चौधरी चरण सिंह विश्वविद्यालय, मेरठ

क्रम संख्या	विषय	पाठयक्रम समिति की आयोजन की तिथि	विषय कोड (नाम सहित) जिसमें परिवर्तन किया गया है	क्या परिवर्तन किए गये	क्या नया विषय कोड दिये जाने की आवश्यकता है अथवा पुराना विषय कोड रहेगा	संशोधन किस सत्र से छात्रो पर लागू होगा	टिप्पणी
1.	**Class: M.Sc.** **Subject: Statistics**	**30-05-2022**	**The whole syllabus is re-structured.**	**Syllabus of M.Sc. (Statistics) for University campus and affiliated colleges is revised as per guidelines of NEP-2020. The details of the revised courses are as follows:**	**Yes**	**2022-23**	
2.			First Semester: Code-1532: Computer Fundamentals and Statistical Programming using C Language Code-1533: Design of Sample Survey Code-1534: Measure and	**For semester-I,** BOS approved the following Core Compulsory/ Elective/ Value added cousres: **Course Name** — **Core Compulsory/ Elective/ Value added** 1. Probability Theory — Core Compulsory 2. Distribution Theory — Core Compulsory 3. Sampling Techniques — Core Compulsory & Value added 4. Any one from the following ccre elective & value added course: a. Statistical Programming with: R-language b. Statistical Programming with: C-language 5. Practical lab — Core compulsory 6. Research Project — Core compulsory The following one minor open elective and value added course for other faculty has been approved: 1. Essential Statistics			

			Probability Theory Code-1535: Discrete and Continuous Statistical Distributions				
3.			**Second Semester:** Code-2532: Linear Estimation and Design of Experiments Code-2533: Theory of Estimation and Testing of Hypothesis Code-2534: Theory of Matrices, Quadratic forms and Linear Difference Equations Any one of the following:	**For semester-II,** BOS approved the following Core Compulsory/ Elective/ Value added cousres: **Course Name** — **Core Compulsory/ Elective/ Value added** 1. Matrix Algebra & Linear Difference Equations — Core Compulsory 2. Theory of Experimental Designs — Core Compulsory & Value added 3. Statistical Inference-I — Core Compulsory 4. Any one from the following core elective course: a. Real & Complex Analysis b. Information Theory 5. Practical lab — Core compulsory 6. Research Project — Core compulsory The following one minor open elective and value added course for other faculty has been approved: 1. Applied Statistics			

			(a) Real & Complex Analysis: Code-2535 (b) Stochastic Process & Survival Analysis: Code-2536				
4.			**Third Semester:** Code-3532: Industrial Statistics: Statistical Quality Control & Reliability Engineering Code-3533: Interval Estimation, Sequential Analysis & Non-Parametric Inference Code-3534: Operations Research	**For semester-III,** BOS approved the following Core Compulsory/ Elective/ Value added cousres: **Course Name** — **Core Compulsory/ Elective/ Value added** 1. Quality Control & Reliability Engineering — Core Compulsory & value added 2. Statistical Inference-II — Core Compulsory 3. Operations Research — Core Compulsory 4. Any one from the following core elective course: a. Advanced Bayesian Statistics b. Actuarial Science & Official Statistics c. Advanced Designs of Experiments 5. Practical lab — Core compulsory 6. Research Project — Core compulsory			

			Any one of the following: (a) Decision Theory & Bayesian Inference: Code-3535 (b) Actuarial Science and Official Statistics: Code-3536				
5.			**Fourth Semester:** Code-4532: Multivariate Statistical Analysis Code-4533: Time Series Analysis and Population Studies Code-4534: Advanced Operations Research Any one of the following:	**For semester-IV,** BOS approved the following Core Compulsory/ Elective/ Value added cousres: **Course Name** — **Core Compulsory/ Elective/ Value added** 1. Multivariate Analysis — Core Compulsory 2. Time Series & Vital Statistics — Core Compulsory 3. Any one from the following core elective & value added course: a. Data Analytics & Pythcn b. Advanced Operations Research c. Bio-Statistics 4. Any one from the following core elective & value added course: a. Stochastic Process & Survival Analysis b. Econometrics c. Research Methodology & Computer Application 5. Practical lab — Core compulsory 6. Research Project — Core compulsory			

			(a) Statistical Programming using R-Language: Code-4535 (b) Information Theory: Code-4536 (c) Econometrics: Code-4537				

Prof. Bhupendra Singh

Convener-I, BOS in Statistics

CHAUDHARY CHARAN SINGH UNIVERSITY, MEERUT

Proceedings of the meeting of Board of Studies in Statistics

held on 30-05-2022

A meeting of Board of Studies (University Campus and Affiliated Colleges) in the subject of Statistics in Chaudhary Charan Singh University, Meerut was held on May 30, 2022 at 12:00 PM through Zoom App

The following were present.

1.	Prof. M.K. Gupta	Dean, Science faculty
2.	Prof. Bhupendra Singh	Convener-I
3.	Prof. Hare Krishna	Member
4.	Dr. Alka Chaudhary	Convener-II
5.	Dr. P.K. Tyagi	Member
6.	Dr. R.B. Singh	Member
7.	Prof. Sanjeev Kumar Tomar	External Expert
8.	Prof. O.K. Belwal	External Expert
9.	Prof. D.K. Garg	External Expert
10.	Dr. Abha Chandra	Retd. Principal
11.	Dr. Anil Kumar	Principal Scientist

The Board met for the formulation of the syllabus of the subject Statistics for the M.Sc. based on guidelines of U.P. government as per National Education Policy (NEP) -2020. After discussing at length, the Board unanimously prepared and approved the syllabus for the same. A copy of the finalized syllabus is enclosed herewith.

(Dr. Anil Kumar) (Dr. Abha Chandra) (Prof. D.K. Garg)

(Prof. O.K. Belwal) (Prof. Sanjeev Kumar Tomar) (Dr. R.B. Singh)

(Dr. P.K. Tyagi) (Dr. Alka Chaudhary) (Prof. Hare Krishna)

(Prof. Bhupendra Singh) 30/5/22 (Prof. M.K. Gupta)

Hon'ble Vice Chancellor

Kindly allow the enclosed syllabus to be put in Academic Council for approval and to implement from the session 2022-2023.

(Hon'ble Vice Chancellor)

चौधरी चरण सिंह विश्वविद्यालय, मेरठ।

Chaudhary Charan Singh University, Meerut

Syllabus of:

M.Sc. (Statistics)

(For fourth and fifth years of Higher education (PG))

(As per guidelines of U.P. Government according to National Education Policy-2020 w.e.f. the session 2022-2023)

(For both University Campus and Colleges)

30/5/22

30/5/22

Members from the Board of Studies

S. No.	Name	Designation	College/ University	Signature
1.	Prof. M.K. Gupta	Dean, Science Faculty	C.C.S. University Campus, Meerut	
2.	Prof. Bhupendra Singh	Convener-I	C.C.S. University Campus, Meerut	
3.	Prof. Hare Krishna	Member	C.C.S. University Campus, Meerut	
4.	Dr. Alka Choudhary	Convener-II	Kanohar Lal College, Meerut	
5.	Dr. Pradeep Kumar Tyag	Member	DPBS, Bulandshar	
6.	Dr. R. B. Singh	Member	D.N. College, Meerut	
7.	Prof. Sanjeev Kumar Tomar	External Subject Expert	B.H.U, Varanasi	
8.	Prof. O.K. Belwal	External Subject Expert	HNB Garhwal University, Srinagar, UK	
9.	Prof. D. K. Garg	External Subject Expert	Panjabi University, Patiala, Panjab	
10.	Dr. Abha Chandra	Retd. Principal	Meerut College Meerut	
11.	Dr. Anil Kumar	Principal Scientist	Indian Agriculture Statistics Research Institute	

SUBJECT: STATISTICS

Semester-wise Titles of the Papers in M.Sc. (Statistics)

Year	Sem.	Course Code	Paper Title	Core Compulsory/ Elective/ Value added	Theory/Practical	Credits
I	I	STAT-101	Probability Theory	Core Compulsory	Theory	04
		STAT-102	Distribution Theory	Core Compulsory	Theory	04
		STAT-103	Sampling Techniques	Core Compulsory & Value added	Theory	04
		STAT-104	Any one of the following (a) Statistical Programming with R-language (b) Statistical Programming with C-language	Core elective & Value added	Theory	04
		STAT-105	Practical Lab	Core Compulsory	Practical	04
		STAT-RP01	Industrial Training/Research Project/Survey	Core Compulsory	Project	04
			Essential Statistics	Minor- Open Elective for other faculty	Theory	04
	II	STAT-201	Matrix Algebra & Linear Difference Equations	Core Compulsory	Theory	04

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	II	STAT-202	Theory of Experimental Designs	Core Compulsory & Value added	Theory	04
		STAT-203	Statistical Inference-I	Core Compulsory	Theory	04
		STAT-204	Any one of the following (a) Real & Complex Analysis (b) Information Theory	Core elective	Theory	04
		STAT-205	Practical Lab	Core Compulsory	Practical	04
		STAT-RP02	Industrial Training/Research Project/Survey	Core Compulsory	Project	04
			Applied Statistics	Minor- Open Elective for other faculty	Theory	04
II	III	STAT-301	Quality Control & Reliability Engineering	Core Compulsory & Value added	Theory	04
		STAT-302	Statistical Inference-II	Core Compulsory	Theory	04
		STAT-303	Operations Research	Core Compulsory	Theory	04
		STAT-304	Any one of the following (a) Advanced Bayesian Statistics (b) Actuarial Science & Official Statistics (c) Advanced Designs of Experiments	Core elective	Theory	04

	STAT-305	Practical Lab	Core Compulsory	Practical	04
	STAT-RP03	Industrial Training/Research Project/Survey	Core Compulsory	Project	04
IV	STAT-401	Multivariate Analysis	Core Compulsory	Theory	04
	STAT-402	Time Series & Vital Statistics	Core Compulsory	Theory	04
	STAT-403	Any one of the following (a) Data Analytics & Python (b) Advanced Operations Research (c) Bio-Statistics	Core elective & Value added	Theory	04
	STAT-404	Any one of the following (a) Stochastic Process & Survival Analysis (b) Econometrics (c) Research Methodology & Computer Application	Core elective & Value added	Theory	04
	STAT-405	Practical Lab	Core Compulsory	Practical	04
	STAT-RP04	Industrial Training/Research Project/Survey	Core Compulsory	Project	04

Subject Prerequisites

To study this subject a student must had the subject(s) Mathematics or Statistics at UG Level.

Course Structure

The courses will be based on Choice Based Credit System (CBCS) structure developed by the University. There will be four compulsory or elective core courses of Statistics in each semester. Apart from these, one minor elective course of other faculty is to be chosen by a student in the first year of M.Sc. (Statistics). In each semester, there will be one research project of 04 credits.

Programme Outcomes (POs)

Students having Degree in M.Sc. (with Statistics) should have the knowledge of different concepts and techniques of Statistics and data analytics and ability to apply this knowledge in various fields of government and private sectors such as banking, medical, defence, agriculture etc. Students may pursue their future career in the field of data analysis and Research.

Programme Specific Outcomes (PSOs)

After completing M.Sc. (with Statistics), the student should have

PSO-1: Knowledge and expertise of different applied univariate and multivariate concepts, methodologies and tools of Statistics.

PSO-2: Ability to collect, validate and analyze data by using appropriate statistical techniques.

PSO-3: Ability to provide informative In different forms including graphical representation, numerical and theoretical description etc. in an efficient manner.

PSO-4: Ability to understand the nature of the data and identify and solve a wide range of real life problems related to Statistics.

PSO-5: Knowledge of applied statistical techniques and statistical softwares including programming language (e.g. C , R, Python and SPSS)

PSO-6: Capability to use appropriate statistical skills for solving problems of interdisciplinary areas including finance, health, agriculture, government, business, industry, medical.

PSO-7: Ability to understand and compete with the challenges to fulfill the demand of the government and non-government sectors in terms of conducting survey and data analysis in a professional manner. These techniques will be helpful to generate the employability skills in the students.

