University of Mumbai

No. UG/112 of 2019-20

CIRCULAR:-

Attention of the Principals of the affiliated Colleges, the Head of the University Departments and Directors of the recognized Institutions in Science & Technology Faculty.

They are hereby informed that the recommendations made by the Board of Studies in Statistics, at its meeting held on 19th June, 2019 have been accepted by the Academic Council at its meeting held on 26th July, 2019 **vide** item No. 4.6 and that in accordance therewith, the revised syllabus of M.Phil/Ph.D. course work in Statistics, has been brought into force with effect from the academic year 2019-20, accordingly. (The same is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
18th September, 2019

(Dr. Vinod P. Patil)
I/c REGISTRAR

To

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

A.C./4.6/26/07/2019

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No. UG/ 112 -A of 2019-20 MUMBAI-400 032 18th September, 2019

Copy forwarded with Compliments for information to:-

1) The I/c Dean, Faculty of 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 and Open Learning (IDOL),
5) The Director, Board of Students Development,
6) The Co-ordinator, University Computerization Centre,

(Dr. Vinod P. Patil)
I/c REGISTRAR

Cover Page

AC 26/7/19
Item No. 4.6

UNIVERSITY OF MUMBAI

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	M.Phil / Ph. D. Course Work in Statistics
2	Eligibility for Admission	M.A./M.Sc.(Statistics) and SET/PET/NET exam passed and Interview
3	Passing Marks	minimum 55% of marks or its equivalent grade in the UGC 7-point scale.
4	Ordinances / Regulations (if any)	N.A
5	No. of Years / Semesters	one or two semesters.
6	Level	~~P.G. / U.G. / Diploma / Certificate~~ (Strike out which is not applicable)
7	Pattern	~~Yearly~~ / Semester (Strike out which is not applicable)
8	Status	~~New~~ / Revised (Strike out which is not applicable)
9	To be implemented from Academic Year	From Academic Year 2019-20

Date: 9-7-2019 Signature: VUDixit

Name of BOS Chairperson / ~~Dean~~: Dr.(Mrs.) V.U. Dixit

UNIVERSITY OF MUMBAI

Syllabus for the Course Work for
M. Phil / Ph.D.
Program: M. Phil / Ph.D.
Course : STATISTICS

(With effect from the academic year 2019–2020)

Course Work for M.Phil / Ph. D. in STATISTICS Syllabus
To be implemented from the Academic year 2019-2020

Program: Pre-Ph.D. course work
Course Code: PHST 001
Course Title: Advanced Probability Theory and Measure Theory
Duration of course: Classroom Teaching 60 hours +60 notional Hours = 120 hours
Credits of the course: 04 credits.
Objectives of the Course: To increase fluency of research student in Mathematical foundations, Probability Theory and Measure Theory required for their research in Statistics.
Outcomes of the Course: Research Student will have knowledge of:

- Calculus (differentiation, integration).
- Modern Probability Theory.
- Elementary Measure Theory.
- Law of Large numbers.
- Central Limit Theorem.

Pre-requisites for the Course:
Number system, sets, bounded and unbounded sets, supremum and infimum of sets, open set, closed set, limit point of a set, countable sets, uncountable sets. Sequence, convergence of a sequence, limit point of a sequence, limit inferior and limit superior of a sequence, non-convergent sequence, Cauchy principle, algebra of sequence., subsequences, Monotone sequence. Infinite series, convergence, tests for convergence, alternate series, absolute convergence.
Course contents:

- Functions, inverse function, Limit of a function, continuous and discontinuous functions, left and right hand limits, uniform continuity. Vector valued function. Derivative, mean value theorems, Taylor series expansion and its applications, extreme values, indeterminate forms, power series. Functions of several variables: explicit and implicit functions, limit and continuity, differentiability, partial derivative, change of order, higher order derivatives, total derivative, Taylor series expansion, maxima and minima. Riemann integration, mean value theorems, integration by parts, change of variable in an integration, derivative under integration
- Classes of sets, field, sigma field, Borel field, minimal sigma field, limit of sequences of subsets, $\pi -$ system, $\lambda -$ system, non measurable functions, introduction to counting measure, measurable space.
- probability measure, random variable and random vector, distribution function (multivariate case), expectation and moments, independence, characteristic function, inversion formula, Laplace transform, conditional probability and conditional expectations, Martingales.
- Probability distributions and their relations, characterizations and generalizations.
- Stable distributions, infinite divisibility, Convergence of random variables, Law of large numbers, strong law of large numbers, central limit theorem.

References:

- Apostol, T. M. (1974): Mathematical Analysis. 2nd edition, Narosa Publishing house.
- Ash, R. B. (2000). Probability & Measure Theory. Academic Press.2nd Edition.
- Athreya, K. B. and Lahiri S. (2006). Measure Theory and Probability Theory, Springer.
- Bartle G. and Sherbert, D. R. (2000): Introduction to Real Analysis. 3rd edition. Wiley.
- Bhat B.R. (1999): Modern Probability Theory: An Introductory test book. 3rd 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.
- 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.

Program: Pre-Ph.D. course work
Course Code: PHST 002
Course Title: Advanced Statistical Inference
Duration of course: Classroom Teaching 60 hours +60 notional Hours = 120 hours
Credits of the course: 04 credits.
Objectives of the Course: To make aware research student to the recent statistical inferential methods.
Outcomes of the Course:

- Research student will be aware of basic estimation and testing of hypothesis problems.
- Research student will be able to solve the research problem in inference by using,
    - MCMC methods
    - EM algorithm.
    - Bootstrap and Jacknife methods.

