To

The Addl. Secretary
Chancellor's Secretariat
Raj Bhawan, Patna

12.06.2018

Sub: Recommendations for MA/M.Sc Statistics CBCS syllabus with modifications

Sir,

Please, find enclosed herewith, the modified MA/MSc syllabus course content for necessary action.

Yours faithfully,

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SYLLABUS FOR M. A./M.Sc. IN STATISTICS

UNDER

CHOICE BASED CREDIT SYSTEM (CBCS)

(To be effective from 2018 -19)

UNIVERSITIES OF BIHAR

&

PATNA UNIVERSITY

OUTLINE OF THE CHOICE BASED CREDIT SYSTEM (CBCS) for PG degree courses:

It consists of a number of courses i.e. **Core Course (CC), Elective Course (EC), Discipline Specific Elective Course (DSE), Ability Enhancement Courses (AEC), and Ability Enhancement Compulsory Courses (AECC).** Each course is equivalent to a paper. The nature of these courses is defined below.

1.1 Core Course (CC):

A course which should compulsorily be studied by a candidate as a core requirement on the basis of subject of MSc studies and is termed as a Core course.

1.2. Elective Course (EC):

Generally a course which can be chosen from a pool of courses (Basket) and which may be very specific or specialized or advanced or supportive to the subject/ discipline of study or which provides an extended scope or which enables an exposure to some other subject/discipline/domain or nurtures the candidate's proficiency/skill is called an Elective Course.

1.3 Discipline Specific Elective Course (DSE):

Elective courses may be offered by the main discipline/subject of study is referred to as **Discipline Specific Elective**. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

1.4 Generic Elective (GE) Course:

An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a **Generic Elective**.

P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and *vice versa* and such electives may also be referred to as Generic Elective.

1.5 Ability Enhancement Courses (AEC):

The Ability Enhancement Courses (AEC) / Skill Enhancement Courses (SEC). "AEC" courses are the courses based upon the content that leads to life skill enhancement.

1.6 Ability Enhancement Compulsory Courses(AECC):

University will run a number of **Ability Enhancement Compulsory Courses (AECC)** which is qualifying in nature and student from all faculties have to qualify in all such courses.

1.7 Dissertation/Project/ Internship/ Industrial Training/ Field Work:

Elective courses are designed to acquire advanced knowledge to supplement /support the main subject through project work/ internship/ industrial training/ field work. A student studies such a course on his/her own with mentoring support by a teacher / faculty member called the guide/ supervisor. In case of internship/ industrial training the student will work under the joint guidance of one teacher-supervisor from the parent department to be termed as Supervisor-1 and one suitably qualified personnel at the research institute/ research laboratory/ industrial organization, to be termed as Supervisor-2. A student may join any recognized research institute/ research laboratory/ the industrial organization with the approval of parent department. The student has to work for a minimum number of days/ hour as decided by the parent department. On completion of the project work/ training at the research institute/ research laboratory/ industrial organization, student will submit a written project report certified by both supervisors to the parent department. Supervisor-2 will issue a letter certifying that the candidate has successfully completed the project and also award marks/ grade to him/ her. The certificate will be submitted to the parent department confidentially. The Board of Courses of Studies (BOCS) of the concerned subject/ department will draft and design the certificate and other documents as per requirement. The parent department will also assist the students to choose proper organizations for their project work/ industrial training/ field work etc.

2.0 CREDIT

The total minimum credits, required for completing a PG program is 100.

The details of credits for individual components and individual courses are given in Table.2.