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List of All Papers in All Four Semesters

Programme	Year	Semester	Course Title	Core Compulsory/ Elective/ Value added	Credits	Teaching Hours
M. Sc	I	First	Probability Theory	Core Compulsory	04	60
			Distribution Theory	Core Compulsory	04	60
			Sampling Techniques	Core Compulsory & Value added	04	60
			Any one of the following (a) Statistical Programming with R-language (b) Statistical Programming with C-language	Core Elective & Value added	04	60
			Practical Lab	Core Compulsory	04	60
			Industrial Training/Research Project/Survey	Core Compulsory	04	60
			Essential Statistics	Minor- Open Elective for other faculty& Value added	04	60
		Second	Matrix Algebra & Linear Difference Equations	Core Compulsory	04	60
			Theory of Experimental Designs	Core Compulsory & Value added	04	60
			Statistical Inference-I	Core Compulsory	04	60
			Any one of the following (a) Real & Complex Analysis (b) Information Theory	Core Elective	04	60
			Practical Lab	Core Compulsory	04	60
			Industrial Training/Research Project/Survey	Core Compulsory	04	60
			Applied Statistics	Minor- Open Elective for other faculty & Value added	04	60

Programme	Year	Semester	Course Title	Core Compulsory/ Elective/ Value added	Credits	Teaching Hours
M.Sc	II	Third	Quality Control & Reliability Engineering	Core Compulsory & Value added	04	60
			Statistical Inference-II	Core Compulsory	04	60
			Operations Research	Core Compulsory	04	60
			Any one of the following (a) Advanced Bayesian Statistics (b) Actuarial Science & Official Statistics (c) Advanced Designs of Experiments	Core Elective	04	60
			Practical Lab	Core Compulsory	04	60
			Industrial Training/Research Project/Survey	Core Compulsory	04	60
		Fourth	Multivariate Analysis	Core Compulsory	04	60
			Time Series & Vital Statistics	Core Compulsory	04	60
			Any one of the following (a) Data Analytics & Python (b) Advanced Operations Research (c) Bio-Statistics	Core Elective & Value added	04	60
			Any one of the following (a) Stochastic Process & Survival Analysis (b) Econometrics (c) Research Methodology & Computer Application	Core Elective & Value added	04	60
			Practical Lab	Core Compulsory	04	60
			Industrial Training/Research Project/Survey	Core Compulsory	04	60

3.15.22

DETAILED COURSES OF STUDY FOR M. Sc (STATISTICS)

FIRST SEMESTER

Programme/Class: **M.Sc.**	Year: **First**	Semester: **First**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Probability Theory**	

Need of the Course- In our day-to-day lives, we deal with the uncertainties. Scientists and Researchers cope-up with these doubts by using the concept of probability. Probability theory and its models serve as a link between the descriptive and inferential statistics, methodologies for assessing and quantifying chance.

Objective of the Course- The purpose of the course is to develop knowledge of the fundamental probability tools for quantitatively determining the risk. The application of these tools lies with the problems encountered in decision making.

Course outcomes:

CO1- The course helps the students to understand the concept of probability along with basic laws and axioms of probability.
CO2- Students design statistical experiments in which they collect, interpret, present and justify their findings.
CO3-Bayes laws has wide application in the applied machine learning and establishes a relationship between data and a model.
CO4- After studying this course, students will have the ability to apply basic probability principles to solve real life problems.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	Sequence of Sets, Lim_sup & Lim_inf of Sequence of Sets, Measure, Probability Measure, Conditional Probability, Bayes Theorem and Independent Events. Monotone classes, Measurable functions & properties, Lebseque measure	**12**
II	Random Variables, Distribution Function of Random Variables, Joint distribution of two Random Variables, Marginal & Conditional Distributions, Expectation, Moment Generating Function, Probability Generating function, Characteristic Functions & their properties, Uniqueness, Inversion & Continuity Theorems of Characteristic Function.	**12**
III	Chebychev's, Markov's, Basic, Kolmogorov's, Jenson's Inequalities. Three Series Criterion, Borel Zero-One Law, Schwartz inequality	**12**
IV	Convergence of Sequences of Random Variables, Convergence in Distribution, Convergence in Probability, rth mean and Almost Sure, Borel-Cantelli Lemma	**12**
V	Weak Law & Strong Law of Large Numbers for iid sequences, Bernoulli's, Khintchine's Theorems of Large Numbers, CLT for Sequence of Independent Random Variables under Lindeberg's & Liaounoff's Conditions, and CLT for iid Random Variables.	**12**

Suggested Readings:

1. Rohatgi V.K., "An Introduction to Probability Theory & Mathematical Statistics", Wiley Eastern Ltd. , New Delhi.
2. Mukhopadhyay Parimal., "Theory of Probability"-New Central Book Agency , Calcutta.
3. Hogg R.V.& Craig A.T., "Introduction to Mathematical Statistics"- Macmillion Publications, New York.
4. Mukhopadhyay P., "Mathematical Statistics"-New Central Book Agency Calcutta.
5. Srinivasan & Mehta., "Probability & Random Process"- Tata Mc-Graw Hill ,New Delhi.
6. Cramer H., "Mathematical Methods of Statistics"- Princeton University Press.
7. Baner H., "Probability Theory"- Narosa Publication House, New Delhi.
8. Parzen E., "Modern Probability Theory & Applications"- Willey Eastern Ltd. New Delhi.
9. Bhatt B.R., "Modern Probability Theory"- Wiley Eastern Ltd. New Delhi.
10. Pitman J., "Probability" –Narosa Publishing House, New Delhi.
11. Schaum Series, "Probability and Statistics"-Wiley Eastern Ltd. New Delhi.
12. Mukherjee K.K., Probability & Statistics- New Central Book Agency ,Calcutta
13. Mood, Graybill & Boss., "Introduction to the Theory of Statistics".Mc-Graw Hill.
14. Bhatt V.N., "Elements of Applied Stochastic Process". John Wiley and Sons, New York.
15. Chandra,T.K. & Chatterjee:"A first course in probability".
16. Ross Sheldom. M.: "Introduction to probability models".
17. Richard,A. Johnson : "Probability and statistics for engineers".

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
https://swayam.gov.in/explorer?searchText=statistics
https://nptel.ac.in/course.html
https://www.edx.org/search?q=statistics
https://www.coursera.org/search?query=statistics&

Total No. of Lectures- 60

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, Surprise Class Tests- The continuing evaluation process through home assignments, quizzes, and surprise tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **M.Sc.**	Year: **First**	Semester: **First**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Distribution Theory**	

Need of the Course- After studying the concept of random variable; in probability theory, the knowledge of Statistical distributions is of prime need. It gives the idea, how the total probability is distributed among the possible values of random variables.

Objective of the Course- The main objective of the course is to provide the detailed knowledge of the characterization of all the useful discrete and continuous distributions.

Course outcomes:

CO1- It provides the knowledge of the discrete and continuous random variables.
CO2- The course equips the students with the understanding of the applications of various discrete and continuous distributions.
CO3- It helps the students to capture the behavior of the random phenomenon by the suitable probability model.
CO4- The aims of the course is to enrich the students with the employability skills.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **0-0-4.**

Unit	Topic	No. of Lectures
I	Study with examples and applications of uniform, Binomial, Poisson , Geometric distributions. Their means, variances, measures of skewness, characteristics functions, moment and probability generating functions, r^{th} descending factorial moments and mode. The various important properties with their proofs related to these distributions including truncated and compound.	**12**
II	Generations and applications of Negative Binomial, Multinomial and hyper geometric distributions. Their characteristics functions, moment and probability generating functions and descending factorial moment. Mean vectors, variance covariance matrix, marginal and conditional distributions of multinomial. Limiting compound and mode of negative binomial and hyper-geometric distributions. Theory of exceedency of hyper-geometric distribution.	**12**
III	Distributions of rectangular, exponential, Gamma, Weibull, Beta, Cauchy and Log normal with their properties including proofs. Their mean variance, and characteristic functions. The characterizations related to above distributions along with their truncated and compound.	**12**
IV	Sampling distributions of mean and variance, student's t, $\chi 2$, F and sample correlation coefficient (r) when population correlation is zero. Their means, variances, measures of skewness, characteristics and moment generating functions, limiting distributions and important properties with their proofs.	**12**
V	Bivariate normal distribution with its applications and important properties. Standard bivariate normal distribution. Development of the formula of recurrence relation for moments and other important related problems to this distribution. Distributions of order statistics, sample range, sample median, joint distributions of r^{th} & s^{th} order statistics. Distributions of minimum and maximum observations. Curve fitting by Orthogonal Polynomials.	**12**

Suggested Readings:

1. Rohtagi V.K., "An Introduction to Probability Theory and Mathematical Statistics".- Wiley Eastern Ltd., New Delhi.
2. Hogg, R.V., Craig A.T.," Introduction to Mathematical Statistics"- Mac-Millan Publication Ltd. New York.
3. Johnson N.L., Kotz, "Continuous Univariate Distribution V-Ist" –John Wiley & Sons , New York.
4. Johnson N.L., Kotz, "Continuous Univariate Distribution V-IInd" –John Wiley & Sons, New York.
5. Johnson N.L., Kotz , "Discrete Distributions" – John Wiley & Sons, New York.
6. Goon Gupta and Das Gupta, "Fundamentals of Statistics V-I" – The World Press Private Ltd., Calcutta.
7. Mood, Grabill & Bose, "Introduction To The Theory of Statistics" –Mc-Graw Hill.
8. Biswas S., "Topics in Statistical Methodology"- Wiley Eastern Ltd., New Delhi.
9. David H.A., "Order Statistics" – John Wiley and Sons , New York.
10. Mukhophadhyay Parimal. "Mathematical Statistics". New Central Book Agency. Calcutta.
11. Fawlkes, E.B., "A falio of distributions".

Suggested Online Links/ Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
https://swayam.gov.in/explorer?searchText=statistics

https://nptel.ac.in/course.html

https://www.edx.org/search?q=statistics https://www.coursera.org/search?query=statistics&

Total No. of Lectures- 60

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, and Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **M.Sc.**	Year: **First**	Semester: **First**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Sampling Techniques**	

Need of the Course- Sampling is that part of statistical practice concerned with the selection of individual observations intended to yield some knowledge about a population of concern, especially for the purpose of Statistical Inference.

Objective of the Course- The course aims to defining the population under study, its sampling frame, studying various sampling methods, determining the sample size and collecting data.

Course outcomes:

CO1- The main objective of this course is to train the students to use various sampling techniques, which are commonly applied to collect primary data for private and government sectors.

CO2- The course deals with estimation of various population parameters.

CO3- The course understands the students how to collect and utilize the auxiliary information to improve the estimates.

CO4- The course equips the students at the postgraduate level to get the employability skills.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	**Introduction:** Census and sample surveys, advantages and disadvantages of sample surveys, Limitations of sampling, Basic principles of sample survey, Principle steps in sample survey, Sampling and non-sampling errors, Inter-penetrating, Sub-samples, Pilot survey. **Simple Random Sampling:** Simple random sampling, Sampling from finite populations with and without replacement, Unbiased estimation and confidence intervals for population mean and total, Simple random sampling of attributes.	**12**
II	**Stratified Random Sampling:** Reasons for stratification , choice of strata , choice of sampling unit, stratified random sampling, estimation of population mean and its variance, choice of sample sizes in different strata, variances of estimates with different allocation, effects of deviation from optimum allocations, estimation of the gain in precision due to stratification, cost function, construction of strata.	**12**
III	**Systematic Sampling :** Estimation of sample mean and its variance, comparison of systematic sampling with simple random and stratified sampling. **Ratio and Regression Estimation:** Ratio and regression methods of estimation, variances of the estimates, optimum property of ratio estimates, comparison among ratio and	**12**

	regression and simple and biased estimates.	
IV	**Cluster Sampling:** Estimates of mean and its variance for equal and unequal clusters, efficiency in terms of intra- class correlation, optimum unit of sampling, sampling with replacement, estimation of mean and its variance. **PPS Sampling:** Sampling techniques with varying probabilities for simple random sampling with and without replacement. Herwits Thompson Estimator, Mid Zuno Sen Sampling Scheme.	12
V	**Multistage and Multiphase Sampling:** Introduction of Multistage sampling, Two stage sampling with equal stage units, Estimation of its mean and variance, Introduction of Multiphase sampling, double sampling for stratification.	12

Suggested Readings:

1. Chocran W.G., " Sampling Techniques" –Wiley Eastern Ltd. ,New Delhi.
2. Sukhatma P.v., "Sampling Theory of Survey with Applications"-Piyush Publications, New Delhi.
3. Raj D. Sampling Survey Theory- Narasa Publication House,New Delhi.
4. Murthy M.N. Sampling Theory and Methods- Statistical Publishing Society, Calcutta.
5. Daroga Singh and F.S.Chaudhary. Sampling Survey Design-Wiley Eastern Ltd.New Delhi.
6. Mukhopadhayay Parimal. Theory and Methods of Survey Sampling-Prentice Hall of India Ltd. New Delhi.
7. Foreman E.K. Survey Sampling Principles-Dekker Vol. 120.
8. Kish L. Survey Sampling.
9. Ravindra S.and Naruang S. Elements of Survey Sampling-Kluwar Academic Press.
10. Goon Gupta and Das Gupta. Fundamentals of Statstics . Vol. I. The world Press Pvt. Ltd. Calcutta.
11. Thomson M.E. Theory of Sample Survey. Chapman and Hall London.

