Name of Department: Statistics

Vision

The Department of Statistics is committed to meet the educational and professional needs of the nation and to develop intellectually vigorous community of students and faculty.

Mission

To develop the Department as reputed center for Quality research, teaching, training and consultancy In Statistics

Name of Program: M.Sc. Statistics

Program Outcomes (POs)

Post Graduates of the M.Sc. Statistics program will be able to:

1. Have a broad background in Statistics, an appreciation of how its various sub disciplines are inter-related, acquire an in-depth knowledge about topics chosen from those offered through the department,
2. Be familiar with a variety of real life situations where statistics helps accurately explain the underlying abstract or physical phenomena and able to recognize and appreciate the connections between theory and applications;
3. Develop **the ability** to effectively and aptly use techniques from different sub-disciplines in a broad range of real life problem solving.
4. Be statistically and numerically **literate**. i.e. graduates will: recognize the importance and value of statistical thinking, training
5. Have the **versatility** to work effectively in a broad range of companies (including R&D sectors of financial, pharmaceutical, market research, software development companies, consultancy etc) , or analytic, scientific, government, financial, health, teaching and other positions or continue for higher education.
6. Be able to independently read statistical literature including survey articles, scholarly books, and online sources;
7. Be life-long learners able to independently expand their statistical expertise when needed, or out of own interest.
8. Exhibit ethical and professional behavior in team work.

Program Specific Outcomes (PSOs)

After completion of M.Sc. Statistics program the student will be able to:

1. Develop stochastic models for studying real life phenomenon in diverse disciplines.
2. Efficiently interpret and translate the outcomes obtained from analysis of stochastic models to an environment understandable to a layman.
3. Effectively use necessary statistical software and computing environment including R, MS-EXCEL among others
4. Apply statistical techniques to optimize and monitor real life phenomena related to industry and business analytics etc.

Year of Implementation of this syllabus: 2019-2020

Syllabus Structure

M.Sc. (Statistics) Programme structure (CBCS PATTERN) (2019-20) M.Sc. Part – I

	Sr. No.	Course Code	Teaching Scheme			Examination Scheme					
			Theory and Practical			University Assessment (UA)			Internal Assessment (IA)		
			Lectures (Per week)	Hours (Per week)	Credit	Maximum Marks	Minimum Marks	Exam. Hours	Maximum Marks	Minimum Marks	Exam. Hours
SEMESTER-I (Duration- Six Month)											
CGPA	1	CC-101	4	4	4	80	32	3	20	8	1
	2	CC-102	4	4	4	80	32	3	20	8	1
	3	CC-103	4	4	4	80	32	3	20	8	1
	4	CC-104	4	4	4	80	32	3	20	8	1
	5	CC-105	4	4	4	80	32	3	20	8	1
	6	CCPR-106	12	12	4	100	40	*	--	--	--
Total (A)			--	--	**24**	**500**	--	--	**100**	--	--
Non-CGPA	1	AEC-107	2	2	2	--	--	--	50	20	2
SEMESTER-II (Duration- Six Month)											
CGPA	1	CC-201	4	4	4	80	32	3	20	8	1
	2	CC-202	4	4	4	80	32	3	20	8	1
	3	CC-203	4	4	4	80	32	3	20	8	1
	4	CC-204	4	4	4	80	32	3	20	8	1
	5	CC-205	4	4	4	80	32	3	20	8	1
	6	CCPR-206	12	12	4	100	40	*	--	--	--
Total (B)			--	--	**24**	**500**	--	--	**100**	--	--
Non-CGPA	1	SEC-207	2	2	2	--	--	--	50	20	2
Total (A+B)					**48**	**1000**	--	--	**200**	--	--

- Student contact hours per week : **32** Hours (Min.)
- Theory and Practical Lectures : **60** Minutes Each

- CC-Core Course
- CCPR-Core Course Practical
- AEC-Mandatory Non-CGPA compulsory Ability Enhancement Course
- SEC- Mandatory Non-CGPA compulsory Skill Enhancement Course

- Total Marks for M.Sc.-I : **1200**
- Total Credits for M.Sc.-I (Semester I & II) : **48**

- Practical Examination is annual.
- Examination for CCPR-106 shall be based on Semester I Practical.
- Examination for CCPR-206 shall be based on Semester II Practical.
- *Duration of Practical Examination as per respective BOS guidelines
- ***Separate passing is mandatory for Theory, Internal and Practical Examination***