Table 1: Structure of the 2 Yrs (Four Semesters) Post Graduate Degree course under CBCS:

Semester	No of COURSE/ Papers	Credit per COURSE/ paper	Total credit	Minimum No of Learning Hours#	No of CORE COURSE/ PAPER	No of ELECTIVE Course/ PAPER	Code & Nature of Elective Course/ paper
I	05	05	25	250	4	1	AECC-1
SEMESTER BREAK							
II	06	05	30	300	5	1	AEC-1
SEMESTER BREAK							
III	06	05	30	300	5	1	AECC-2
SEMESTER BREAK							
IV	03	05	15	150	0	3	EC -1* EC -2* DSE-1 or GE-1
Total	**20**		**100**	**1000**	**14**	**6**	

#For Tutorial (T)/ Practical (P)/ Field Work (FW)/ Internship etc. extra working hour to be added as per requirement and will be decided by the BOCS of the respective subject.

* The two **Elective Courses (EC)** to be studied in semester IV may be

Both theory papers

/ One Theory paper and One Practical paper

/ One Theory paper and One Project work

/ One Theory paper and One Field work

/ Both Project work/ Internship

IMP : It is desirable that all students of all courses be given adequate exposure over and above the class room teaching to enhance the scope of skill development/ entrepreneurship and employability.

2.1. There shall be six elective courses - two EC, one DSE or one GE, two AECC, one AEC. Students may opt for any elective course out of a list of elective papers **(Basket)** offered by the parent department or any other department/s as per his/her choice with the prior permission of the parent department. The list of elective papers, syllabus and prerequisite of the elective course will be as decided by the Board of Courses of Studies (BOCS) of the concerned subject/ department. All elective course listed may not be available in all semesters. Based on the availability of resource persons and infrastructure the parent department will assist the students to select elective courses of their choice.

2.2. The final CGPA/ class will be decided on the performance of the student in the 16 courses / papers including the 14 Core Courses (CC) / papers and two EC / papers.

2.3 The one DSE or one GE, two AECC, one AEC papers will be qualifying in nature and a student has to score at least 45% marks in these papers. Grade will be awarded separately for these courses, however, performance in these elective courses/ papers will not be considered for awarding the final CGPA/ class.

2.4 **Ability Enhancement Compulsory Courses (AECC):**

University will run two **Ability Enhancement Compulsory Courses** (AECC) which are qualifying in nature and a student has to qualify in both these courses. The courses are:

AECC-1 : Environmental Sustainability (3 Credit)
& Swachchha Bharat Abhiyan Activities (2 Credit)

Students will do assignments/project work related to institutional social responsibilities including Swachchha Bharat Abhiyan Activities during SEMESTER BREAK.

2.5 University will run a number of **Ability Enhancement Courses** (AEC) and Skill Enhancement Courses; a student can choose one from these. For example:

Basket Ability Enhancement Courses (AEC)

- Computers and IT Skill
- Web Designing
- Financial Risk Management/
- Solid waste Management/
- Mushroom Culture /
- Bio-fertilizer production/
- Environmental Law/
- Tourism & Hospitality Management/
- Lifeskill & skill development /
- Yoga Studies

etc.

2.6 Discipline Specific Elective (DSE):

In each subject the CC / paper -5 being taught in the second semester will be open to be selected as a DSE paper. In the first phase a student will be allowed to choose a paper from any subject other than his/ her Core Course (CC) from the same faculty in the same university.

2.7 Generic Elective (GE) Course:

University will run a number of **Generic Elective Courses** (GE); a student can choose one from these. For example:

Basket of GE courses

- Music
- Dramatics
- Fine Arts
- Graphic Design
- Inclusive Policies
- Human Rights
- Any course run by any department

M.A. /M.Sc. STATISTICS

SCHEME OF EXAMINATION

First year: Semester I (July to December)

Course code	Course	Max. Marks	Credits
MSTA CC 01	Real Analysis and Probability	70	5
MSTA CC 02	Linear Algebra and Operations Research	70	5
MSTA CC 03	Statistical Computing	70	5
MSTA CC 04	Practical		5
	Part A: Based on Paper (CC 01 to CC 03) + Viva voce	25	
	Part B: Group Discussion	25	
	Continuous Internal Assessment (CIA)	140	
	Total	400	20

