Choice Based Credit System (CBCS) Syllabus for M.A./M.Sc. Statistics

2nd - Semester for Batch 2022 wef 2022 and onwards

BOSPG held on 23/05/2022

General Instructions for the Candidates

1. The **two** years (**4 semesters**) PG Programmes is of **96** credit weightage i.e. **24** credits/semester (**24×4 = 96**).
2. Out of **24** credits in a semester a candidate has to obtain **14** credits compulsorily from the **Core Courses**, while the remaining **10** credits can be obtained from the **Electives (DCE, GE & OE)** in the following manner:
   - A candidate can obtain a maximum of **8** credits within his /her own Department out of specialization offered by the Department as **Discipline Centric Electives (DCE)**.
   - **2** credits shall be obtained by the candidate from the **Electives (GE, OE)** offered by the Department other than his/her own. The candidate shall be free to obtain these **2** credits from the **General** or **Open Elective or a Combination of both.**

SEMESTER – II			
Course Type	**Course Code**	**Title of the Course**	**No. of Credits**
Core (CR)	ST22201CR	Probability and Distribution Theory – II	**04**
	ST22202CR	Linear Models and Regression Analysis	**04**
	ST22203CR	Statistical Computing using R	**04**
	ST22204CR	Advanced Sampling Techniques	**02**
Discipline Centric Elective (DCE)	ST22205DCE	Operations Research - I	**04**
	ST22206DCE	Actuarial Sciences	**02**
	ST22207DCE	Inventory and Queuing Theory	**02**
	ST22208DCE	Practical based on ST22201CR & ST22202CR	**02**
	ST22209DCE	Practical based on ST22203CR & ST22204CR	**02**
Generic Elective (GE)	ST22210GE	Sampling Theory	**02**
	ST22211GE	Non-Parametric Tests	**02**
Open Elective (OE)	ST22212OE	Design of Experiments	**02**

PROBABILITY AND DISTRIBUTION THEORY - II

COURSENO: ST22201CR. **No. of Credits-4**

Course objectives: To Introduce the advanced concepts of probability theory.

Course outcomes: On successful completion of this course, the students will be able to

- Describe the advanced techniques of Probability theory including LLN.
- Apply the results of advanced Probability in statistical theory.

UNIT-I

Sampling distributions: Chi-square distribution and its properties and applications. Test of significance of Chi-square. Relation of Chi-square distribution with the other distributions. Examples based on Chi-square distribution. Non-central Chi-square distribution and related examples.

UNIT-II

Sampling distributions: F distribution and its properties and applications. Test of significance of F. Relation of F distribution with the other distributions. Examples based on F distribution. Non-central F-distribution and related examples.

UNIT-III

Sampling distributions: Z-distribution & Z-test and its properties and applications. t distribution and its properties and applications. Test of significance of Z and t. Relation of z & t distribution with the other distributions. Examples based on t distribution and Z test. Non-central t-distribution and related examples.

UNIT-IV

Bivariate distributions: Bivariate normal distribution and multinomial distributions and their properties, marginal and conditional distributions. Expectations and conditional expectations, covariance. examples.

Convergence: Convergence of a sequence of random variables, convergence in probability, almost sure, Convergence of a sequence of pair of random variables. Convergence of moments.

Weak law of large numbers (WLLNs): Condition for the WLLNs. Strong law of large number (SLLN) and examples.

RECOMMENDED TEXT BOOKS & REFERENCES:

- Dudewicz, E.J. and Mishra, S.N. (1988): Modern Mathematical Statistics, Willy, Int'l Students edition
- Rohatgi, V.K. (1994): An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.
- Rao, R.C. (1973): Linear Statistical Inference and its Applications, 2/e, Wiley Eastern
- Ash, Robert. (1972): Real Analysis and Probability, Academic Process
- Dudley, R.M. (1989): Real Analysis and Probability, Wads worth and Brooks /Cole
- Pitman, J. (1993): Probability,Narosa Publishing House.
- Johnson, S.andKotz, (1972): Distributions in Statistics, vol. III, Houghton and I, II AndMiffin.
- Johnson, Kotz and Kemp (1992): Univariate discrete distribution, John Willy

LINEAR MODELS AND REGRESSION ANALYSIS

COURSE NO: ST22202CR **No. of Credits-4**

Course objectives: To introduce basic and advance concepts of general linear model.

Course outcomes: On successful completion of this course, the students will be able to

- Describe the concepts of linear models in real applications of statistics modelling
- Apply concepts of linear models to illustrate its application areas like design of experiments, econometrics, survival analysis and demography.

UNIT-I

Linear models; Gauss Markov set up, Model classification, Normal equations and least squares estimates, Error and estimation space, Variance and covariance of least square estimates, Estimation of error variance, estimation with correlated observations, least square estimates with restriction on parameters.

