vector, minimal cut sets, reliability of different systems, reliability bounds.

References

- Barlow, R. E. and Proschan, F. (1965): Mathematical theory of reliability
- Barlow, R. E. and Proschan, F. (1975): Statistical theory of reliability and life testing. Holt, Reinhart and Winston.
- Deshpande, J. V. and Purohit, S. G. (2005). Life Time Data: Statistical Models and Methods, World Scientific.
- Hanagal, D. D. (2011). Modeling Survival Data Using Frailty Models. CRC Press.
- Hosmer, D. and Lemeshow, S. (1999). Applied Survival Analysis: Regression Modeling of Time to Event Data, Wiley, New York.
- Kalbfleisch, J. D. and Prentice, R.L. (1986): The Statistical Analysis of Failure Time Data, John Wiley.
- Kleinbaum, D. G. and Klein, M. (2012). Survival Analysis**:** A Self-Learning Text, 3rd Ed, Springer, New York.

- Lawless, J.F.(1982): Statistical models and methods for life time data. John Wiley.
- Lee, E. T. and Wang, J. W. (2003). Statistical Methods for Survival Data Analysis, 3rd Edition. John Wiley.
- Liu, X. (2012). Survival Analysis: Models and Applications, Wiley, New York.
- Ross S. M. (2014): Introduction to Probability Models. Elsevier. 11th Edition.
- Smith, P.J. (2002): Analysis of Failure and Survival data. CRC.
- Wienke, A. (2011). Frailty Models in Survival Analysis, CRC.

Program: Pre-Ph.D. course work

Course Code: E-PHST08

Course Title: Advanced Design of Experiments

Duration of course: Classroom Teaching 60 hours

Credits of the course: 04 credits.

Objectives of the Course: To increase fluency of research student in design of experiments.

Outcomes of the Course: Research Student will have knowledge of:

- Block designs and its properties.
- Standard designs like BIBD, cross-over designs, .
- Response surface methodology.
- Determining of optimal conditions for experiment.
- Mixture experiment

Pre-requisites for the Course: Fundamental concepts in design of experiments.

Course contents:

General block design, properties of design: connectedness, orthogonality, balanced, optimality of design, Balanced incomplete block design, lattice design, cross over design, Factorial designs, confounding, fractional factorial design, resolution.

Response surface methodology, first order designs, Plackett-Burman designs, second order designs, Box-Behnken designs, central composite designs, optimal conditions,

Mixture experiments, designing of mixture experiments, canonical polynomials, screening of components.

References:

- Chakrabarti, M. C. (1962): Mathematics of Design and Analysis of Experiments. Asia Publishing house.
- Cornell, J. A. (2002): Experiments with mixtures. Designs, models and the analysis of mixture data. John Wiley.
- Das, M. N. and Giri, N. C. (2002): Design and Analysis of Experiments. New Age International. 2nd Edition.
- Dean, A., Voss, D, and Draguljic, D. (2017): Design and Analysis of Experiments. Springer. 2nd Edition.
- Kempthorne, O. and Hinkelman, K. (2008):- Design and analysis of experiments: Introduction to experimental design. Volume I. John Wiley. 2nd Edition.
- Kempthorne, O. and Hinkelman, K. (2005):- Design and analysis of experiments: Advanced experimental design. Volume II. John Wiley. 2nd Edition.
- Khuri, A. and Cornell, J. A. (1996): Response surfaces: Design and analyses. Marcel Dekker. 2nd Edition.
- Meyers, R. H., Montgomery, D. C. and Christine, M. (2016) : Response surface methodology: Process and Product Optimization using designed experiments. John Wiley. 4th Edition.
- Montgomery, D. C. (2017): Design and Analysis of Experiments. John Wiley. 9th Edition.
- Raghavarao, D (1988): Construction and Combinatorial Problems in Design of Experiments. Dover Pubns.
- Wu, C. F. Jeff and Hamada, M. (2002): Experiments: planning, analysis, and parameter design optimization, John Wiley.
- Shah, K. R. and Sinha, B. K. (1989): Theory of Optimal Designs. Springer.