First year: Semester II (January to May)

Course code	Course	Max. Marks	Credits
MSTA CC 05	General Statistics	70	5
MSTA CC 06	Liner Models and Regression Analysis	70	5
MSTA CC 07	Sample Survey & Design of Experiment	70	5
MSTA CC 08	Distribution Theory & Non- Parametric Tests	70	5
MSTA CC 09	Practical		5
	Part A: Based on Paper (CC 05 & CC 06)	25	
	Part B: Based on Paper CC 07 & CC 08	25	
	Continuous Internal Assessment (CIA)	140	
	Total	470	25

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Second year: Semester III (July to December)

Course code	Course	Max. Marks	Credits
MSTA CC 10	Reliability theory	70	5
MSTA CC 11	Statistical Inference	70	5
MSTA CC 12	Multivariate Analysis	70	5
MSTA CC 13	Stochastic Process	70	5
MSTA CC 14	Practical		5
	Part A – Based on Paper (CC 10 to CC 13)	20	
	Part B – Field work	30	
	Continuous Internal Assessment (CIA)	140	
	Total	470	25

Second year: Semester IV (January to May)

Course code	Course	Max. Marks	Credits
MSTA EC 01	Demography	70	5
MSTA EC 02	Operation Research	70	5
	Continuous Internal Assessment (CIA)	140	
	Total	280	10

Grand total of Semester I to Semester IV	1620
Grand total of Credits for all the Semester	80

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M.A. /M.Sc. STATISTICS

SCHEME OF EXAMINATION

Passing of Examination and Promotion Rule

The Post Graduate Course in STATISTICS shall be of two academic sessions comprising of FOUR SEMESTERS. Each academic session shall consist of two Semesters – I & III from July to December and Semester - II & IV from January to June.

The total credits including all the four Semesters will be of 80 ; 20 Credits for each Semester. One credit will consist of ten hours of instructions.

Each theory paper irrespective of their nature and credits shall be of 100 marks out of which the performance of a student in each paper will be assessed on the basis of Continuous Internal Assessment (CIA) of 30 marks and the End Semester Examination (ESE) consisting of 70 marks.

The components of CIA shall be

(a) Two Mid Semester Written Tests of one hour duration each	15 Marks
(b) Seminar/Assignments	10 Marks
(c) Regularity, Punctuality & Conduct	5 Marks

In Case of Practical 50 Marks will be for CIA and 50 marks for ESE.

1. There shall be no supplementary examination in any of the Semester Course (I, II, III & IV).
2. A student who has appeared at the CIA and attended the required minimum percentage (75%) of the attendance both in theory and Practical separately shall be permitted to appear in the End Semester Examination (ESE).
3. To be declared passed in ESE in any subject, a students must secure at least 40% marks in each paper separately and a minimum of 45% in total.

   A student has to secure minimum 50% marks in CIA of any paper. In case, a student fails to secure minimum 50% marks in CIA of any paper, he/she will be declared fail in that paper. Students shall have to reappear in that paper and in CIA examination also in the same semester of next academic session.

   If students fail to secure minimum 50% marks in CIA of any paper his result will be declared as fail in that paper. Students shall have to reappear in that paper in the same semester of next academic session.

   A promoted candidate, if he has passed in CIA but fails in theory paper/papers, he/she shall retain his/her CIA award and will reappear in the theory paper only of the semester whenever available. However, if a candidate is declared fail in any End Semester Examination, shall retain nothing and will have to redo the course work of failed semester again and he has to appear again in CIA as-well-as in theory paper.

4. If a candidate passes in at least two paper in his/her First, Second and third End Semester Examination, he/she shall be promoted to next higher semester. But he/she will have to clear their backlog papers in the next end semester examination of that semester whenever it is available. Even if a student is promoted to fourth semester his final result will only be declared when he/she has cleared all their backlog papers.
5. Final result of M.Sc. will be published only after he/she has cleared all the 16 paper securing minimum qualifying marks.
6. Student shall be awarded Grade Point (GP) at the end of each semester examination and Cumulative Grade Point (CGP) at the end of final End Semester Examination in 10 point scoring system.