M.Sc. (Statistics) Programme structure (CBCS PATTERN) (2019-20) M.Sc. Part – II

SEMESTER-III (Duration- Six Month)												
	Sr. No.	Course Code	Teaching Scheme			Examination Scheme					
			Theory and Practical			University Assessment (UA)			Internal Assessment (IA)		
			Lectures (Per week)	Hours (Per week)	Credit	Maximum Marks	Minimum Marks	Exam. Hours	Maximum Marks	Minimum Marks	Exam. Hours
CGPA	1	CC-301	4	4	4	80	32	3	20	8	1
	2	CCS -302	4	4	4	80	32	3	20	8	1
	3	CCS-303	4	4	4	80	32	3	20	8	1
	4	CCS-304	4	4	4	80	32	3	20	8	1
	5	DSE -305	4	4	4	80	32	3	20	8	1
	6	CCPR-306	12	12	4	100	40	*	--	--	-
Total (C)			--	--	**24**	**500**	--	--	**100**	--	
Non-CGPA	1	AEC-307	2	2	2	--	--	--	50	20	2
	2	EC (SWM MOOC)-308	Number of lectures and credit shall be as specified on SWAYAM MOOC								
SEMESTER-IV (Duration- Six Month)											
CGPA	1	CC-401	4	4	4	80	32	3	20	8	1
	2	CCS -402	4	4	4	80	32	3	20	8	1
	3	CCS-403	4	4	4	80	32	3	20	8	1
	4	CCS-404	4	4	4	80	32	3	20	8	1
	5	DSE -405	4	4	4	80	32	3	20	8	1
	6	CCPR-406	12	12	4	100	40	*	--	--	--
Total (D)			--	--	**24**	**500**	--	--	**100**	--	--
Non-CGPA	1	SEC-407	2	2	2	--	--	--	50	20	2
	2	GE-408	2	2	2	--	--	--	50	20	2
Total (C+D)					**48**	**1000**	--	--	**200**	--	--

• Student contact hours per week : **32** Hours (Min.)	• Total Marks for M.Sc.-II : **1200**
• Theory and Practical Lectures : **60** Minutes Each	• Total Credits for M.Sc.-II (Semester III & IV) : **48**
• CC-Core Course • CCS- Core Course Specialization • CCPR-Core Course Practical • DSE-Discipline Specific Elective • AEC-Mandatory Non-CGPA compulsory Ability Enhancement Course • SEC- Mandatory Non-CGPA compulsory Skill Enhancement Course • EC (SWM MOOC) - Non-CGPA Elective Course • GE-Generic Elective	• Practical Examination is annual. • Examination for CCPR-306 shall be based on Semester III Practical. • Examination for CCPR-406 shall be based on Semester IV Practical. • *****Duration of Practical Examination as per respective BOS guidelines • ***Separate passing is mandatory for Theory, Internal and Practical Examination***

	M.Sc.-I	**M.Sc.-II**	**Total**
Marks	1200	1200	2400
Credits	48	48	96

I. CGPA course:

1. There shall be 12 Core Courses (CC) of 48 credits per programme.
2. There shall be 06 Core Course Specialization (CCS) of 24 credits per programme.
3. There shall be 02 Discipline Specific Elective (DSE) courses of 08 credits per programme.
4. There shall be 4 Core Course Practical (CCPR) of 16 credits per programme
5. Total credits for CGPA courses shall be of 96 credits per programme

II. Mandatory Non-CGPA Courses:

1. There shall be 02 Mandatory Non-CGPA compulsory Ability Enhancement Courses (AEC) of 02 credits each per programme.
2. There shall be 01 Mandatory Non-CGPA compulsory Skill Enhancement Course (SEC) of 02 credits per programme.
3. There shall be one Elective Course (EC) (SWAYAM MOOC). The credits of this course shall be as specified on SWAYAM MOOC.
4. There shall be one Generic Elective (GE) course of 02 credits per programme. Each student has to take generic elective from the department other than parent department.
5. The total credits for Non-CGPA course shall be of 08 credits + 2-4 credits of EC as per availability.
6. The credits assigned to the courses and the programme are to be earned by the students and shall not have any relevance with the work load of the teacher.