Program: Pre-Ph.D. course work

Course Code: E-PHST09

Course Title: Advanced Regression Analysis.

Duration of course: Classroom Teaching 60 hours

Credits of the course: 04 credits.

Objectives of the Course: To gain deep knowledge in regression different methods.

Outcomes of the Course: Research Student will have knowledge of:

CO1) Classical Multiple linear regression and assumptions and their consiquences.

CO2) Regression dignostics and methods.

CO3) how to find significant variables using Variable selection methods.

CO4) consequences of multicollinarity and remedies.

CO5) Generalized linear models and link functions.

CO6) Partitioned based methods and semi linear methods.

Pre-requisites for the Course: Fundamental concepts in Matrix theory.

Course contents:

Origin of regression analysis, Classical Multiple Linear regression models, Assumptions of MLR and their consequences and remedies, estimation and testing of significance of parameters.

Regression diagnostics: 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. Box-Cox Power transformation,.

Variable selection methods: subset selection, Forward selection, backward elimination and stepwise regression. Sensitivity analysis in regression.

Shrinkage Estimators: Diagnostics of Multicollinearity, Ridge regression, The Least Absolute Shrinkage and Selection Operator (LASSO), Principal components regression, Elastic Net.

Generalized Linear models: link functions, Logistic regressions , Poisson regression, gamma regression,

CART, Random forest , Bagging, Boosting, XG Boost

Semi- Linear methods: K-NN with linear smoothing, Support vector Machines, Neural network.

References:

- Agresti, A. (2002): Categorical data analysis. John Wile, New York.
- Chaterjee, S. and Hadi, A. S. (2012): Regression Analysis with example. John Wiley.
- Cox, D. R. and Snell, E. J. (1989): Analysis of binary data. CRC Press.
- Draper, N.R and Smith, H. (2003): Applied Regression Analysis. John Wiley. New York
- Hosmer, D. W. and Lemeshow, S. (1989). Applied Logistic Regression, Wiley
- Kleinbuam, D. G. And Klein, M. (2000): Logistic regression: A self-learning text. Springer
- Montgomery, D. C., Peck, B.A. and Vining, G. G. (2003): Introduction to linear regression analysis. John Wiley.
- Wang, S. G. and Chow, S. C. (1994): Advanced Linear Models: Theory and Applications. Marcel Dekker.
- Samprit Chatterji, A.S. Hadi(1988): Sensitivity Analysis in Linear Regression, Wiley.
- Sen, A and Srivastava, M. (1990): Regression analysis: Theory methods and applications. . Springer.

EXAMINATION PATTERN FOR THEORY COURSES

Each course will be evaluated in two components,

Component A] Continuous Internal Evaluation (CIE) and

Component B] Course End Examination (CEE)

	Total marks	Class test	Presentations/ Paper review etc.
Internal Evaluation(CIE)	50	30	20
Course End Examination(CEE)	50		

CEE will be a theory examination of 50 marks of two hours duration based on entire syllabus. The question paper will consist of six questions of 10 marks each. Student should answer any five questions out of six questions.

Standard of Passing:

- Standard of passing is as per the circular No. Exam/Thesis/Univ/VCD/947 of 2018 of Mumbai University.
- Student has to obtain atleast 55% marks or equivalent grade in the UGC 7 point scale in the continuous internal examination (CIE) and Course End examination(CEE) combined.
- If research student is not able to secure minimum marks for passing then He/She has to reappear for CEE of 100 marks.

Sign of the BOS Chairman
Dr. Santosh Gite
BOS in Statistics

Sign of the Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science & Technology

Offg. Dean
Prof. Shivram S. Garje
Faculty of Science and Technology
University of Mumbai

19