Declaration of Result

The following grading system shall be used by teacher/ Examination department

Letter Grade	Percentage Range	Number of Letter Grade	Description of Grade
A	90-100	10	Outstanding
B	80-89	9	Excellent
C	70-79	8	Very Good
D	60-69	7	Good
E	50-59	6	Average
P	45-49	5	Pass
F	Less than 45	Less than 5	Fail

A student shall be declared to have passed and promoted to the next semester when he/she earns P or above grade in the semester examination covering continuous evaluation, mid term and end term examination.

Semester – I

MSTA CC 01 : Real Analysis and Probability **Credit : 5**

Unit – I

Compact Set, Bolzano-Weirstrass theorem, Heine-Borel theorem, Uniform convergence, Power series & Radius of convergence

Unit – II

Classes of Sets, field, sigma-field, minimal sigma-field, Borel -field in R^k, Sequence of sets, limsup and liminf of sequence of sets, Measure, Probability measure, properties of a measure, catatheodory extension theorem (statement only), Lebesgue and lebesgue Stieltjes measure on R^k

Unit – III

Random variables, sequence of random variables, almost sure convergence. Convergence in probability (and in measure), Integration of a measurable function with respect to a measure, Monotone convergence theorem. Fatou's lemma, Dominated convergence theorem.

Unit – IV

Borel-Cantelli Lemma, Independence, Weak law and Strong law of large numbers for iid sequence

Unit – V

Convergence in distribution, characteristic function, uniqueness theorem, levy's continuity theorem (statement only), CLT for a sequence of independent random variables under Lindberg's condition, CLT for iid random variables.

Reference:

Apistol, T.M. : Mathematical Analysis, Narosa, Indian Ed.
Ash, Robert : Real Analysis and Probability, Academic Press
Bhat, B.R.: Modern Probability theory, wiley Eastern Limited
Billingsley, P : Probability and Measure, John –Wiley NY.
H.L.Royden: Real Analysis, Prentice Hall of India.
Parzen E, : Modern Probability Theory and its Applications, Jonn wiley, 1960 New York.
Shanti Narayan and Singhania M.D.R: Elements of Real Analysis, S. Chand & Company, New Delhi

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MSTA CC 02 : Linear Algebra and Operations Research **Credit : 5**

Unit – I
Linear transformations, algebra of matrices, row and column spaces of a matrix, elementary matrices, rank and inverse of a matrix, partitioned matrices

Unit – II
Solution of matrix equations, characteristics root and vectors. similar matrices, generalised inverse of a matrix.

Unit- III
Definition and scope of operations research, different type of models in operations research. elements of Linear Programming Problem. Formulation of LPP, Solution of LPP through graphical and simplex method, artificial basis technique. Principles of duality in LPP, dual - primal relationship.

Unit – IV
Transportation and Assignment problems and their solutions. Sequencing and scheduling problems: 2 machine – n job problems, 2 job – n machine problem.

Unit – V
Queuing Models : Specifications and effectiveness measures, steady state solutions of (M/M/I) and (M/M/C) models with associated distributions of queue length and waiting time.
Inventory theory: Elementary models with and without shortage.

Reference:

Biswas, S : Topic in Algebra of Matrices, Academic Publication.
Gan, G.I.(1958) : Linear Programming Methods and Applications, McGraw Hill Publications.
Kanti Swarup, Gupta, P.K and Singh M.M (1985) : Operations Research; Sultan Chand & Sons
Narayan,S : A text Book of Matrices, S. Chand Publishing Company.
Philips D.T, Ravindran A and Solberg J. : Operations Research, Principle and Practice
Taha H.A. (1982) : An introduction of Operations Research, Macmillan
Vasishtha A.R. & Vasishtha, A.K.: Matrices, Krishna Publication, Meerut

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MSTA CC 03 : STATISTICAL COMPUTING **Credit : 5**

Unit –I

Programming in C++, Input/ Output Statements, constant and variables, data type, variable's scope, control statements, arrays, function and pointer.