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
https://swayam.gov.in/explorer?searchText=statistics

https://nptel.ac.in/course.html

https://www.edx.org/search?q=statistics https://www.coursera.org/search?query=statistics&

Total No. of Lectures- 60

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, and Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **M.Sc**	Year: **First**	Semester: **First**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Statistical Programming with R-language**	

Need of the Course- The primary needs are to acquaint students with the functionalities of the components of the computer and to abreast them with the latest developments in the computing world thereby enabling them to perform data analysis effectively and efficiently in any specialized statistical software.

Objective of the Course- The objective of the course is to enhance the programming skills and working knowledge of available numerical and statistical softwares.

Course outcomes:

After completing this course, students will be able to

CO1- Initiate and lead projects within the scientific field and be responsible for the work of individuals and groups.

CO2- Ability to think logically and write pseudo code or draw flow charts for problems.

CO3- Make use of different R Data Structures.

CO4- Analyze the datasets using R programming capabilities.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	**Introduction & Data Handling in R:** Introduction to the statistical software R, Data objects in R, Creating vectors, Creating matrices, data frame, Manipulating data, Accessing elements of a vector or matrix, Lists, Addition, Multiplication, Subtraction, Transpose, Inverse of matrices. Functions operated on data objects. Merging of two or more data frames, Importing data, Read and Write files. Boolean operators. Handling of missing and duplicated cases/observations. Writing own functions.	**14**

II	**R-Graphics:** Types of plotting functions and their applications. Histogram, Boxplot, Steam and leaf plot, Scatter plot, matplot, Plot options; Multiple plots in a single graphic window, Adjusting graphical parameters.	12
III	**Looping & Simulation:** For loop, repeat loop, while loop, if command, if else command. A simulation application: Monte Carlo Integration, Random sampling, Bootstrapping.	08
IV	**Statistical Methods:** Univariate and Multivariate statistics; Mean, Median, Variance, Covariance, Skewness, kurtosis, Correlation, Distribution functions in R, maximum likelihood estimation using R-functions. Model fitting, Parametric and Non-parametric tests, Chi-square tests: goodness of fit, Contingency tables, Normality tests in R.	14
V	**ANOVA & Regression:** Analysis of Variance (ANOVA): Factor variables, ANOVA table, Multiple comparisons; Simple and Multiple Linear regression analysis, Generalized linear model: logistic and Poisson regressions.	12

Suggested Readings:

1. Alain F. Zuur, Elena N. Ieno, and Erik Meesters, "A Beginner's Guide to R", Springer, 2009.
2. Michael J. Crawley, "Statistics: An Introduction using R", Wiley, 2005.
3. Phil Spector, "Data Manipulation with R", Springer, New York, 2008
4. Maria L. Rizzo, "Statistical computing with R", Chapman & Hall/CRC, Boca Raton, FL, 2008.
5. W. John Braun and Duncan J. Murdoch, "A first course in Statistical programming with R", Cambridge University Press, Cambridge, 2007.

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
https://swayam.gov.in/explorer?searchText=statistics

https://nptel.ac.in/course.html

https://www.edx.org/search?q=statistics https://www.coursera.org/search?query=statistics&

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Total No. of Lectures- 60

Teaching Method - The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, and Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **M.Sc**	Year: **First**	Semester: **First**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Statistical Programming with C-language**	

Need of the Course- In the modern age of computing, Statistician uses computers for large and fast calculations. The advanced knowledge of computers and a scientific programming language is must for a student of Statistics.

Objective of the Course- The objective of this course is to introduce a student with basic know how of a computer system and to train him in the middle level computer programming language 'C'.

Course outcomes:

CO1-This course aware students about the fundamentals of computer programming.

CO2- It is mainly focused to enhance the logical skills of the students.

CO3- This course equips the students with the understanding of the basics of C-language such as functions, loops pointers etc.

CO4- After studying this course, students will be able to develop own programs of the applied statistical techniques in C-language, which will greatly help in the employability in commercial Sector.

Credits: 04	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	**Programming Methods:** Problem analysis, Algorithms, Flow charts, Programming Designs, Criteria for a good programming method.	6
II	**C Programming Language :** Basic features of C Language, constants, Variables and data types, operators and expressions Arithmetic, relational and logical, input and output statements with their formats, decision making statements, branching and looping, Arrays, user and system defined functions, structures and pointers .	14
III	**C Language Programs For :** **Statistical Methods:** Measures of central tendency and Dispersion. Moments, Correlation, Regression, Curve fitting. Test of significance, t-test and Chi-Square test for given data. **Matrix Algebra:** Addition, Multiplication, Transpose, Determinant and Inverse of Matrices. Solution of system of Linear Equations.	14

IV	**C Language Programs For :** **Numerical Analysis:** Types of errors in computation, roots of algebric and transcendental equations by Bisection and Newton-Rapson methods. Difference table, Newton's forward, backward, Lagranges formulae for interpolation, Numerical integration, Trapezoidal, Simpson's 1/3 rd and 3/8 th rules, Weddle rule.	14
V	**C Language Programs For :** **Properties of Statistical Distributions:** Calculating pmf and cdf of Uniform, Binomial, Poission, Normal, Cauchy, Gamma, Beta, Students' t and Chi-square distributions, Generation of random numbers from these distributions.	12

Suggested Readings:

1. Balagurusamy E.: Programming in ANSI C , Tata Mc-Graw Hill Publishing company,Ltd. New Delhi (1998).
2. Kanetkar Yashwant P.: Let us C , BPB Publications, New Delhi (1999)
3. Kernighan B.W and: The C Programming Language, Prentice Hall of India Pvt Ltd. Ritchie Dennis M., New Delhi (1997).
4. Raja Raman V.: Computer Programming In C, Prentice Hall of India Pvt. Ltd. New Delhi (1999)
5. Gottfried Byron S.: Programming with C, (Schaum's Outline) Tata Mc Graw Hill Publishing company Ltd. New Delhi (1999).

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
https://swayam.gov.in/explorer?searchText=statistics

https://nptel.ac.in/course.html

https://www.edx.org/search?q=statistics https://www.coursera.org/search?query=statistics&

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Total No. of Lectures- 60

Teaching Method - The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizes, and Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **M.Sc.**	Year: **First**	Semester: **First**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Practical Lab based on the courses taught in first semester.**	

Course outcomes:

CO1- It provides the practical knowledge of the model fitting approach.

CO2- It designs to solve real life problems with the knowledge of the programming language.

CO3- It provides the platform to interact with the group members.

CO4- The aims of the course is to apply the knowledge of the theoretical developments of statistical techniques to the corporate sector.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **0-0-4.**

	Topic	No. of Lectures
	1. Problems based on the fitting of distributions. 2. Problems based on sampling techniques such as simple random sampling, stratified sampling, ratio and regression estimators etc. 3. Problems based on data handling with R-software. 4. Problems based on data analysis with R-software. 5. Problems based on statistical programming in C.	**60**

Suggested Coutinuous Evaluation Methods:

Continuous Internal Evaluation shall be based on Practical File/Record, Class Activities and Overall performance. The marks shall be as follows:

Practical File/Record	**(10 marks)**
Class Interaction	**(05 marks)**
Report Preparation/ Presentation	**(10 marks)**

Suggested Practical Examination Evaluation Methods: (75 Marks)

Practical Examination Evaluation shall be based on Viva-voce and Practical Exercises. The marks shall be as follows:

Practical Exercise (Major) 01 x 25 Marks	**25 Marks**
Practical Exercise (Minor) 02 x 15 Marks	**30 Marks**
Viva-voce	**20 Marks**

Programme/Class: **M.Sc.**	Year: **First**	Semester: **First**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Essential Statistics**	

Need of the Course- The knowledge of basic concepts of statistics is becoming prime need to a student/ researcher of every discipline. Keeping in view the demands, this course is designed with the primary statistical tools needed for everyone to apply statistics in their studies.

Objective of the Course- The main object of the present course is to provide the fundamental knowledge of statistics students and researchers other than statistics so that, they can understand the tools of statistics in depth.

Course Outcomes:

CO1- It is helpful in basic understanding of applied statistical tools.

CO2- It covers all essential statistics to get equipped with employability skills.

CO3- The knowledge of the correlation analysis will help in understanding of variable dependency in real life problems.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	**Classification, Tabulation and Diagrammatic Presentation of Data:** Primary and Secondary data and their collection, Types of classification: Chronological, Geographic, Qualitative and Quantitative, Construction of frequency distributions, Cumulative frequency distribution. Tabulation of data, Preparing a table, Types of table, Diagrammatic representation of data using various Bar diagrams, Area diagrams, Pie chart, Graphs: Histogram, Frequency Polygon, Frequency curve, Ogive	12
II	**Measure of Central Tendency:** Meaning of Measures of Central Tendency, Characteristics of a good average, Arithmetic mean, Geometric mean, Harmonic mean, Median, Mode, Partition values: Quartiles and Percentiles. Their properties, merits, demerits and applications of the above measures, Weighted Means	12
III	**Measure of Dispersion:** Meaning of variability or dispersion, Measures of Dispersion: Range, Quartile Deviation, Inter-quartile Range, Mean Deviation, and Standard Deviation, coefficient of variation with their merits, demerits and applications. Concepts of Skewness and Kurtosis	12

IV	**Correlation and Regression:** Meaning of correlation, Types of correlation, Scatter diagram, Karl-Pearson correlation coefficient with its properties, Spearman's Rank Correlation. Meaning of Regression analysis, Lines of Regression of Y on X and of X on Y, method of Least squares, Fitting of a Straight line and Parabola, properties of Regression lines, Prediction with Regression lines.	**12**
V	**Probability, Random Variable and Expectation:** Sample space, Equally likely cases, Mutually exclusive cases, independent events, definitions of probability, Addition and Multiplication rules of probability, Conditional probability. Definition of random variables and its probability distributions, Discrete and Continuous random variable functions of a random variable and its calculation.	**12**

Total No. of Lectures- 60

Teaching Method - The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, Surprise Class Tests- The continuing evaluation process through home assignments, quizzes, and surprise tests will be done by the concerned teacher teaching that course at regular interval of time.

BOOKS RECOMMENDED:

1. K.K. Sharma, Arun Kumar, A. Chaudhary (2006), "Statistics in Management Studies", Krishna Publication Media Pvt. Ltd., Meerut.
2. S.C. Gupta ( ), "Business Statistics", Sultan Chand & Sons, New Delhi..
3. S.C. Gupta, & V. K. Kapoor ( ), "Fundamentals of Mathematical Statistics", Sultan Chand & Sons, New Delhi.
4. Hogg, Mckean, Craig (2007), "Introduction to Mathematical Statistics", Pearson Education, Inc.
5. George W. Snedecor, William G. Cochran, (1989), "Statistical Methods", Iowa State University Press, Ames, Iowa.

SECOND SEMESTER

Programme/Class: **M.Sc**	Year: **First**	Semester: **Second**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Matrix Algebra & Linear Difference Equations**	

Need of the Course- This course forms the mathematical background for courses such as multivariate analysis, design of experiments, quadratic forms etc. So, the study of the course is of prime need.

Objective of the Course- To enable the readers to have a proper appreciation of the subject matter and to fortify their confidence in the understanding and application of methods.

Course Outcomes:

CO1- Students apply matrix techniques to applied problems from various disciplines.