Structure of M. Sc. (Statistics) Programme

Semester I

	Course code	Title of course
CGPA	CC-101	Real Analysis
	CC-102	Linear Algebra
	CC-103	Distribution Theory
	CC-104	Estimation Theory
	CC-105	Statistical Computing
	CCPR-106	Practical I
Mandatory Non- CGPA	Compulsory	AEC: Communicative English-I

Semester II

	Course code	Title of course
CGPA	CC-201	Probability Theory
	CC-202	Theory of Testing of Hypothesis
	CC-203	Regression Analysis
	CC-204	Design and Analysis of Experiments
	CC-205	Sampling Theory and Official Statistics
	CCPR-206	Practical II
Mandatory Non- CGPA	Compulsory	SEC: Fundamentals of Information Technology-I

Semester III

	Course code	Title of course
CGPA	CC-301	Asymptotic Inference
	CCS-302	Multivariate Analysis
		Bayesian Inference
	CCS-303	Stochastic Processes
		Functional Data Analysis
	CCS-304	Data Mining
		Artificial Intelligence
	DSE-305	Time Series Analysis
		Statistical Ecology
	CCPR-306	Practical III
Mandatory Non- CGPA	Compulsory	AEC: Communicative English-II
	Compulsory	EC: SWYAM/ MOOCS

Semester IV

	Course code	Title of course
CGPA	CC-401	Generalized Linear Models
	CCS-402	Survival Analysis
		Actuarial Statistics
	CCS-403	Biostatistics
		Econometrics
	CCS-404	Optimization Techniques
		Circular Data Analysis
	DSE-405	Spatial Data Analysis
		Statistical Quality Control
	CCPR-406	Practical VI and Project
Mandatory Non- CGPA	Compulsory	SEC: Fundamentals of Information Technology-II
	Compulsory	GE: Data Management and Analysis using MSEXCEL

Semester-wise courses and their COs

CC-101: Real Analysis

Upon successful completion of the requirements for this course, students will be able to:

1. Differentiate between countable and uncountable sets; open, closed, dense and compact sets.
2. Obtain Supremum and Infimum of bounded sets, limit point of a set; apply Bolzano-Weierstrass and Heine-Borel Theorem to ensure existence of limit points.
3. Identify convergent, divergent, Cauchy sequence, Compute Limit inferior and limit superior of sequences.
4. Identify convergent, divergent and absolutely convergent Series of numbers,
5. Examine continuity and uniform continuity of sequences and series of functions,
6. Obtain radius of convergence of a power series.
7. Evaluate Riemann and Riemann-Steltjes Integrals, apply Fundamental theorem on calculus and mean value theorem.
8. Differentiate Vector and Matrix valued functions, Obtain Maxima, minima and constrained maxima, minima of functions of several variables, Apply Taylor's theorem, implicit function theorem.
9. Evaluate multiple integrals and use in connection with multivariate distributions, apply Leibnitz rule.

CC-102: Linear Algebra

Upon successful completion of this course, the student will be able to:

1. Explain the vector Space, its dimension, and linear dependence/independence of vectors.
2. Identify the orthogonal matrices, non-singular matrices, idempotent matrices.
3. Obtain rank, eigen values and eigen vectors, inverse, g-inverse, MP inverse, and various decompositions of matrices.
4. Solve systems of linear equations.
5. Classify the quadratic forms as definite, semi-definite, and indefinite.
6. Apply matrix theory in statistics.

CC-103: Distribution Theory

Upon successful completion of this course, the student will be able to:

1. Explain pdf, pmf, cdf of a random variable.
2. Decompose mixture type cdf into discrete and continuous cdf's.
3. Explain and apply moment inequalities to obtain bounds on entity of interest.
4. Explain standard discrete and continuous, and truncated and compound distributions.
5. Identify distribution of a function of univariate and bivariate random variable and use convolution.
6. Compute variance-covariance matrix, joint mgf, conditional expectation and variance of random vectors in general and with specific reference to bivariate normal and exponential distributions.
7. Derive distributions of order statistics (marginal and joint), spacings, normalized spacings and sample range.
8. Explain distribution of linear and quadratic forms and non-central distributions.