Unit-II

Concept of Object Oriented Programming, class and object, structure, property of Inheritance, Polymorphism, Constructor and Destructor, Overloading and Overriding of functions, static member variable and functions and virtual functions in C++.

Unit-III

Elementary Java programming. Input/Output statements, arrays, function, control statements, Class and object. Properties of Inheritance, Overloading and Overriding of functions, Concept of Packages. Solutions of Statistical Problems based on C++ and JAVA.

Unit IV

MINITAB and SPSS for Graphics, Descriptive Statistics, Representation of Multivariate data, simple hypothesis tests, analysis of variance and linear regression.

Unit-V

Data base management, data warehousing and data mining.

References:

Bala Guruswany E: Programming in ANSI C++, Tata Mc Graw Hill

Dunham, M.H. : Data Mining Introduction and Advanced Topics, Dorling Kinerley (India) Pvt. Ltd.

Gottfried, Byson S. (1998) Progressing with C. Tata Mc Graw Hill Publishing Co. Ltd, New Delhi.

Guddis Tonny : Starting out with C++ Dream Tech, Press, New Delhi

Herbert. S. : Java TM 2, The Complete Reference, Tata Mc Graw Hill

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MSTA CC 04 : Practical and Group Discussion **Credit : 5**

There will be one sitting of practical examination of three hours duration based on theory paper CC01 to CC03. The distribution of marks will be as follows

Practical note-book and viva-voice	25 marks
Group Discussion	25marks

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Semester – II

MSTA CC 05 : General Statistics **Credit : 5**

Unit -I

Measures of variability, Skewness and Kurtosis for the study of nature of data. Simple linear model, ordinary bent squares, estimation and prediction, properties of regression coefficients, Multiple regression, Multiple and Partial correlations.

Unit -II

Basic concept of Sampling from a finite population, Sampling versus complete enumeration, simple random sampling, sample size determination, Stratified random sampling. Analysis of variance one way and two way classified data, Data analysis using SPSS and R programming.

UNIT-III

Time series and its various components, Test of significance, Large sample test, small sample test based on t and F, Tests based on X^2, Non parametric tests.

Unit-IV

Fertility and Mortality, Standardised rate, Life table, Basic concept of Process control Charts for Attributes and variables $\bar{X}$, R, c and p charts

Unit-V

Concept of probability and its basic rules, conditional probability, Baye's theorem, Probability distributions, Binomial, Poisson, uniformal, normal.

References:

Cox, P.R. (1970) : Demography, Cambridge University Press

Goin, A.M., Gupta K and Dasgupta B (1991) : Fundamentals of Statistics Vol. I & Vol. II, World Press, Calcutta

Keyfit, N (1970) : Applied Mathematical Demography, Springer Verlag

Mitra, Amitava (2008) : Fundamentals of Quality Control and Improvement, Prentice Hall of India, New Delhi.

Montagomery, D.C. (2009): Introduction of Statistics Quality Control: John wiley & Sons

Mukopadhya, P (1996) : Mathematical Statistics, New Central Book agency

Murthy M.N. (1977) : Sampling Theory and Methods, Statistics Publication Society Calcutta

Rohatgi, V.K. : An Introduction to probability theory & Mathematical Statistics, Wiley Eastern Limited.