CO2- The student will learn to manipulate matrices and to do Matrix algebra, determinants, Eigen values Eigen vectors and to solve the system of linear equations.

CO3- The knowledge of the Eigen values and Eigen vectors helps the students in the analysis of multi-dimensions data.

CO4- These skills will provide job opportunity in private sector.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	**Matrix:** Algebra of matrices, matrices associated with a given matrix. Symmetric, Skew-symmetric, Hermitian and Skew-Hermitian matrices with their properties, Inverse of a matrix and the related theorems, Trace of a matrix, Idempotent, Involuntary and Nilpotent matrices.	12
II	Definition of rank, Elementary transformations and their impact on rank, Elementary matrices and their inverse, Normal form of a matrix and related important theorems, rank of a product of two matrices. Vector and Vector-space, linearly dependent and independent set of vectors and the related theorems, Sub-Space of an n-vector space, Basis of a sub space.	12
III	System of linear homogeneous and non-homogeneous equations, Necessary and sufficient conditions for the consistency of a system of non-homogeneous equations. Characteristic matrix, equation and roots of a matrix, Caley Hamilton theorem, Unitary and Orthogonal matrices, Inner product of vectors and length of a vector, orthogonal vectors.	12

IV	Quadratic forms, Congruence of quadratic forms, Canonical form, Definite, semi-definite and indefinite quadratic forms, Orthogonal reduction of a real symmetric matrix, Simultaneous reduction of a pair of quadratic forms	12
V	**Linear Difference Equations:** Difference equation with its applications and properties in various fields. Solutions of the first order linear homogeneous/non-homogeneous difference equations with constant coefficient by operator and trial methods. Solutions of the linear homogeneous difference equations with variable coefficients.	12

Suggested Readings:

1. Vashishtha A.R, "Matrices:", Krishna Prakashan Media Pvt.Ltd.
2. Narayan, S., "A Text Book Of Matrices", S Chand & Co Ltd., New Delhi.
3. Bishwas S., "A Text Book Of Matrix Algebra", Khanna Publications, New Delhi.
4. Goel & Mittal, " Numerical Mathematics"
5. Saran,N., "Introduction to matrices"
6. Sharma, M.M., "Linear Difference Equations." Krishna Prakashan
7. Goel and Mittal, "Numerical Methods."
8. Gupta and Aggarwal, "Linear Difference Equations."

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
https://swayam.gov.in/explorer?searchText=statistics

https://nptel.ac.in/course.html

https://www.edx.org/search?q=statistics https://www.coursera.org/search?query=statistics&

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Total No. of Lectures- 60

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizes, and Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **M.Sc**	Year: **First**	Semester: **Second**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Theory of Experimental Designs**	

Need of the Course- In many areas like Industrial, Biological, Agricultural etc., the prime focus is to formulate the layout of the design of experiment so that appropriate information regarding the population can be gathered and analysed. Thus, it is must to have the knowledge of the experimental techniques such as CRD, RBD, LSD, BIBD and factorial designs.

Objective of the Course- To provide background of the fundamental theories and practices of statistical modelling and the analysis of observational, experimental and survey data, including continuous, binary and categorical data.

Course Outcomes:

CO1- It provides the knowledge of the basic principles of the design of experiments.

CO2- It helps the students to understand the real applications of the ANOVA.

CO3- It provides the knowledge of factorial experiments to find out best interaction effective.

CO4- It has wide applications in the fields like agriculture, pharmaceutical, engineering etc.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I & II	**Linear Estimation Theory:** Linear Estimation, Gauss-Markov set-up, Random & Mixed Models, Error & Estimation Space, Gauss-Markov Theorem, Least Square Estimates, Normal Equations, Residual Sum of Squares, BLUE, Conditions for Quadratic forms to be Chi-Square distributed, and Cochran's Theorems.	16
III	**Design of Experiments** Analysis of Variance, One-way ANOVA, Two-way ANOVA and Three-way ANOVA with their layout and statistical analysis, Analysis of Covariance for a one-way layout with one concomitant variable, Analysis of Covariance for a RBD layout with one concomitant variable.	16
IV	Principles of design of experiments, Uniformity trials, completely randomized, Randomized block and Latin square designs including missing plot techniques and their efficiency comparison, Split plot and strip plot designs	14
V	Factorial experiments (2^n, 3^2, 3^3 systems only), Complete and Partial confounding, balanced incomplete block designs with parametric relations and analysis under a fixed effect model.	14

Suggested Readings:

1. Biswas Suddendu, A Linear Model Approach To Regression Analysis & Its Application- New Age International Publication.
2. Bapot R.B. , Linear Algebra and Linear Model- Cambridge University Press.
3. Goon Gupta and Das Gupta, Fundamentals Of Statistics- S. Chand & Company, New Delhi
4. Das and Giri, Design Of Experiments- Wiley Eastern Ltd. New Delhi.
5. Chochran W.G. and G.M. , Experimental Design- John Wiley and Sons New York.
6. Waynee Lee, Experimental Design and Analysis- W.H. Freema and Company San Francisco
7. Kempthorne, O , The Design and Analysis Of Experiment- Wiley Eastern Ltd, New Delhi .
8. Winer B.J. , Statistical Principles In Experimental Design- Tata Mc-Graw Hill Publishing Co.
9. Federer W.T , Experimental Design- Oxford & IBM Publishing Company.

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
https://swayam.gov.in/explorer?searchText=statistics

https://nptel.ac.in/course.html

https://www.edx.org/search?q=statistics https://www.coursera.org/search?query=statistics&

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Total No. of Lectures- 60

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, and Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **M.Sc**	Year: **First**	Semester: **Second**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Statistical Inference-I**	

Need of the Course- In Statistics population parameters describe the characteristics under study. These parameters need to be estimated on the basis of collected data called sample.

Objective of the Course- The purpose of estimation theory is to arrive at an estimator that exhibits optimality. The estimator takes observed data as an input and produces an estimate of the parameters.

Course outcomes:

CO1- The main objective of this course is to train the students to use the estimation methods for finding better solutions of the real life problems.

CO2- The testing of hypothesis is widely used in manufacturing farms to control the quality and production of the products.

CO3- It helps in decision making under uncertainty in business.

CO4- The knowledge of course contents helps the students to get employability skills.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	**Properties of good estimators:** consistency, unbiasedness, efficiency, sufficiency and completeness, minimal sufficiency, Crammer Rao-Inequality its applications and examples, Characterization of distribution admitting sufficient statistics, Rao-Blackwell theorem and Lehman-Scheffe' theorem, Uniformly minimum variance unbiased estimation. Exponential and Pitman family of distributions.	14
II	**Methods of Point Estimation**: Method of maximum likelihood, Moments, Minimum Chi-Square, properties of M.L.E, existence of a best asymptotically normal estimate under regulatory conditions, Hazor Bazar theorem.	12
III	**Interval Estimation:** Confidence Regions, Best Confidence Intervals, Shortest Confidence Intervals, General Method of finding Confidence Interval, Tolerance confidence interval and Relationship with the Testing of Hypothesis. Examples based on Normal, Poisson, Exponential and Gamma distributions.	14
IV & V	**Testing of Statistical Hypothesis**: Simple & Composite Hypothesis, Concept of Critical Regions, Test Functions, Two Types of Error, Power of the Test, Level of Significance, Neyman-Pearson Lemma & its Generalization, Uniformly Most Powerful Tests, UMP Test of One-sided Hypothesis for Distributions with Monotone Likelihood Ratio Test, Randomized Tests, UMPU, Types A, A1 Critical Regions, Likelihood Ratio Test, Similar Test.	20

Suggested Readings:

1. Goon A.M. , Gupta M.K., & Das Gupta B. An Outline of Statistical Theory V-II- The World Press Private Ltd., Calcutta.
2. Rohtagi V.K. An Introduction to Probability Theory and Mathematical Statistics- Wiley Eastern Ltd., New Delhi.
3. Hogg R.V. & Craig A.T. Introduction to Mathematical Statistics- Mac-Millan Publications Ltd. New York.
4. Lehmann E.L. Theory of Point Estimation – John Wiley & Sons New York.
5. Mood Grabill & Bose Introduction to the Theory Of Statistics- Mc-Graw Hill
6. Rohtagi V.K. Statistical Inference- Wiley Eastern Ltd. New Delhi.
7. Kalbfleiseh J.G. Probability and Statistical Inference Vol-I & II- Springer- Verlag New York
8. Saxena & Surendran Statistical Inference – S.Chand & Co Ltd., New Delhi.
9. Jacks S. The Theory Of Statistical Inference- Chapman & Hall London.
10. Kale B.K. Parametric Inference – Narosa Publishing House , New Delhi.
11. Mukhopadhyay P. Mathematical Statistics- New Central Book Agency , Calcutta.

Suggested Online Links/Readings:

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https://www.edx.org/search?q=statistics https://www.coursera.org/search?query=statistics&

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Total No. of Lectures- 60

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

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Programme/Class: **M.Sc**	Year: **First**	Semester: **Second**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Real & Complex Analysis**	

Need of the Course- It is a branch of mathematical analysis dealing with the set of real and complex numbers which plays the vital role to follow the complexities of statistical topics in their research studies.

Objective of the Course- The main object of studying the course is to follow up various properties and important formulae related to real and complex numbers with their proofs.

Course outcomes:
After completing this course,

CO1- Students will be able to get equipped with the understanding of the fundamental concepts of functions of real and complex variables along with the concepts of analyticity

CO2- Apply the methods of complex analysis to evaluate definite integrals and infinite series.

CO3- Students will: Compute sums, products, quotients, conjugate, modulus, and argument of complex numbers.

CO4- Find all integral roots and all logarithms of nonzero complex numbers.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	**Real Analysis:** Concepts of continuity and differentiability , Roll's theorem with its geometric interpretation, Lagrange's and Cauchy's mean value theorems, Taylor's development of a function in a finite form with Lagranges's, Cauchy's and Roche's forms of remainders.	12
II	Double and Multiple integrals, Change of order of integration, Beta and Gamma functions, Dirichlet's multiple integrals and its Liouville's extension. Convergence of Improper integrals.	12
III	Laplace and Laplace-Stieltjes transforms with their important properties. Inverse Laplace-transform and various methods to obtain it. Mean and Variance in terms of L.T. Solution of simple differential and differential-difference equations by using L.T.	12
IV	**Complex Analysis:** Fundamental operations of complex numbers, Properties of the moduli and arguments, Geometric representation of algebric operations. Limites, continuity and differentiability of a complex valued function. Analytic function, Cauchy-Riemann equations. Harmonic function, Methods for construction of analytic function.	12

V	Complex integration, Cauchy's fundamental theorem, Cauchy's integral formula and its extension, Cauchy's integral formula for the first and nth derivative of analytic function, Liouville's , Taylor's and Laurent's theorems. Zeros and various types of singularities of an analytic function. Contour integration.	**12**

Suggested Readings:

1.Shanti Narayan : A course of mathematical analysis.
2. Rudin, W. : Principles of mathematical analysis.
3. Richardson, C.H.: An Introduction to calculus of finite differences.
4.Goel & Mittal : Numerical mathematics.
5.Sharma ,J.N. : Infinite series.
6. Phillips, E.G. : Functions of a complex variable.
7. Sharma, J.N. : Functions of a complex Variable.
8. Sharma,J.N. & Vasishtha,A.R.: Real analysis.
9. Gupta,R.K.: Theory of functions of a complex variables.
10. Spiegel, M.R.: Complex variables.

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
https://swayam.gov.in/explorer?searchText=statistics

https://nptel.ac.in/course.html

https://www.edx.org/search?q=statistics https://www.coursera.org/search?query=statistics&

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Total No. of Lectures- 60

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, and Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **B.Sc with Research**	Year: **Forth**	Semester: **Second**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Information Theory**	

Need of the Course- Information theory studies the quantification storage and communication of information. In the era of information technology, the flow of information is huge. We therefore need tools to filter and analyse the information.

Objective of the Course- To introduce information theoretic concepts for the transmission, processing, utilization and extraction of information. To impart the knowledge of coding, theory for increasing the efficiency and reducing the error of data communication.

Course outcomes:

After studying this course a student will be able to

CO1- use concepts of entropy, uncertainty and coding that can be applied to numerous fields of modern technology.