CC-104: Estimation Theory

Upon successful completion of this course, the student will be able to:

1. Explain the concepts of sufficiency, completeness, and ancillarity.
2. Obtain sufficient, minimal sufficient and complete statistics for various families of distributions.
3. Obtain UMVUE of parameters of various distributions using Rao-Blackwellization and various bounds on variance.
4. Obtain maximum likelihood estimator (MLE) of parameters.
5. Apply method of scoring to obtain an MLE.
6. Obtain estimators using method of moments and method of minimum chi-square.
7. Derive an U-statistic (up to degree 2) for a parametric function.
8. Obtain Bayes estimators under squared error and absolute error loss functions.

CC-105: Statistical Computing

Upon successful completion of this course, the student will be able to:

1. Use MSEXCEL and R for data organization, data manipulation, statistical data analysis, and other statistical computations.
2. Generate random numbers from various probability distributions using different methods.
3. Study various phenomena/systems through simulations.

4. Apply Monte Carlo method of integration.
5. Use resampling techniques: Bootstrap and Jack-knife.
6. Apply numerical methods to solve systems of linear equations, to obtain the roots of a nonlinear equation, and to solve definite integrals.
7. Develop codes for numerical methods in R.

CCPR-106: PRACTICAL – I

Upon successful completion of this course, the student will be able to:

1. Construct orthonormal basis using Gram-Schmidt orthogonalization method
2. Compute inverse, characteristic roots and vectors of a matrix.
3. Sketching of various distribution functions and finding possible probability distribution to observed Data.
4. Compute UMVUE, MME and MLE using various methods.
5. Develop program / source code for computing various statistical tools using statistical software like R/MINITAB/MATLAB/SAS/SYSTAT

CC- 201: Probability Theory

Upon successful completion of this course, the student will be able to:

1. Obtain limsup, liminf and limit of sequence of sets, Explain a field, σ- field, and Borel σ-field.
2. Define a Probability measure and explain its properties, Distinguish between a continuous, discrete and mixed probability measures, identify various types of measures.
3. Define a random variable and its distribution function. Distinguish between simple, elementary and arbitrary random variable. Obtain liminf, limsup and limit of sequences of random variables.
4. Explain Characteristic function, its properties and able to apply the inversion theorem
5. Apply Monotone convergence theorem, Fatous Lemma, Dominated Convergence theorem, Borel - Cantelli Lemma.
6. Explain various types of Convergence of random variables and inter-relationships between them, Apply Yule Slutsky results.
7. Apply Weak and Strong laws of large numbers, and various theorems on CLT.

CC-202: Theory of Testing of Hypotheses

Upon successful completion of this course, a student will be able to:

1. Construct MP, UMP, UMPU, similar tests and a test with Neyman structure.
2. Construct LRT.
3. Obtain and interpret interval estimates of parameters.
4. Differentiate between parametric and nonparametric tests.
5. Explain nonparametric tests for one-sample and two-sample problems and goodness of fit tests.
6. Apply various testing and interval estimation procedures to real problems.

CC-203: Regression Analysis

Upon successful completion of this course, the student will be able to:

1. Fit a multiple linear regression model using method of maximum likelihood and least squares and perform diagnostic analysis of the model.
2. Perform statistical tests and construct statistical intervals in a multiple linear regression set up.
3. Implement variable selection methods to identify appropriate model for further analysis.
4. Detect problems like multicollinearity and outliers in data.
5. Estimate regression parameters in the presence of multicollinearity using ridge regression.
6. Estimate regression parameters in the presence of outliers using robust estimator like M-estimator.
7. Fit a nonlinear regression model to given data and draw inference.

CC-204: Design and Analysis of Experiments

Upon successful completion of this course, the student will be able to:

1. Obtain least square estimates of parameters of a linear model, identify estimable linear parametric functions and obtain their BLUEs, and apply tests of different hypotheses related to the parameters of a linear model.
2. Apply multiple comparison procedures.
3. Design and analyze two-level and three-level full factorial and un-replicated experiments.
4. Design and analyze two-level and three-level confounded and fractional factorial experiments.

5. Design, analyze and interpret first and second order response surface experiments.
6. Construct and analyze robust parameter designs.