Sukhatme P.V, Sukhatme B.V., Sukhatme S and Ashok, C (1964) : Sampling Theory of Survey with Applications

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MSTA CC 06 : Liner Models And Regression Analysis **Credit : 5**

Unit-I

Gauss-Markov Set-up, Normal equations and Least square estimates. Variance and Covariances of least square estimates, estimation of error variance, least square estimates with restrictions on parameters. Simultaneous estimates of linear parametric functions. Test of hypotheses for one and more than one linear parametric functions. Confidence intervals and regions.

Unit- II

Fitting of different curves, fitting & use of orthogonal polynomials.

Unit- III

Estimability, best point estimates/interval estimates of estimable linear parametric functions and testing of linear hypotheses.

Unit-IV

Residuals and their plots Tests for departure from assumptions such as fitness of the model, normality, homogeneity of variances and detection of outliers. Remedies.

Unit-V

Multicollinearity, Ridge regression, subset selection of explanatory variables, Introduction to logistic regression.

References:

Graybill, F.A. : Theory and Application of the Linear Model, Duxbury Press
Neter, I., Kutner, M.H. Nechtsheim, C.J. and Wasserman, W.(1996): Applied Liner Statistical Models WCB, Mcgraw Hill.
Rao, C.R. (1973) Linear Statistical Inference and its Application. Wiley Estern.
Searle, S.R. : Linear Models, John Wiley & Sons Inc.

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MSTA CC 07 : Sample Survey & Design of Experiment **Credit : 5**

Unit – I

Unequal Probability Sampling: pps wr/wor methods including Lahri scheme and related estimators of finite population mean, Hansen- Hurwiytz and Desraj estimators for a general sample size and Murthy's estimators for a sample of size two, Ratio and regression estimators based on srswor method of sampling

Unit – II

Two stage sampling with equal number of second stage unit. Double sampling, Cluster sampling, Randomized response technique, Warner's model: related and unrelated questionnaire methods.

Unit – III

Introduction to designed experiments. General Incomplete block design, Criteria for connectedness, balance and orthogonally Intrablock analysis of .BIBD-recovery of Interblock information. Youden Square design – intrablock analysis. Analysis of covariance.

Unit – IV

Fixed, mixed and random effect models, Variance component's estimation. Study of various models. Multiple comparison tests due to Tukey and Scheffe, Simultaneous confidence interval.

Unit – V

Application areas: Response surface experiments first order and orthogonal designs. Fractional replication for symmetric factorials, Split Plot design.

Reference:

Chaubey, P.K. (2004): Inequality: Issues and Indices. Kanishka Publisher, Distributors New Delhi.

Chaudhari, A (2010) : Essentials of Survey sampling PHI learning Pvt. Ltd, New Delhi

Cochran, W.G. (1977): Sampling Techniques 3rd Edition, Wiley USA,

CSO (1980) : National Accounts Statistics – Sources and Health

Des Raj and Chandak (1998): Sampling theory, Narosa,

Keyfitz, N (1997) : Applied Mathematics Demography, Springer verlag

Mukhopadhyay, P (1997): Theory & Methods of Survey Sampling, Prentice Hall of India, New Delhi

Murthy, M.N. (1967) : Sampling theory & methods, Statistical Publishing Society, Culcutta

Singh, D & Chaudhary F.S. (1996): Theory and Analysis of Sample Survey Designs, New Age International Publishers, New Delhi

Sukhatme et al. (1984): Sampling theory of Surveys with Applications, lowa State University Press & Indian Society of Agriculture Statistics, IASRI campus, Library Avenue, New Delhi

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MSTA CC 08 : Distribution Theory and Non- Parametric Tests **Credit : 5**

Unit – I

Brief review of basic distribution theory, Joint marginal and conditional p.m.fs and p.d.fs Standard discrete and continuous distributions, Bivariate normal & Bivariate exponential distribution. Function of random variables and their distributions using Jaicobian of transformation and other methods.

Unit – II

Compound, truncated and mixture distributions, Markov, Holder, Jensen and Liapounoff inequalities, Sampling distribution, Non-central Chi- square, t and F- distributions and their properties.