UNIT-II

Test of hypotheses for one and more than one linear parametric functions, Tests of linear hypotheses, estimable linear hypotheses, confidence intervals and prediction intervals, Generalized F test, generalized t test.

UNIT-III

Experimental Design models; Introduction, Point estimation, Re-parameterization, Variance and Covariance of estimable function, testing of hypotheses, Regression models.

UNIT-1V

Simple linear regression fit of polynomials, Residual and their plot as tests for departure from assumption such as fitness of model, normality, and homogeneity of variances and detection of outliers, Analysis of covariance, estimation and testing, one way model with one covariance, two-way model with two covariance

RECOMMENDED TEXT BOOKS & REFERENCES:

- Cookers.and Weisberg, S (1982). Residual and Influence in Regression. Chapman and Hall
- Draper,N.R. and Smith, R.L. (1998). Applied Regression Analysis.3rd Ed. Wiley.
- Gunst, R.F. and Mason, R.L. (1980). Regression Analysis and its Applications- A Data Oriented Approach. Marcel and Decker.
- Roa, C.R. (1973). Linear Statistical Inference and its Applications.Wiley Eastern.
- Weisberg, S. (1985). Applied Linear Regression.Wiley.
- Rencher,A.C And Schaalje,G.B(2007),Linear Model in Statistics, John Wiely and Sons.

STATISTICAL COMPUTING USING R

COURSE NO.: ST22203CR **No. of Credits-4**

Course objectives: This Course is developed to help the students to learn various advanced techniques of data analysis in R Software.

Course outcomes: After successful completion of this course, the students will be able to:

- Have full knowledge of R software.
- Find solutions of problems of optimization through R.
- Articulate statistical modelling using R.
- Apply these modelling tools in Statistical/Machine learning.

UNIT-I

Introduction to R language, R as a calculator, Vectorization, notation and naming. Creation of data object, vector, factor and data frame. Extraction operators in R, data import/export, manipulation of data, Summary of data and statistical graphics with R. Representation of Multivariate data in R.

UNIT-II

Managing matrices in R: creating matrices, adding on to matrices, adding attributes to matrices, sub-setting matrices. Correlation and Regression analysis in R: simple and multiple. Tests of significance, Test of single proportion, Test of significance of difference of proportions.

UNIT-III

Using R Software's: Chi-Square tests: The Chi-Square distribution: Chi-Squared goodness of fit tests, Chi-Squared tests of independence and Chi-Squared tests of homogeneity. t-test for single mean, difference of means and paired t-test. Test for correlation in sampling from normal population, F-test, testing of two variances of two univariate normal population.

UNIT-IV

Simulation Studies using R Software, random number generation of various probability distributions. Codes for different programmes in R-Software. Estimation of parameters of different probability functions by using R. Linear Programming with R, Optimization with R.

RECOMMENDED TEXT BOOKS & REFERENCES:

- Bradley C. Boehmke (2016): Data Wrangling with R. Springer.
- E.J. Dudewicz and S.N. Mishra. (1988): Modern Mathematical Statistics, Willy, Int'l Students edition.
- John Verzani. (2005): Using R for Introductory Statistics. Chapman & Hall/CRC.
- S.C. Gupta and V.K. Kapoor (2012): Fundamentals of Mathematical Statistics, Sultan Chand & Sons.

ADVANCED SAMPLING TECHNIQUES

Course No: STM22204CR **No. of Credits-2**

Course objectives: To introduce the concepts of sample surveys and designs.

Course outcomes: On successful completion of this course, the students will be able to

- Use double samples to collect information for ratio and regression estimation.
- Compute the estimators when double sampling is used to collect information for stratification.
- Use two stage sampling under equal/ unequal first stage units.

UNIT- I

Double Sampling: Double Sampling for Stratification including estimation of variance. Variance of ratio and regression estimates in double sampling. Sampling on successive occasions: Sampling on two occasions, estimation of current population mean.

UNIT- II

Two-stage sampling: (a) Equal first stage unit; estimation of population mean and its variance and estimates of variance. Comparison with one stage sampling

(b) Unequal first stage unit; estimation of population mean. Expected values and variance of different estimates including the case of probability proportional to size

RECOMMENDED TEXT BOOKS & REFERENCES:

- Cochran, W. G: Sampling Techniques, 3rd edition, Wiley.
- Mukhopadhyay, P. (2000): Theory and Methods of Survey Sampling, Prentice Hall of India, Private limited, New Delhi
- Des Raj &Chandak (1998): Sampling Theory, Narosa.
- Murthy, M. N. (1977): Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
- Skate teal (1984): Sampling Theory of Surveys with Applications, Iowa University Press, & IARS.
- Singh, D and Chuddar, F. S. (1986): Theory and Analysis of Sample Survey Design, New Age International Publisher.