CO2- Explain concept of Dependent & Independent Source, measure of information, Entropy, Rate of Information and Order of a source.

CO3- Model the continuous and discrete communication channels using input, output and joint probabilities.

CO4- Represent the information using Shannon Encoding.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	Concept of Entropy and information measures, Formal requirements of the average uncertainty, Shanon's measure of information and its properties, Joint and Conditional Entropy, Relative entropy and mutual information, Uniqueness of the entropy function Jensen's Inequality and its consequences, Fano's Inequality, Asymptotic Equipartition Property, Entropy Rate.	**14**
II	Elements of encoding, redundancy and efficiency, binary codes , Shanon Fano Encoding ,Necessary and sufficient condition for noiseless coding, Average length of encoded message Kraft Inequality, McMillan Inequality, Optimal Codes, Huffman Code, Fundamental theorem of discrete noiseless coding.	**14**
III & IV	Differential Entropy, Joint and Conditional Differential Entropy, Properties of Differential and Relative Entropy, Differential Entropy of distribution, Relationship of Differential Entropy to Discrete Entropy, Differential entropy bound on discrete entropy Entropy Optimization Principles, Maximum Entropy Principle, MaxEnt Formalism, Maximum Entropy Distribution.	**18**

V	Channel capacity, symmetric channels, Binary symmetric channel, Binary Erasure channel, Properties of channel capacity. Joint AEP theorem, channel coding theorem (statement only), Fano's inequality and converse to the coding theorem, Hamming codes.	**14**

Suggested Readings:

1. Robert Ash — Information Theory
2. Reza, F.M. — An Introduction to Information Theory
3. Mathai, A.M. and Rathie, P.N. — Basic Concepts in Information Theory and Statistic.
4. Kullback, S. — Information Theory and Statistic.

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
https://swayam.gov.in/explorer?searchText=statistics

https://nptel.ac.in/course.html

https://www.edx.org/search?q=statistics https://www.coursera.org/search?query=statistics&

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Total No. of Lectures- 60

Teaching Method - The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizes, and Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **M.Sc.**	Year: **First**	Semester: **Second**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Practical Lab based on the courses taught in second semester.**	

Course outcomes:

CO1- It provides the practical knowledge of the test of significance.

CO2- It designs to solve real life problems with the knowledge of the statistical inference.

CO3- It provides the skills of data analysis and interpretation using designs of experiments.

CO4- Students will be able to provide the Statistical solutions of live projects.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **0-0-4.**		
	Topic	No. of Lectures
	1. Problems based on one-way and two-way ANOVA. 2. Problems based on CRD, RBD and LSD. 3. Problems based on factorial experiments. 4. Construction of critical regions for testing of hypothesis. 5. Problems based on finding Eigen values and Eigen vectors of ma matrix. 6. Problems based on finding rank, inverse of matrix. 7. Problems based on solving system of liner equations.	60

Suggested Continuous Evaluation Methods:
Continuous Internal Evaluation shall be based on Practical File/Record, Class Activities and Overall performance. The marks shall be as follows:

Practical File/Record	**(10 marks)**
Class Interaction	**(05 marks)**
Report Preparation/ Presentation	**(10 marks)**

Suggested Practical Examination Evaluation Methods: (75 Marks)
Practical Examination Evaluation shall be based on Viva-voce and Practical Exercises. The marks shall be as follows:

Practical Exercise (Major) 01 x 25 Marks	**25 Marks**
Practical Exercise (Minor) 02 x 15 Marks	**30 Marks**
Viva-voce	**20 Marks**

Programme/Class: **M.Sc.**	Year: **First**	Semester: **Second**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Applied Statistics**	

Need of the Course- Every discipline of study requires data analysis for verifying their theory. For this purpose, one needs applied statistical tools such as sampling techniques, time series models and quality control techniques etc.

Objective of the Course- The main aim of this course is to provide the knowledge of applied statistics to equip students of various disciplines to enhance their job prospects.

Course Outcomes:

CO1- Students will learn the applications of the statistics in practical life.

CO2- Students will gain the knowledge of index numbers, vital statistics etc.

CO3- It provides the skills of the analysis of financial and demographic data.

CO4- Students will be able to get job opportunities in corporate sector.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	**Basic Statistical Distributions:** Introduction, Binomial and Poisson discrete distributions with their properties and fitting. Continuous Uniform distributions, The Normal probability distributions, A Normal probability curve, area under the normal curve, applications of the normal distribution.	**12**
II	**Sampling Theory and Tests of Significance:** Complete enumeration and sample survey, advantage of sampling over census, Types of sampling, Simple random sampling, Stratified random sampling, Systematic sampling with their applications. Sampling & Non-sampling errors. Testing of hypothesis null and alternative hypothesis, simple and composite hypothesis, Two types of errors, Level of significance and Critical Region, Test of significance using Z, t, F and X^2 statistics.	**12**
III	**Time Series Analysis:** Definition of Time series, its utility and applications, Components of a Time series, Additive and Multiplicative models. Measurements of Trend by Graphical method, Method of Semi averages, Moving average method and Fitting a straight line, Seasonal Variation, Method of Simple average, Ratio to Trend method, Ratio to Moving average method, Link Relative method, Estimation of Cyclical variation.	**12**

IV	**Statistical Quality Control:** Causes of quality variation, Assignable and Chance causes, Product control, Process control, Types of Control Charts for variables and attributes $\bar{X}$, R, p, c charts, Acceptance sampling plans, Single and Double sampling plans, The OC curve.	12
V	**Analysis of Variance and Design of Experiments:** Analysis of one way and two way classification, Basic principles of design of experiments, Completely Randomized Design, Randomized Block Design and Latin Square Design with their applications. Basic ideas of Factorial Experiment with factors each at two levels.	12

Total No. of Lectures- 60

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, Surprise Class Tests- The continuing evaluation process through home assignments, quizzes, and surprise tests will be done by the concerned teacher teaching that course at regular interval of time.

BOOKS RECOMMENDED:

1. K.K. Sharma, Arun Kumar, A. Chaudhary (2006), "Statistics in Management Studies", Krishna Publication Media Pvt. Ltd., Meerut.
2. S.C. Gupta, "Business Statistics", Sultan Chand & Sons, New Delhi.
3. S.C. Gupta & V.K. Kapoor. "Fundamentals of Applied Statistics", Sultan Chand & Sons, New Delhi.
4. Gun, A.M. , M.K. Gupta & B. Dasgupta , "Fundamentals of Statistics", Vol- II, The world press Pvt. Ltd., Kolkata.
5. George W. Snedecor, William G. Cochran, (1989), "Statistical Methods", Iowa State University Press, Ames, Iowa.
6. Richard A. Johnson, C.B. Gupta (2006), "Probability and Statistics for Engineers", Dorling Kindersley (India) Pvt. Ltd.

THIRD SEMESTER

Programme/Class: **M.Sc.**	Year: **Second**	Semester: **Third**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Quality Control & Reliability Engineering**	

Need of the Course- In engineering and manufacturing, the knowledge of this course deals with assurance and failure testing in design and production of products or services to meet or exceed customer requirements.

Objective of the Course- The objective of the course is to have the knowledge of various methods to control the quality of a product and to increase the reliability of a device/system.

Course outcomes:

CO1- It provides the knowledge of the quality control techniques.

CO2- It is helpful for the quality controller to understand and use the concept of statistical quality control in industries.

CO3- Students will be able to apply the knowledge of reliability engineering in designing of the product.

CO4- It is completely the job-oriented course.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	**Quality Control:** Concept of quality and meaning of control, Product and Process controls. Concept of 3-sigma limits. Modified and Specifications limits. Different types of control charts like $\bar{X}$, R, np, p and c with their applications in industry.	**12**
II	100% inspection sampling, sampling inspection v/s 100% inspection. Single, Double, Multiple and sequential sampling plans for attributes. OC, AOQL, ASN and ATI curves. Concept of producer's and consumer's risk, AQL and LTPD. Variable sampling plans.	**12**
III	**Reliability Theory:** Concepts of reliability, point wise and steady state availabilities, hazard rate, failure and bath-tub failure rate curve. Constant, linearly increasing and non-linear increasing hazard models.	**12**
IV	Gamma, normal, log-normal and truncated normal failure laws. Mean time to system failure (MTSF) and mean time between failures. Series, parallel, k-out of n, series-parallel, parallel-series, and non-series parallel configurations. Concept of redundancy, comparison of component, unit and standby redundancies.	**12**

V	Analysis of reliability and MTSF of n-unit standby redundancy. Concepts of repair and preventive-maintenance (P.M.). Analysis of-n non-identical unit series system with constant failure and repair rates, two identical unit active and passive redundant systems with constant failure and repair rates. Concepts of imperfect switching device, priority and non-priority repairs, preemptive repeat and preemptive resume repairs.	12

Suggested Readings:

1. Barlow R.F. and Proschan F. Mathematical Theory of Reliability- John Wiley and Sons.
2. Sri Nath L.S. , Mathematical Theory Of Reliability- Affiliated East West Press Pvt. Ltd.
3. Balagurusamy , E. , Reliability Engineering- Tata Mc- Graw Hill Publications , New Delhi.
4. Govil A.K. , Reliability Engineering.
5. Duncan A.J., Quality Control and industrial Statistics
6. Ekambaram , Acceptance Sampling
7. Bowkder A.K. and Goode H.P. , Sampling Inspection by Variables- Mc-Graw Hill Edition.
8. Montogomary, Introduction to Statistical Quality Control- John Wiley and Sons , New York
9. Goon Gupta and Das Gupta, Fundamentals Of Statistics Vol-II . The World Press Pvt. Ltd.
10. Dimitri Kececioglu, Reliability and Life Testing Hand Book- Prentice Hall PTR , New Jersey
11. Suddendu Biswas, Statistics Of Quality Control- Prentice Hall Of India , Pvt. Ltd.
12. Ernest,G.Frankel : System reliability and risk analysis.

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
https://swayam.gov.in/explorer?searchText=statistics

https://nptel.ac.in/course.html

https://www.edx.org/search?q=statistics https://www.coursera.org/search?query=statistics&

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Total No. of Lectures- 60

Teaching Method - The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizes, and Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **M.Sc.**	Year: **Second**	Semester: **Third**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Statistical Inference-II**	

Need of the Course- Sometimes, the number of observations required by the procedure to reach a decision is not fixed in advance of the experiment. In such cases, inferences can be drawn by the use of the sequential procedure. More so, when we do not know the form of the population, non-parametric statistical tools like Sign, Run, Median, Mann-Whitney, K-S and Chi-squire tests are used to infer about the characteristics of the population.

Objective of the Course- The aim of the course is to provide deeper knowledge of the inferential statistics such as sequential estimation, OC and ASN functions, loss and risk functions, one, two and k-samples non-parametric tests.

Course outcomes:

CO1 The Student will learn to analyze and solve the fundamental problems of statistical inference.

CO2- The knowledge of sequential analysis will be helpful in decision making while testing of sophisticated items.

CO3- Non-parametric tests are widely used for analysing survival data, hence, students have better opportunity to get job in medical fields.

CO4- This course is mainly design to provide employability skills to students.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	**Decision Theory:** Loss function, Risk function, Randomised and Non-Randomised Decision Rules, Admissible Decision Rule, Complete, Essential complete and minimal complete classes of decision rules and their relationship, Minimax and Bayes decision rules, Estimation testing viewed as decision rule problem, Bayes and minimax estimators. Minimax and Bayes tests in simple cases.	**20**
II & III	**Sequential Analysis:** Sequential probability ratio test and their applications to Binomial, Poisson, Normal, Exponential and Gamma. O.C. and A.S.N. functions and their applications, termination theorem of SPRT with probability one. Wald's fundamental identity and its uses.	**20**
IV & V	**Non-Parametric Inference :**Probability Integral Transformation, Estimation Of Quantiles, Construction of Confidence Interval for Population Quantiles, Estimation & Testing, Test for Randomness, Test based on Runs & Sign for one & two samples problems, Median test, Wilcoxon and Mann-Whitney tests. Kolmogorov-Smrinov test for one and two samples.	**20**

Suggested Readings:

1. Wald A, "Sequential Analysis"- John Wiley and Sons New York
2. Gibbons J.D., "Non- parametric Statistical Inference". McGraw Hill International Edition.
3. Siegel S, "Non Parametric Statistics for Behavioral Sciences"- Mc Graw Hill Edition.
4. Mood Grabill and Boss, "Introduction to the Theory of Statistics".-Mc-Graw Hill .
5. Goon A.M.,Gupta M.K. and Das Gupta B. "An Outline of Statistical Theory V-II".-The World Press Private Ltd. Calcutta.
6. Rohatgi V.K., "An Introduction to Probability Theory and Mathematical Statistics- Wiley Eastern Ltd. New Delhi.
7. Wald A. Statistical Decision Functions"- John Wiley and Sons, New York.
8. Ferguson T.S., "Mathematical Statistics-A Decision Theoretic Approach"- Academic Press.