CC-205: Sampling Theory and Official Statistics

Upon successful completion of this course, the student will be able to:

1. Explain probabilistic and non-probabilistic sampling methods.
2. Explain the concept of population, sample, sampling unit, sampling design, sampling frame, sampling scheme etc.
3. Determine appropriate sample size in various sampling methods.
4. Design good questionnaire relevant to a survey for a specific investigation.
5. Explain sampling and non-sampling errors
6. Select and implement appropriate probabilistic/non-probabilistic sampling scheme for a specific situation and estimate desired population entities using various estimation methods.
7. Explain elements of Indian official statistics.

CCPR 206: PRACTICAL – II

Upon successful completion of this course, the student will be able to:

1. Test hypothesis about the parameters and provide interval estimates involved in random experiments based on random sample.
2. Fit linear regression model to the data, perform diagnostic analysis and apply rectifying measures to overcome the problem of multicollinearity, outliers and non-linearity.
3. Design and analyze the factorial and Taguchi experiments
4. Select and implement appropriate probabilistic/non-probabilistic sampling scheme for a specific situation and estimate desired population entities using various estimation methods

CC-301: Asymptotic Inference

Upon successful completion of this course, the student will be able to:

1. Explain weak and strong consistency, marginal and joint consistency.
2. Construct consistent, CAN, and BAN estimators.
3. Compare two consistent estimators using ARE.
4. Apply Cramer-Huzurbazar theorem to identify distribution of MLE.
5. Explain invariance property of consistent and CAN estimator.
6. Construct large sample confidence intervals based on variance stabilizing transformation (VST).
7. Explain large sample tests LRT, Wald test, Rao's Score test, etc.
8. Explain consistent tests and compare tests using Pitman and Bahadur efficiency.

CCS-302: Multivariate Analysis

Upon successful completion of this course, the student will be able to:

1. Compute sample mean vector, sample covariance matrix, partial and multiple correlation coefficients, and covariance and correlations of linear transforms of random vectors.
2. Explain multivariate normal distribution and its properties, characteristic function, moments, marginal and conditional distribution, etc.
3. Explain Wishart distribution and its properties.
4. Apply Hotelling's T^2 for testing of hypotheses on mean vector of multivariate normal distribution.
5. Explain and apply Fisher's discriminant function and minimum ECM rule for two class classification and perform statistical tests associated with discriminant function.
6. Apply clustering techniques, single linkage, complete linkage, average linkage and k-means algorithm to form meaningful clusters from multivariate data.
7. Perform canonical correlation analysis of multivariate data.
8. Apply dimension reduction techniques, PCA and Factor analysis to summarize multivariate data using few uncorrelated variables.

CCS- 303: Elementary Stochastic Processes

Upon successful completion of this course, the student will be able to:

1. Explain the stochastic modelling tools, namely, Markov chains, Poisson process, renewal processes, branching process, and queuing systems.
2. Identify appropriate stochastic process model for a given real life process.
3. Specify a given discrete time Markov chain in terms of a transition probability matrix and a transition diagram, and calculate higher step transition probabilities.
4. Classify Markov chains and states.
5. Find stationary and limiting distributions for discrete time Markov chains and explain the relation between them.
6. Use the backwards and forwards differential equations to compute transition probabilities in birth-death processes.
7. Explain basic elements of queuing model, find steady state probabilities and various average characteristics for the M/M/1, M/M/1 with balking, M/M/c and M/G/1 queuing models

CCS - 304: Data Mining

Upon successful completion of this course, the student will be able to:

1. Differentiate between classical techniques and data-oriented techniques.
2. Explain supervised and unsupervised learning.
3. Construct classifiers namely, decision tree, naïve Bayes, and k-nearest neighbour(s).
4. Compare different classifiers and employ techniques to improve their performance.
5. Apply artificial neural network model for classification and prediction.
6. Explain support vector machine (SVM) for classification and regression.
7. Generate association rules using apriori algorithm.
8. Apply clustering techniques, k-mediods, CLARA, DBSCAN, DENCLUE, probability model based clustering algorithm to form meaningful clusters.