Pre-requisites for the Course:
Methods of estimation, properties of estimator, uniformly most powerful test, uniformly most powerful unbiased test.
Course contents:

- Maximum likelihood estimation (MLE) under restricted parameter space, inconsistent MLE, MLE in discrete case, iterative procedures for MLE.
- 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.

- EM algorithm: Incomplete data problems, E and M steps, convergence of EM algorithm, standard errors in the context of EM algorithm, applications of EM algorithm, Bayesian approach to EM algorithm.
- Markov Chain Monte Carlo (MCMC) methods: Methods of generating random sample, Metropolis-Hastings and Gibbs Sampling algorithms, convergence, applications, Bayesian approach.
- 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, wavelet estimators, Splines, Choice of bandwidth and other smoothing parameters.

References:

- Bolstad, W. M. (2010): Understanding computational Bayesian statistics. John Wiley.
- Bolstad, W. M. (2017): Introduction to Bayesian Statistics, 3rd Edition. John Wiley.
- Congdon, P. (2006): Bayesian Statistical Modeling, John Wiley
- Davison, A.C. and Hinkley, D.V. (1997): Bootstrap methods and their Applications. Chapman and Hall.
- Dixit, U. J. (2016): Examples in Parametric Inference with R. Springer.
- Efron, B. and Hastie, T. (2016): Computer Age Statistical Inference: Algorithms, Evidence and Data Science. Cambridge University Press.
- Gamerman, Dani (1997): Markov chain Monte Carlo: Stochastic simulation for Bayesian inference. Chapman and Hall.
- Gelman, A., Carlin, J. B., Stern, H. S. and Rubin, D. B. (2003): Bayesian Data Analysis, second edition. Chapman and Hall.
- Gilks, W. R., Richardson, S., and Spiegelhalter, D. (eds.) (1995): Markov Chain Monte Carlo in Practice. Chapman and Hall.
- Ghosh, J. K., Delampady M. and T. Samantha (2006): An Introduction to Bayesian Analysis: Theory & Methods, Springer.
- Kundu, D. and Basu, A. (2009): Statistical Computing: Existing Methods and Recent Developments. Narosa.
- Lehmann, E.L. and Casella, G. (1998): Theory of Point Estimation. Springer. 2nd Edition.
- Lehmann, E. L. and Romano, J. (2005): Testing Statistical Hypotheses, Springer
- McLachlan, G.J. and Krishnan, T. (2008): The EM Algorithms and Extensions. Wiley.
- Rajgopalan, M. and Dhanavanthan, P. (2012): Statistical Inference. PHI Learning private limited.
- Srivastava, M. K. and Srivastava, M. (2014): Statistical Inference: Estimation Theory. PHI Learning private limited.
- Srivastava, M. K. and Srivastava, M. (2014): Statistical Inference: Testing of Hypotheses. PHI Learning private limited.

Examination and Evaluation pattern for the courses PHST 001 and PHST 002:

Course will be evaluated in two parts,

Part A] Continuous Evaluation (CE).

Part B] Course End Examination (CEE) and

CE will be of 40 marks which will include one mid-test of 20 marks of one hour duration and other 20 marks are composed of any one or combinations of group discussion, viva-voce, open book test, presentations, or assignments.

CEE will be a theory examination of 60 marks and of three hours duration based on entire syllabus. Answer book of research students will be evaluated by the concerned teacher or examiner appointed by Board of Studies in Statistics.

Standard of passing:
Standard of passing is as per the circular No. Exam./Thesis/Univ/VCD/947 of 2018 of Mumbai University.
A student has to obtain at least 55% marks or equivalent grade in the UGC 7 point scale in the CE and CEE combined.
If a research student is not able to secure minimum marks for passing then he / she has to reappear for CEE of 100 marks.

Program: Pre-Ph.D. course work
Course Code: PHST 003
Course Title: Research Methodology
Duration of course: Classroom Teaching 60 hours +60 notional Hours = 120 hours
Credits of the course: 04 credits.
Objectives of the Course: To expose research student to the different research methodologies for research in Statistics.
Outcomes of the Course:
Research student will understand:

- Tools to solve a Research problem.
- Different software.
- Different types of research

Pre-requisite for the Course: -
Course contents:

- Identification of research problem.
- Research ethics, plagiarism, copyright.
- Collection of and review the research methodologies such as qualitative, quantitative methods in the relevant field of research in Statistics in concern with his/her research guide.
- Collection and review of published research papers and reference books in the relevant field of research in Statistics in concern with his/her research guide.

- Statistical software such as R-Environment, SAS, SPSS, MINITAB, LATEX in the relevant field of research in Statistics in concern with his/her research guide.

Examination and Evaluation pattern:

Course will be evaluated in two parts,

Part A] Continuous Evaluation (CE).

Part B] Course End Examination (CEE) and

CE will be of 40 marks which will include, collection of research papers, report writing based on collected research papers, viva-voce, presentations, or assignments and will be assigned by his/her guide.

CEE will be of 60 marks and will be a presentation based on the review of published research articles and reference books , research student has gone through in the course.

Evaluation of CEE will be done by a following committee,

- Head of the department (Chairperson) and
- Guide of research student and One / two research guides from the department.

Standard of passing:

Standard of passing is as per the circular No. Exam./Thesis/Univ/VCD/947 of 2018 of Mumbai University.

A student has to obtain at least 55% marks or equivalent grade in the UGC 7 point scale in the CE and CEE combined.

If a research student is not able to secure minimum marks for passing then he / she has to give presentation again of 100 marks. Evaluation will be done by same committee before the expiry of registration period of that research student.