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
https://swayam.gov.in/explorer?searchText=statistics

https://nptel.ac.in/course.html

https://www.edx.org/search?q=statistics https://www.coursera.org/search?query=statistics&

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Total No. of Lectures- 60

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Home Assignments, Quizes, and Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **M.Sc.**	Year: **Second**	Semester: **Third**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Operations Research**	

Need of the Course- It is purely applied course having wide applicability towards business/industries.

Objective of the Course- To provide the ideas of formulating mathematical modelling and their optimum solution in the context of practical problems belonging to Govt./Pvt. Sectors.

Course Outcomes:

CO1 The Student will learn to understand the concepts of allocation and transportation problems.

CO2- The knowledge of LPP will help the students to formulate the real life problems in mathematical forms.

CO3- The knowledge of various queuing models has wide applications in service sector.

CO4- This course is mainly design to provide the skills of solving assignment, transportation and maintenance problems.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	**Introduction:** Definition and scope of operations research, Different types of models used in OR. Various phases of OR. **Allocation Problems:** Mathematical formulation of L.P.P, Graphical method to solve a L.P.P, Convex set, Convex combination and extreme points. Simplex method to solve a L.P.P with slack, Surplus and Artificial variables. Construction of dual of a L.P.P.	**12**
II	**Inventory Control:** Problems of inventory and the various costs associated with inventory control. EOQ models with uniform/non-uniform rate of demands when shortages are allowed and not allowed while the replenishment of inventory is instantaneous. EOQ models with uniform rate of demands when shortages are allowed/not allowed and replenishment of the inventory is non-instantaneous. Single period inventory models with no set up cost and demand rate is discrete/continuous r.v. Newspaper Boy problem.	**12**
III	**Transportation Problem:** Mathematical formulation of a transportation problem, Northwest corner rule, unit cost penalty method and method of matrix minima. Optimality test, Unbalanced transportation problem, Degenerecy in transportation problems. **Assignment Problems:** Assignment problems, formulation of these problems and their solutions, Unbalanced Assignment	**12**

	problems.	
IV	**Game Theory:** Criteria of pure and mixed strategies, pay-off matrix and saddle point. Solution of zero sum two person games- 2×2, 2×n, m×2 and m×n by minimax and maximin technique, arithmetic method, algebraic method, dominance principle, graphical method matrix method, sub-game method and linear programming techniques.	12
V	**Queueing Theory:** Introduction of the queuing system, Various components of a queueing system. Pure Birth Process; Pure Death Process, Birth and Death Process, M/M/1 , M/M/1(Generalised), M/M/1 FCFS/K/∞, M/M/C, Ample Server models, Erlang's loss model, Machine repair problem.	12

Suggested Readings:

1. Gass, S.I , A Linear Programming Methods and Applications- Mc-Graw Hill Publishing Co.
2. Taha , Operations Research and Introduction- Mac-Millan Publishing Co., New York.
3. Churchman C.W., Ackoff R.L. and Arnoff E.L., Introduction To Operations Research- John Wiley and Sons , New York.
4. Saaty T.L., Mathematical Methods Of operations Research, Mc-Graw Hill Book Co., New York.
5. Satty, T.L., Elements Of Queueing Theory – Mc-Graw Hill Book Co.,. New York.
6. Yaspan A., Sasieni M.,& Fiedman L., Linear Programming methods and Applications- John Wiley and Sons New York.
7. Churchill R.V. , Operation Mathematics-Mc- Graw Hill Kogakusha Ltd., Calcutta.
8. KantiSwaroop and Manmohan, Operations Researcb- S.Chand and Co. , New Delhi.
9. Sharma S.D., Operations Research- Pragati Prakashan, Meerut.
10. Gupta R.K., Linear Programming- Krishna Prakashan Media Pvt.Ltd., Meerut.
11. Jones A.J., Games Theory- John Wiley and Sons- New York.
12. Straffin E.D., Games Theory and Strategy- The Mathematical Association Of America.
13. Thomas L.C., Games Theory and Applications- John Wiley and Sons, New York.

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
https://swayam.gov.in/explorer?searchText=statistics

https://nptel.ac.in/course.html

https://www.edx.org/search?q=statistics https://www.coursera.org/search?query=statistics&

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Total No. of Lectures- 60

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she

will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, and Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **M.Sc.**	Year: **Second**	Semester: **Third**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Advanced Bayesian Statistics**	

Need of the Course- A part from estimating parameters, Statistics also attempts to test the conventional wisdom or guesses or conjectures made by experienced experimenters. Testing of hypothesis does exactly that.

Objective of the Course- The course aims to include the methods of testing of hypothesis and its counterpart interval estimation both in classical as well as Bayesian frame work.

Course outcomes:

CO1 This is the only course that covers all aspects of risk management in depth.
CO2- It has wide applications in marketing and business.
CO3- After studying the concepts of Bayesian inference, Students will be able to get job in insurance sector.
CO4- Students can address the problems of parametric estimation, predictive inference and hypothesis testing according to the Bayesian viewpoint.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	**Bayes Estimation:** An outline of Bayesian framework, Bayes Theorem, Types of priors, Conjugate prior, proper and improper prior, subjective prior etc., Methods of obtaining priors.	**12**
II	Types of loss functions, Squared error loss function, Absolute error loss, 0-1 loss, Asymmetric loss functions such as LINEX and Entropy loss functions, Mixture of loss functions,	**12**
III	Computation of posterior distribution, Bayesian calculations, Monte Carlo Technique, Approximation methods, Emperical method, Gibbs sampler.	**12**

IV	**Bayesian Interval Estimation:** Credible Intervals, Highest Posterior Density Regions, Interpretation of the Confidence Coefficient of an Interval & its Comparison with the Coefficient of Classical Confidence Intervals.	12
V	**Bayesian Hypothesis testing**: Specification of the Appropriate Form of the Prior Distribution for a Bayesian Testing of Hypothesis Problem, Prior Odds, Posterior Odds, Bayes Factor, Bayesian Information Criterion(BIC).	12

Suggested Readings:

1. Mood Grabill and Boss, "Introduction to the Theory of Statistics"-Mc-Graw Hill .
2. Goon A.M.,Gupta M.K. and Das Gupta B., "An Outline of Statistical Theory V-II"-The World Press Private Ltd. Calcutta.
3. Rohatgi V.K., "An Introduction to Probability Theory and Mathematical Statistics" Wiley Eastern Ltd. New Delhi.
4. Hogg R.V. and Craig A.T., "Introduction to Mathematical Statistics"-Macmillion Publications.
5. Wald A., "Statistical Decision Functions"- John Wiley and Sons.New York.
6. Ferguson T.S., "Mathematical Statistics"-A Decision Theoretic Approach- Academic Press.
7. Robert, C.P., Casella, "Monte Carlo Statistical methods" G. Springer, New York.
8. Berger, J.O., "Statistical Decision Theory and Bayesian Analysis", Springer Series.

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
https://swayam.gov.in/explorer?searchText=statistics

https://nptel.ac.in/course.html

https://www.edx.org/search?q=statistics https://www.coursera.org/search?query=statistics&

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Total No. of Lectures- 60

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, and Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **M.Sc.**	Year: **Second**	Semester: **Third**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Actuarial Science & Official Statistics**	

Need of the Course- One needs to develop and apply statistical tools to study the aging variables and there covariates so that optimum financial policies for human life security can be formulated.

Objective of the Course- To introduce and expose students to application of statistics in Actuarial field and to make them aware of various government statistical offices, their policies for their functioning with optimization.

Course outcomes:

CO1- An Actuarial Science course is designed to teach the students about risk assessment, financial Modelling and future risk predictions.

CO2- It deals with financial modelling, pricing and risk management, among others.

CO3- Students get the job opportunities in insurance industry.

CO4- The official statistics course teaches students about institutional, legal and organizational aspects of official statistic in India.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curate future lifetime, force of mortality.Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.	**12**
II	Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws	**12**
III	Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.	**12**
IV	Distribution of aggregate claims, compound Poisson distribution and its applications. Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.	**12**

V	Present official statistical system in India relating to population, agriculture, industrial production, trade and prices, methods of collection of official statistics, their reliability and limitation and the principal publications containing such statistics, various official agencies responsible for data collection and their main functions. Functions and organization of CSO and NSSO, Agricultural Statistics, area and yield statistics. National income and its computation, utility and difficulties in estimation of national income.	12

Suggested Readings:

1. N.L. Bowers, H. U. Gerber ,J. C. Hickman, D.A. Jone and C.J. Nesbitt, (1986), 'Actuarial Mathematics,'
2. Society of Actuarias, Ithaca, Illiois, U.S.A. Second Edition (1997). Section 1- Chapters: 1, 2, 8,9,11.
3. Spurgeon E.T. Life Continuances, Cambridge University Press.
4. Neil, A. Life Continuances, Heinemann.
5. M.R. Saluja: Indian Official Statistics. ISI publication.
6. Basic Statistics relating to the Indian Economy (CSO) 1990.
7. Statistical system in India (CSO) 1975.
8. Guide to official Statistics (CSO) 1999.
9. Principles and accommodation of National Populations Census UNIESCO.
10. Panse, V.G., Estimation of crop Fields (FAO).

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
https://swayam.gov.in/explorer?searchText=statistics

https://nptel.ac.in/course.html

https://www.edx.org/search?q=statistics https://www.coursera.org/search?query=statistics&

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Total No. of Lectures- 60

Teaching Method - The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, and Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **M.Sc.**	Year: **Second**	Semester: **Third**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Advanced Designs of Experiments**	

Need of the Course- Experimental designs are those by which the knowledge of various statistical topics can be applied in agriculture field for improving the crop-plants through genetic-techniques.

Objective of the Course- The objective of the course is to provide the knowledge of the construction and analysis of various applied designs such as BIBD, Factorial, Different types of L.S.D. etc.

Course outcomes:
Keeping the knowledge of the course, one can
CO1- apply the techniques of advanced designs in Biological and Agriculture research in order to see the significant effect of different new drugs/treatments.

CO2- Describe how to design experiments, carry them out, and analyse the data they yield.
CO3- Understand the process of designing an experiment including factorial and fractional factorial designs.
CO4- Examine how a factorial design allows cost reduction, increases efficiency of experimentation.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	**Constructions:** Elementary Theory of groups, Elements of projective and Euclidean Geometries, Galois.	**14**
II	**Construction of -** (i) Mutually orthogonal Latin squares.(ii)Hyper Graeco Latin Squares (iii)Incomplete Block Designs (Balanced and Partially Balanced)(iv)Totally and partially Confounded symmetric factorial designs.	**14**
III & IV	**Analysis:** Analysis of factorial design (2×4, 3×3, 3^2) Square and rectangular lattice designs, partially balanced incomplete block designs with recovery of interblock information.	**18**
V	Response Surfaces: Fractional replication in case of 2^n and 3^{TM} types, Analysis of group experiments.	**14**

Suggested Readings:

1. Levi, F.W : Algebra Vol-.I
2. Mann, H.B. : Analysis and Design of Experiments.(Dover Publication Inc. New York.
3. Cockran, W.G.and Cox, G.M : Experimental Designs (Asia Publishing House, Bombay)
4. Kelmpthrone, O. : The Design and Analysis of Experiments (John Wiley & Sons)

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
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Total No. of Lectures- 60

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, and Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **M.Sc.**	Year: **Second**	Semester: **Third**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Practical Lab based on the courses taught in third semester.**	

Course outcomes:

CO1- It provides the practical knowledge of quality control techniques.

CO2-Students will learn how to implement sampling inspection plans.

CO3- Students will learn how to perform non-parametric tests on real datasets.