OPERATIONS RESEARCH - I

Course No: ST22205DCE **No. of Credits-4**

Course objectives: To introduce the basic and advanced concepts of Operations Research

Course outcomes: After successful completion of this course, the students will be able to:

- Formulate the LPP of the industrial problems.
- Describe the technique of Operations Research
- Apply the Operation Research in decision making.

UNIT I

Definition and scope of Operational research, Necessity of Operations Research in Industry; phases in Operations Research. Formulation of Linear programming problems (LPP), Cannonical and standard form of LPP, Basic definitions of LPP. Methods of solving LPP: Graphical method, Simplex method, Big-M method, Two-phase method and Extreme point theorems; Revised Simplex Method.

UNIT II

Duality in Linear programming problem, Symmetric and asymmetric dual problems, Unrestricted variables in dual LPP. Relationship between Primal and Dual LPP. Duality theorems: Weak duality theorem, Optimality criterion theorem, Unboundedness theorem, Fundamental theorem of duality, Complementary Slackness theorem and Complementary Slackness conditions and their applications. Dual Simplex Method.

UNIT III

Introduction to game theory. Strategy and its types. Decision Making in the face of competition, two–person, Zero sum games, payoff matrix. Maximin and Minimax principles. Games with pure and mixed strategies, existence of solution and uniqueness of value in zero-sum games, finding solutions in 2x2. Dominance principle, finding solutions in 2xm and mx2 type games, Equivalence between game theory and linear programming problem.

UNIT IV

Sequencing and scheduling problems: 2 machine n-job; 3 machine n-job problems with identical machine sequence for all jobs; 2-job n-machine problem with different routings. Project management; PERT and CPM; Probability of project completion.

RECOMMENDED TEXT BOOKS & REFERENCES:

- Taha H.A. (1982) Operational Research: An introduction; Macmillan.
- Philips D.T., Ravindran A. and Solberg J. Operation Research, Principles and Practice.
- KantiSwarup, P.K. and Singh,M.M.. (1985) Operation Research; Sultan Chand & Sons.
- Hillier F.S. and Lieberman G.J. (1962) Introduction to Operation Research; HoldenDay.
- Saaty T.L. (1961) Elements of Queuing Theory with Applications; McGraw Hill.
- Churchman C.W, Ackoff R.L. and Arnoff E.L. (1957) Introduction to Operations Research
- R. Panneerselvam(2002): Operations Research: Prentice Hall

ACTUARIAL SCIENCE

Course No.: ST22206DCE **No. of Credit-2**

Course objectives: To introduce the concepts of Acturial Science.

Course outcomes: After successful completion of this course, the students will be able to:

- Understand the concepts of Markov processes.
- Describe the technique of Gompertz-Makeham laws of mortality.

UNIT I

Survival models, sickness and marriage models in terms of Markov processes, force of mortality, hazard rate. Actuarial symbols tp_x and tq_x and integral formulas, Gompertz-Makeham laws of mortality, life tables

UNIT II

Lifetime distributions and estimation, Failure rate, mean residual life and their elementary properties, types of censoring, Estimation of survival function, Kaplan-Meier estimate, Nelson-Aalen estimate and their applications, Semi-parametric regression for failure rate, Cox proportional hazard model

RECOMMENDED TEXT BOOKS & REFERENCES:

- Cox, D.R. and Oakes, D., Analysis of Survival Data, Chapman and Hall, New York.
- Gross A.J. and Clark, V. A., Survival Distributions: Reliability, Applications in the Biomedical Sciences, John Wiley and Sons.
- Elandt – Johnson, R.E. Johnson N.L., Survival models and Data Analysis, John Wiley and Sons
- Miller, R.G., Survival Analysis (Wiley)
- Zacks, S., Reliability

INVENTORY AND QUEING THEORY

Course No.: ST22207DCE **No. of Credit-2**

Course objectives: To introduce the elementary and advanced concepts of queuing theory.

Course outcomes: On successful completion of this course, the students will be able to

- Describe the applied concepts of the stochastic process in the analysis of various queuing models.
- Apply the queuing models in various real-life problems

UNIT- I

Analytical structure of inventory problems; ABC Analysis: EOQ problem with and without shortages with (a) production is instantaneous (b) Finite Constant rate (c) shortages permitted random models where the demand follows uniform distributing, multistage inventory subject to constraints,

UNIT - II

Queuing models-specifications and effectiveness measures. Littles formula, Steady-state solutions M/M/1 and M/M/C models with associated distributions of queue-length and waiting time. M/G/1 queue. Steady-state solutions of M/Ek/1.Transient solution of M/M/1 queue.