DSE-305: Time Series Analysis

Upon successful completion of the requirements for this course, students will be able to:

1. Understand the concept of stationarity to the analysis of time series (TS) data in various contexts (such as actuarial studies, climatology, economics, finance, geography, meteorology, political science, and sociology)
2. Identify stationarity/non-stationarity status of an observed TS;

3. Identify and isolate non deterministic components of observed TS; learn to translate an observed non-stationary series to stationarity TS series using an appropriate transformation.
4. Model, estimate, interpret and forecast observed TS through ARMA and ARIMA approach.
5. Perform residual analysis for checking model adequacy.
6. Learn basics of frequency domain analysis
7. Learn basics of time dependent volatility in TS and basics of ARCH and GARCH TS models.

CCPR-306: PRACTICAL -III

Upon successful completion of this course, the student will be able to:

1. Construct consistent, CAN, BAN estimators and large sample confidence intervals based on variance stabilizing transformation (VST).
2. Compute one step and higher order TPM, classify states and find limiting distribution of Markov Chain.
3. Model and forecast time series data
4. Able to classify multivariate data using data mining based classification techniques using open source software's
5. Able to develop codes for regression and classification problems in R.
6. Perform statistical analysis of multivariate data.

CC-401: Generalized Linear Models

Upon successful completion of this course, the student will be able to:

1. Fit a GLM using ML and Quasi-likelihood estimation, perform statistical tests and construct statistical intervals.
2. Perform diagnostic analysis of the model based on deviance, Pearson, Anscombe and quantile residuals.
3. Implement variable selection methods to identify appropriate model for further analysis.
4. Fit a logistic regression model for dichotomous response variable, perform Hosmer-Lemeshow goodness of fit test and construct ROC curve, interpret parameters and odds ratio.
5. Fit a logistic regression model for multilevel response variable particularly, baseline category model and proportional odds model.
6. Fit a Poisson regression model for count response variable and draw inference.
7. Detect problem of over dispersion in count data regression and fit NB-2 model.

CCS - 402: Survival Analysis

Upon successful completion of this course, the student will be able to:

1. Explain the concept of censoring and know various types of censoring.
2. Obtain Non-parametrically point and interval estimates of survival function, cumulative hazard function, hazard function, median, and percentiles of survival times based on censored data.
3. Formulate situations involving survival data with covariates as Cox- regression problems. Build, estimate and assess the fit of Cox regression model under various scenarios.
4. Explain the concept of competing risk models, and perform its parametric and nonparametric analysis.
5. Perform and interpret two-sample analyses of survival data using Log rank test, Wilcoxon test.
6. Get introduced with various frailty models.

CCS – 403: Biostatistics

Upon successful completion of this course, the student will be able to:

1. Get introduced with the need and ethics of clinical trials and various concepts used in conduct of clinical trials.
2. Know the objectives and endpoints of clinical trials, know and design various phases of clinical trials
3. Design and analyze Phase I - III bio-equivalence trials.
4. Know about case-control and cohort designs, Measures of disease occurrence and association, various issues and inference procedures relevant to epidemiology.

CCS-404: Optimization Techniques

Upon successful completion of this course, the student will be able to:

1. Develop a general understanding of the Operational Research (OR) approach to decision making.
2. Formulate a problem as an appropriate optimization problem (LPP, IPP, QPP)
3. Apply various methods to obtain optimum solution of a LPP, IPP and QPP.
4. Obtain dual of a given LPP and apply dual simplex method.
5. Solve two person zero sum games with pure and mixed strategies using various methods.
6. Explain, formulate and solve dynamic Programming problem.

DSE-405: Statistical Quality Control

Upon successful completion of this course, the student will be able to:

1. Apply various basic quality control and improvement tools.
2. Design and implement univariate Shewhart, CUSUM, and EWMA control charts.
3. Apply various modifications in design and implementation of Shewhart control charts.
4. Design and implement multivariate control charts.
5. Design and implement nonparametric control charts, Bayesian control charts, control charts based on change point model, SPRT chart, and GLR charts.
6. Perform process capability analysis.
7. Apply six sigma methodology.
8. Design and implement sampling inspection plan.

CCPR-406: Practical – IV and Project

Upon successful completion of this course, the student will be able to:

1. Build generalized linear regression model for real data.
2. Perform parametric and non parametric analysis of survival data.
3. Formulate LPP, ILPP, QPP, DPP, Game problem and obtain optimum solution using different optimization methods.
4. Apply statistical quality control tools for several real life industrial monitoring processes.
5. Apply nonparametric methods and regression methods to analyze categorical data and time-to-event data in biostatistics using statistical software like SAS, R etc.