CO4- The knowledge of advanced designs of experiments will help students to analyze filed data.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **0-0-4.**

	Topic	No. of Lectures
	1. Problems based on mean and range charts. 2. Problems based on charts for qualitative data. 3. Problems based on single and double sampling inspection plans. 4. Problems based on non-parametric tests.. 5. Problems based on advanced designs of experiments.	60

Suggested Continuous Evaluation Methods:

Continuous Internal Evaluation shall be based on Practical File/Record, Class Activities and Overall performance. The marks shall be as follows:

Practical File/Record	**(10 marks)**
Class Interaction	**(05 marks)**
Report Preparation/ Presentation	**(10 marks)**

Suggested Practical Examination Evaluation Methods: (75 Marks)

Practical Examination Evaluation shall be based on Viva-voce and Practical Exercises. The marks shall be as follows:

Practical Exercise (Major) 01 x 25 Marks	**25 Marks**
Practical Exercise (Minor) 02 x 15 Marks	**30 Marks**
Viva-voce	**20 Marks**

FOURTH SEMESTER

Programme/Class: **M.Sc.**	Year: **Second**	Semester: **Forth**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Multivariate Analysis**	

Need of the Course- Due to the multi-dimensional nature of the data arising from the various fields, it is then primary need to infer about the multivariate techniques such as correlation analysis, regression analysis, discriminate analysis, factor analysis, etc. which are used in reduction, factorization, classification and analysis of the high-dimensional data.

Objective of the Course- To provide practical training and experience in the application of the theory to the statistical modelling of data from real applications, including model identification, estimation and interpretation.

Course outcomes:

CO1-This course is designed to teach students the applications of multivariate statistical techniques.
CO2- Students will learn the use of multiple correlation and regression tools to observe the effect of one variable to the others.
CO3- It helps to handle and analyse big data.

CO4- It helps students to get employability skills.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	Multivariate Normal Distribution, Distribution of Random Vector Y = CX when C is a Non-Singular Matrix, Distribution of p-variate Random Vector Z = DX when D is a qxp matrix of rank q(<p), Marginal & Conditional Distributions of a Sub-Vector of a Normally Distributed Vector, Moment Generating Function & Characteristic Function of a Normally Distributed Random Vector, Additive property of a p-variate Normal Distribution.	12
II	Maximum Likelihood Estimators of Mean Vector and Co-Variance Matrix, Distribution of the Sample Mean Vector, Distribution of the Quadratic Form, $Y'T^{-1}Y$ when $Y \sim Np(0, T)$, and T is Non-Singular, Tests & Confidence Regions for μ when Λ is known, Sufficient statistics for μ and Λ.	12
III	Hotelling's T^2 Statistic as a function of Likelihood Ratio Criterion, its Distribution, Applications and Invariant property, Mahalanobis D^2 Statistic, Wishart Distribution with derivation & its properties.	12

IV	Problem of Classification into one of two categories, Procedures of Classification into one of two populations with known density functions, Priori probabilities & costs of misclassification, Best Regions of Classification into one of two known Multivariate Normal Populations, Fisher's Discriminant Functions.	12
V	Multiple regression Analysis, Multiple & Partial Correlations and their Estimation, Distributions of Partial & Multiple Correlation Coefficients in Samples from Multivariate Normal Populations in the Null cases only. Concepts of MANOVA and Principal Component Analysis.	12

Suggested Readings:

1. Anderson T.W., "Multivariate Analysis"- Wiley Eastern Ltd., New Delhi.
2. Giri N.C., "Multivariate Statistical Inference" – Charles Griffin and Co.Ltd. London
3. Rao, C.R, "Advanced Statistical Methods In Biometric Research"- John Wiley and Sons.
4 Morrison , D.F. "Multivariate Statistical Methods" Mcgraw Hill .International Edition.
5. Roy, S.N. "Some aspects of Multivariate analysis".
6. Singh,B.M. "Multivariate statistical analysis".

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
https://swayam.gov.in/explorer?searchText=statistics

https://nptel.ac.in/course.html

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Total No. of Lectures- 60

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, and Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **M.Sc.**	Year: **Second**	Semester: **Forth**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Time Series & Vital Statistics**	

Need of the Course- Time series is a sequence of data points indexed in time order. It is needed to forecast the future events. For social and economic purposes one needs to study the societies or groups in view of their birth and mortality rates. Demography studies the measurement of population processes.

Objective of the Course- The course aims to study various models and components of time series analysis for forecasting purposes. It also gives the study of distribution of population with respect to birth, migration, aging and death.

Course outcomes:

CO1-This course is very helpful to get the depth knowledge of time series analysis.

CO2-It also covers the study of the vital. Statistics including construction of life table, source of demographic data etc.

CO3- Students will learn the effect of seasonal and cyclic variation on the time series data like sales, production, interest rates etc.

CO4- After completing this course, students are expected to apply various techniques of time series models, including the seasonal autoregressive moving average (SARIMA) models, regression with ARMA models

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	**Time Series Analysis:** Objects, Decomposition, Tests of Randomness, Trend Component, Polynomial, Logistic, Gompertz, Log-normal trend functions, Smoothing of Moving average , Spencer's formulae and effects, Variate Difference method,	15
II	Measurement of Seasonal and Cyclical functions, Peridogram and Harmonic Analysis.	10
III	**Stationary and Non stationary Time Series:** Concepts, Auto regression, Autocorrelation, Partial Autocorrelation and Correlogram analysis.	10
IV & V	**Population Studies:** Sources of Demographic data, Limitations and uses of demographic data, Vital rates and ratios, Definition, Construction and uses, Life tables, Complete and Abridged construction of life table from vital statistics and census returns, Uses of life tables. Logistic and other population growth curves, Measure of fertility, Gross and Net reproduction rates, Stationary and Stable population theory. Uses of Lotka's stable population theory in estimation	25

	of demographic parameters, Methods of Intercensal and Postcensal estimation.	

Suggested Readings:

1. Goon Gupta and Das Gupta, Fundamentals Of Statistics V-II, The World Press, Pvt.Ltd.,
2. Kendall M .G.., The Advanced Theory of Statistics Vol-I & II- Charles Griffin & Co Ltd.,
3. Wald H, Demand Analysis- The Academic Press
4. Johnsonton J, Economic Models –John Wiley and Sons, New York.
5. Cox P.R., Demography- Cambridge University Press.
6. Biswas, S : Stochastic processes in demography and applications.

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
https://swayam.gov.in/explorer?searchText=statistics

https://nptel.ac.in/course.html

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Total No. of Lectures- 60

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, and Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **M.Sc.**	Year: **Second**	Semester: **Forth**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Data Analytics & Python**	

Need of the Course: The data analytics course is needed to train students for handling, analyzing and interpretation of different types of datasets such as marketing, medical, agricultural, banking, insurance etc.

Objective of the Course: The aims is to build a strong foundation of data science concepts that help students to learn practical implementation of machine learning through real-world datasets.

Course outcomes:

After studying this course, students will be able to

CO1- Understand and use python data science libraries as a tool for data science.

CO2- Describe common Python functionality and features used for data analytics.

CO3- Clean and identify the data from dataset by performing analysis and pre-processing on dataset.

CO4- Understand and apply statistical methods for classifications and predictions.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	**Python:** Introduction to programming using Python, Syntax and Data Types, Variables, Operators, Input/output, Flow of Control (Modules, Branching), If, If- else, Nested if-else, Looping, For, While, Nested loops, Control Structure Iterators, User-defined functions, Strings and Tuples, Accessing Strings, Basic Operations, String slices, Working with Lists, Introduction, Accessing list, Operations, Function and Methods, Files, Modules, Dictionaries, Functions and Functional Programming, Declaring and calling Functions, Declare, assign and retrieve values from Lists, Introducing Tuples, Accessing tuples, NumPy, Pandas, Exploratory Data Analysis, Summary statistics (mean, median, mode, variance, standard deviation), Seaborne, matplotlib.	16
II	**Data Analytics:** **Machine Learning Techniques:** Linear and Logistic Regression, Multiple linear regression, Fitted regression lines, AIC, BIC, Model Fitting (Over-fitting, Balanced fitting, Under-fitting), Multicollinearity, Heteroscedasticity, Outliers, Training and Test Data, Introduction to Logistic regression, interpretation, odds ratio, Misclassification, Probability, AUC, R-Square.	12

III	**Supervised Learning Classification:** CART, KNN (classifier, distance metrics, KNN regression), Decision Trees (hyper parameter, depth, number of leaves), Naive Bayes, Support vector Machines.	**12**
IV	**Unsupervised Learning:** Clustering - K-Means & Hierarchical, Distance methods - Euclidean, Manhattan, Cosine, Mahalanobis, Features of a Cluster - Labels, Centroids, Inertia, Eigen vectors and Eigen values, Principal component analysis.	**10**
V	**Ensemble Techniques:** Bagging & Boosting, Random Forest.	**10**

Suggested Readings:

1. Eric Matters: Python crash course – A Hands on Projects based Introduction to Programming.
2. David Beazley and Brian K Jones: Python Cookbooks Recipes for Mastering Python 3.
3. Krishna Rungta : Learn Python in One day – Complete Python Guide with examples.
4. Sebastian Raschka and Vahid Mirjalili : Python Machine Learning, 2nd Edition, Packt Publications.
5. Wes Mekinney: Python for Data Analytics.
6. Paul Barry: Head first Python, 2nd Edition
7. Lucaino Ramalho, Fluent Python
8. Sinan Ozdemir: Principles of Data science.

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
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Total No. of Lectures- 60

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

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Programme/Class: **M.Sc.**	Year: **Second**	Semester: **Forth**
Subject: **STATISTICS**		
Course Code: -	(a) Course Title: **Advanced Operations Research**	

Need of the Course- The course is designed to introduce students to idea of various types of programming, sequencing and replacement problem of items that deteriorate.

Objective of the Course- To give students a firm foundation in the advanced optimization techniques for the solution of the problems covered in course contents.

Course outcomes:

CO1-This course helps students to get the knowledge of mathematical and computational modelling of real decision-making problems, including the use of modelling tools and computational tools, as well as analytic skills to evaluate the problems.

CO2- It deals with the design, implementation, and analysis of computational experiments.

CO3- Students will get proficiency with tools from optimization and simulation including the fundamental applications of those tools in industry and the public sector in contexts involving uncertainty and scarce or expensive resources.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	**Integer Linear Programming:** Concept of integer linear programming problems, Gomory's all IPP techniques, Branch and Bound method for solving IPP, Applications of IPP.	12
II	**Quadratic Programming:** Structure of quadratic programming, Kuhn-Tucker conditions, Wolfe's modified simplex and Beale's methods for solving a Q.P.	12
III	**Revised Simplex Method:** Standard forms for revised simplex method, computational procedure for standard form-1 and standard form-2.	12
IV	**Job Sequencing:** Assumptions, Solution of sequencing problems, Processing n jobs through two machines, Processing n jobs through three machines, Processing two jobs through n-machines, Processing n-jobs through n-machines. **Replacement Problem:** Replacement policy of items whose maintenance cost increases with time constant and varying scrap value.	12

V	**CPM-PERT:** Development of CPM/PERT techniques, events and activities, application of CPM/PERT techniques. Network diagram representation, rules for drawing Network diagram, Critical Path Analysis, Project evaluation and review technique (PERT).Updating of the project, resource allocation.	12

Suggested Readings:

1. Gass, S.I , A Linear Programming Methods and Applications- Mc-Graw Hill Publishing Co.
2. Taha , Operations Research and Introduction- Mac-Millan Publishing Co., New York.
3. Churchman C.W., Ackoff R.L. and Arnoff E.L., Introduction To Operations Research- John Wiley and Sons , New York.
4. Saaty T.L., Mathematical Methods Of operations Research, Mc-Graw Hill Book Co., New York.
5. Satty, T.L., Elements Of Queueing Theory – Mc-Graw Hill Book Co.,. New York.
6. Yaspan A., Sasieni M.,& Fiedman L., Linear Programming methods and Applications- John Wiley and Sons New York.
7. Churchill R.V. , Operation Mathematics-Mc- Graw Hill Kogakusha Ltd., Calcutta.
8. KantiSwaroop and Manmohan, Operations Research- S.Chand and Co. , New Delhi.
9. Sharma S.D., Operations Research- Pragati Prakashan, Meerut.
10. Gupta R.K., Linear Programming- Krishna Prakashan Media Pvt.Ltd., Meerut.
11. Jones A.J., Games Theory- John Wiley and Sons- New York.
12. Straffin E.D., Games Theory and Strategy- The Mathematical Association Of America.
13. Thomas L.C., Games Theory and Applications- John Wiley and Sons, New York.