RECOMMENDED TEXT BOOKS & REFERENCES:

- Taha H.A. (1982) Operational Research: An introduction; Macmillan.
- KantiSwarup, P.K. and Singh,M.M.. (1985) Operation Research; Sultan Chand & Sons.
- Hadley G. and Whitin T.M. (1963) Analysis of Inventory Systems; Prentice Hall.
- Hillier F.S. and Lieberman G.J. (1962) Introduction to Operation Research; Holden Day.
- Kleinrock L. (1975) Queuing Systems Theory Vol.1, John Wiley.
- Saaty T.L. (1961) Elements of Queuing Theory with Applications; McGraw Hill.

COURSE NO: ST22208DCE No. of credits -2

PRACTICAL BASED ON COURSES

ST22201CR & ST22202CR

Using Statistical Software

COURSE NO: ST22209DCE No. of credits-2

PRACTICAL BASED ON COURSES

ST22203CR & ST22204CR

Using Statistical Software

SAMPLING THEORY

COURSE NO: **ST22210GE** **No. of Credits-2**

Course objectives: To introduce the concepts of sample surveys and techniques.

Course outcomes: On successful completion of this course, the students will be able to

- Understand the methods of sampling.
- Apply the methods in data collections.
- Apply these techniques in Data Analysis.

UNIT-I

Basic concepts of sampling from a finite population; sampling versus complete enumeration; simple random sampling with replacement and without replacement, Concept of sampling design, expected value and sampling variance of the sample mean, expected value of the sample mean square and estimation of the variance.

UNIT-II

Stratified random Sampling: Estimation of the population mean/total and its variance, choice of sample sizes in different strata, variance under different allocations. Comparison with un-stratified sampling. Estimation of the gain in precision due to stratification, construction of strata.

RECOMMENDED TEXT BOOKS & REFERENCES:

- Cochran, W. G: Sampling Techniques, 3rd edition, Wiley.
- Mukhopadhyay, P. (2000): Theory and Methods of Survey Sampling, Prentice Hall of India, Private limited, New Delhi
- Des Raj &Chandak(1998): Sampling Theory, Narosa.
- S.C. Gupta & V.K Kapoor (2010), Fundamentals of Applied Statistics, Sultan Chand & Sons,

NON – PARAMETRIC TESTS

Course No: ST22211GE **No. of Credits-2**

Course objectives: To Introduce the concepts of non-parametric tests.

Course outcomes: On successful completion of this course, the students will be able to

- Describe the techniques of non-parametric tests.
- Apply the non-parametric test in statistical theory and related fields.
- Identify the distribution based on non-parametric tests.

UNIT-I

Non- Parametric Inference: Introduction, Advantages and disadvantages of non- parametric tests. Sign Test-one sample and two samples, Wilcoxon-Signed rank test- one sample and two samples, Wilcoxon –Mann Whitney test.

UNIT-II

Test of randomness based on total number of runs, Wald –Wilfwitz run test. Empirical distribution functions, Kolmogrov-Smirnov- one sample and two samples test (for samples of equal size)

RECOMMENDED TEXT BOOKS & REFERENCES:

- Mukh opadhayay, P.; Mathematical Statistics.
- Gibbons, J.D and Chakraborty, (2003): Nonparametric Statistical Inference,4th edition Marcel Dekker,CRC.

DESIGN OF EXPERIMENTS

Course No: ST22212OE **No. of Credits-2**

Course objectives: To introduce the elementary and advanced concepts of design and analysis of experiments.

Course outcomes: On successful completion of this course, the students will be able to

- Describe the techniques of design of experiments in real life scenario.
- Apply the response surface methodology in different application areas like food science, quality improvement, etc.

UNIT-I

Design of experiments, Principles of Design of experiments (randomization, replication, local control) Assumptions, layout and Analysis of Completely Randomized Design (CRD), Randomized Block Design (RBD), One missing observation in RBD.

UNIT-II

Factorial experiments: General factorial experiments, factorial effects; Main effects and Interactions. Best estimates and testing the significance of factorial effects; study of 2 and 3 factorial experiments in randomized blocks; Yates method for computing different factorial effects.

RECOMMENDED TEXT BOOKS & REFERENCES:

- S.C. Gupta & V.K Kapoor (2010), Fundamentals of Applied Statistics, Sultan Chand & Sons,
- Alokdey (1986): Theory of Block Designs, Willey Eastern
- Angela Dean Daniel Voss (1999): Design and Analysis of Experiments, Springer.
- Das, M.N and Giri, N. (1979): Design and Analysis of Experiments, Willey Eastern
- Giri, N (1986): Analysis of Variance, South Asia Publishers
- John, P.W.M. (1971): Statistical Design and Analysis of Experiments,
- Mcmillain Joshi.D.D. (1987): Linear estimation and Design of Experiments Willey Eastern
- R. Rangaswamy (2005): A Text book of Agricultural Statistics. New Age International (P) Limited.

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