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
https://swayam.gov.in/explorer?searchText=statistics

https://nptel.ac.in/course.html

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Total No. of Lectures- 60

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, and Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **M.Sc.**	Year: **Second**	Semester: **Forth**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Bio-Statistics**	

Need of the Course- To know the genetic structure of populations and the forces that alter that structure, one should have the knowledge of deterministic and probabilistic models of random matting, generalized treatment of mutation, migration and selection, and plant genetics.

Objective of the Course- The course objectives are:

- To formulate probability models for the laws of genetic transmission.
- To identify and assess the impact of basic forces that changes the genetics of a population.

Course outcomes:

After studying this course, Students will be able

CO1- To formulate probability models for the laws of genetic transmission.
CO3- To identify and assess the impact of basic forces that changes the genetics of a population
CO3- To analyse genetic data to estimate the forces of genetic change.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I & II	Structure of a Breeding Population, Genetic Correlation under dominance, deterministic models of random mating under chromosomes and chromatid segregation, Generalized treatment of Mutation, Migration and Selection.	22
III & IV	Applications of Fisher's fundamental theorem of Natural Selection, Theory of Inbreeding, sex linked genes, Path Coefficients, Homozygosity in Finite Populations, Stationery distributions of genes, Haploid and Diploid Models,	22
V	Diffusion models in Genetics, Estimation of Components Of variation, Detection and estimation of Epistatic interaction and linkage in heredity, Chromosome mapping, Plant Genetics, Estimation of Gene frequencies in different blood group systems.	16

Suggested Readings:

1. Johnson, E. : Probability Models In Genetics.
2. Meran, P.P. : Statistical Process In Heredity.
3. Li, C.C : Population Genetics.
4. Baily : Genetics.
5. Kempthome, O. : Statistical Genetics.

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http://heecontent.upsdc.gov.in/SearchContent.aspx
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Total No. of Lectures- 60

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, and Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **M.Sc.**	Year: **Second**	Semester: **Forth**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Stochastic Process & Survival Analysis**	

Course outcomes:

CO1- The knowledge of the survival analysis will help students to get job in Bio-Statistics fields.

CO2- Students gets basic knowledge about stochastic processes in the time domain.

CO3-The student is able to formulate simple stochastic process models in the time domain and provide qualitative and quantitative analyses of such models.

CO4- The skills of stochastic analysis will provide job opportunity in share market.

CO5- The knowledge of this course can be applied in various diverse fields such as operations research, finance and insurance sectors, banking, planning & forecasting.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	**Stochastic Process:** Markov Chain, Champman Kolmogorov equation, classification of states, criteria for ergodic, persistent null and transient states, stationary distributions, limit theorems on transient and persistent null states.	**12**

II	**Survival Analysis:** **Basic concepts:** Definition of survival function, Failure rate or hazard function, Mean residual life and their relationship, Life testing plans or censoring methods, Right and left censoring, Type I and II censoring with and without replacement, Random Censoring.	12
III	**Some failure time distributions:** One and two parameter exponential, Gamma, Weibull, the extreme value and normal probability models as used in the analysis of life time data and in problems related to the modeling of aging or failure processes, some mixture models in a lifetime distribution.	12
IV	**Reliability Estimation Procedures:** Estimation of Parameters and reliability function associated with various life time distributions and life testing plans, Various properties of these estimators, confidence intervals for parameters and reliability function.	12
V	**Bayesian Techniques In Reliability Estimation:** Bayes Estimator of parameters and reliability function associated with life time distributions. Their properties and comparison with classical estimators.	12

Suggested Readings:

1. Cox, D.R. and Miller,H.D. : The Theory Of Stochastic Processes.
2. Deeb, J.L. : Stochastic Processes.
3. Srinivasan, S.K. and Menata,K.K. : Stochastic Processes.
4. Bartlett, M.S. : Introduction to Stochastic Processes.
5. Prabhu, N.U. : Stochastic Processes.
6. Sinha, S. K. : Reliability and Life Testing.
7. Lawless, J. F. : Statistical Models and Methods for Life Time Data.
8. Mann Scheffer and Singupurwalla : Methods for Statistical Analysis of Reliability and Life Data.

Suggested Online Links/Readings:

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Total No. of Lectures- 60

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

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Programme/Class: **M.Sc.**	Year: **Second**	Semester: **Forth**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Econometrics**	

Need of the course- One needs to develop and apply statistical methods to study the economic policies of an organizations or Government. Econometrics combines economic theory with statistics to analysis and test economic relationships.

Objective of the course- The purpose of this course is to give students a solid foundation in econometric techniques, various functions for economic analysis and future forecasting.

Course outcomes:

After studying this course, students will be able to

CO1- Recognize simple and multiple linear regression as a tool for analysing economic data (cross-section and time series).

CO2- perform basic model validation procedures.

CO3- Develop models for economic forecasting both from micro as well as macroeconomics points of views.

CO4- rigorously understand issues in connecting data, statistics and economic theory.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	A review of least squares and maximum likelihood methods of estimation of parameters in classical linear regression model and their properties (BLUE), Generalized Least Square Models, construction of confidence regions and tests of hypothesis, prediction, use of extraneous information in the form of exact and stochastic linear constraints, Restricted regression and mixed regression methods of estimation and their properties. Testing of extraneous information.	**14**
II	Multicollinearity, its effects and deletion, Remedial methods including the ridge regression. Specification error analysis, inclusion of irrelevant variables and deletion of dominant variables, their effects on the efficiency of optimization procedure.	**12**

III	Hetroscedasticity, consequences and tests for it, estimation procedures under hetroscedastic disturbances. Auto correlated disturbances, Effects on estimation of parameters, Cochran Orcutt and Prais-Winston transformation, Durbin-Watson test. Errors-in-varables model, Inconsistency of least squares procedures, Consistent estimation of Parameters by instrumental variables.	14
IV & V	Seemingly unrelated regression equation model, Ordinary least squares and feasible generalized least squares methods and their asymptotic properties. Simultaneous equation model, problem of identification, A necessary and sufficient condition for the identifiability of Parameters in a structural equation, Ordinary Least squares, indirect least squares, two stage least squares and limited information maximum likelihood method, K-class estimators, Asymptotic properties of estimators.	20

Suggested Readings:

1. Tinburger, J. : Economic Policy, Principles and Designs
2. Baumel, W.J. : Economic Theory and Operations Analysis.
3. Henderson, R.E. and Quandt, J.M. : Micro- Economic Theory, A Mathematical Approach.
4. Louis Phlips : Applied Consumption Analysis.
5. Kelvin Lancester : Mathematical Economics.
6. Dorfman, Samulsob and Solow : Linear Programming & Economic Analysis.
7. Allen, R.G.D. : Macro- Economic Theory.
8. Klein and Goldburger : An Econometric Model for the U.S. Economy.

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
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https://www.edx.org/search?q=statistics https://www.coursera.org/search?query=statistics&

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Total No. of Lectures- 60

Teaching Method – The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

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Programme/Class: **M.Sc.**	Year: **Second**	Semester: **Forth**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Research Methodology & Computer Application**	

Need of the Course: The researcher has to learn how to do research and what tools he should use.

Objective of the Course: The Objectives of the course is to make research students learn the scientific research methods and approaches.

Course Outcomes:

After studying this course, students will earn

CO1- The knowledge basic principles of research, objectives of research, importance, types of research. The basics of computer application in our research work.

CO2- The skills of research paper writing.

CO3- The knowledge of citation, bibliography, h-index, plagiarism etc.

CO4- The knowledge of INFLIBNET, e-journals, e-library, Scopus, database etc.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	**Introduction to Research Methods**: Definition of research, role and objectives of research, applications and types of research, research process and steps in it. Collecting and reviewing the literature, conceptualization and Formulation of a research problem, Identifying variables, constructing hypothesis, Synopsis.	**12**
II	**Research Design**: Selecting and defining a research problem, need for research design, features of a good research design, different research designs (exploratory, descriptive experimental and diagnostic research). **Design of Sample Survey**: Census V/s Sample enumerations, objectives and principles of sampling, Types of sampling, Sampling and Non-sampling errors. Designing Questionnaires and interview. Determination of the sample size.	**12**
III	**Measurement of Scaling Concepts**: Scales of measurements, nominal, ordinal, internal and ratio scales, Errors in measurements. Validity and Reliability in measurement, Scale Construction Techniques.	**12**

IV	**Data Collection & Analysis**: Primary & secondary data, Validity and Reliability of data collection procedures, data preparation, exploratory data analysis, parametric and non-parametric tests, correlation and regression analysis, ANOVA, Multivariate Techniques. **Report Writing**: Discussions, Conclusion, referencing and various formats for reference writing, Bibliography, Thesis Writing, Thesis writing, Formats of publications in research journals including subject classification, Impact factor, Citation index.	12
V	**Computer Applications**: Data Communication and networks, LAN, WAN,GAN, Internet, Website, Webpage, E-mail, Search Engines, Scientific search engines. PDF and Latex files. **MS WORD** : Test formatting, Math Type, MS Equation editor, INFLIBNET, e-journals, e-library, Scopus, Central blatt Math, Mathematical reviews.	12

Suggested Readings:

1. "Research Methodology methods and techniques" by C.R. Kothari, second revised edition.
2. "Research Methodology a step by step guide for beginners" by Ranjit Kumar
3. "Research Methodology Methods and Statistical techniques" by Santosh Gupta
4. "Statistical Methods" by S P Gupta.
5. "Research Design, Qualitative, Quantitative and mixed methods approaches" by W. Creswell, third edition.
6. "Information Communication Technology" by Tim Shortis.
7. "Handbook of Communication and Social interaction skills" by John O Green, Brant Raney Burleson

Suggested Online Links/Readings:

http://heecontent.upsdc.gov.in/SearchContent.aspx
https://swayam.gov.in/explorer?searchText=statistics

https://nptel.ac.in/course.html

https://www.edx.org/search?q=statistics https://www.coursera.org/search?query=statistics&

Z-Library. The world's largest ebook library.

Total No. of Lectures- 60

Teaching Method - The teacher in his/her lecture initially will revise the contents of previous lecture and then he will draw the outlines of new contents of today's lecture. Thereafter he/she will explain in detail one by one the contents of the today's outlines. Finally he/she will make a quick revision of today's new contents taught.

Home Assignments, Quizzes, and Surprise Class Tests - The continuing evaluation process through Home Assignments, Quizzes, and Surprise Tests will be done by the concerned teacher teaching that course at regular interval of time.

Programme/Class: **M.Sc.**	Year: **Second**	Semester: **Forth**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Practical Lab based on the courses taught in Forth semester.**	

Course outcomes:

After completing this course, students will have:

1. Ability to deal with the problems based on estimation of the mean vector and variance-covariance matrix using multivariate data.
2. Ability to deal with problems based on multiple correlation and regression analysis.
3. Ability to deal with the problems based on time series analysis..
4. Ability to fit models using supervised and unsupervised learning.
5. Knowledge of statistical programming in Python software.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): 0-0-4.

	Topic	No. of Lectures
	6. Problems based on multivariate data analysis. 7. Problems based on time series data analysis. 8. Problems based on fitting trend. 9. Construction of life table. 10. Data analysis using Python.	**60**

Suggested Continuous Evaluation Methods:

Continuous Internal Evaluation shall be based on Practical File/Record, Class Activities and Overall performance. The marks shall be as follows:

Practical File/Record	**(10 marks)**
Class Interaction	**(05 marks)**
Report Preparation/ Presentation	**(10 marks)**

Suggested Practical Examination Evaluation Methods: (75 Marks)

Practical Examination Evaluation shall be based on Viva-voce and Practical Exercises. The marks shall be as follows:

Practical Exercise (Major) 01 x 25 Marks	**25 Marks**
Practical Exercise (Minor) 02 x 15 Marks	**30 Marks**
Viva-voce	**20 Marks**

There shall be 04-05 Practical Exercises in Examination comprising 01 as Major (Compulsory) and 03-04 as Minor (Students have to attend any 02).