Unit – III

Order Statistics, Their distributions and properties. Joint and marginal distributions of order statistics. Distribution of extreme values and range and asymptotic distribution of median Empirical distribution function and its distributional properties, K-S goodness of fit test.

Unit-IV

Rank-test. One sample location problem, sign test and signed- rank-test, two sample K-S test, two sample location & scale problems, Wilcoxon Mann-Whitney test, Non-parametric regression and analysis of variance techniques.

Unit – V

Indices of development, Human Development index. Estimation of national income-product approach, income approach and expenditure approach. Population growth in developing and developed countries. Poverty Measurement.

References:

Gibbon's J.D. : Non-parametric Statistical Inference, Mc Graw-Hill, Student Edition.
Mood, A.M.; Graybill, F. A and Bose, D.C. : Introduction to theory of Statistics 3rd Edition.
Rao C.R. (1973) : Linear Statistical Inference and its Application, Wiley Eastern
Rohatgi, V.K. (1984) : Introduction of Probability Theory and Mathematical Statistics,
Sen Amartya (2003) : Poverty and Famines, Oxford University Press, New Delhi
UNDP Human Development Report 2011: Sustainability and Equity, A better Future for All UNDP Publication, USA
UNESCO – Principles of vital statistics system series M-12.

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MSTA CC 09 : PRACTICAL AND FIELD WORK — Credit : 5

There will be two parts each of three hours duration. The distribution of marks will be as follows

Part A : Based on Paper CC 05 & CC 06	-	25 Marks
Part B : Based on Paper CC 07 & CC 08	-	25 Marks

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Semester – III

MSTA CC 10 : Reliability **Credit : 5**

Unit-I

Reliability, concept and measures; components and systems; coherent systems; reliability of coherent systems; cuts and paths; modular decomposition; bounds on system reliability; structural and reliability importance of components. Life distribution; reliability function; hazard rate; common life distributions-exponential, Weibull, gamma etc. Estimation of parameters and tests in these models.

Unit-II

Notions of ageing; IFR, IFRA, NBU, DMRL and NBUE Classes and their duals; closures of these classes under formation of coherent systems, convolutions and mixtures. Univariate shock models and life distribution arising out of them; bivariate shock models; common bivariate exponential distributions and their properties.

Unit-III

Reliability estimation based on failure times in variously complete and censored life tests and in tests with replacements of failed items; stress strength reliability and its estimation.

Unit-IV

Maintenance and replacement policies; availability of repairable systems; modelling of a repairable system by a non homogenous poisson process.

Unit-V

Reliablity growth models; probability plotting technique; Hollander-Proschan and Deshpande tests for exponentiality tests of HPP vs NHPP with repairable systems. Basic ideas of accelerated life testing .

References:

Reliability and life testing by S.K. Sinha, John Wiley Eastern Limited
Reliability Engineering by A.K. Govil, Tata McGraw- Hill Publication Company Limited
Reliability Engineering by L.S. Srinath, Affiliated East –West Press Pvt. Ltd.
Stochastic Methods in Reliability theory by N. Ravichandran, Wiley Eastern Limit.

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MSTA CC 11 : Statistical Inference **Credit : 5**

Unit -I

Sufficiency, Neyman Factorization criterion, Exponential families and Pitman families ,Invariance Property of Sufficiency ,Minimum Variance Unbaised estimators, completness, Lehmann-Scheffe Theorem.

Unit -II

BAN and CAN estimators. Pitman's method,Method of Scoring,Multinomial distribution with cell probabilities depending on a parameter, MLE in censored and truncated distributions.

UNIT-III

Neyman- Pearson Lemma and its applications. MP and UMP tests.UMP tests for simple null hypothesis against one sided alternatives Liklihood Ratio-test, Asympotic distribution of LR criterion.

Unit-IV

MP and UMP tests in Pitman family. Distribution with MLR property. UMP tests for one sided null against one sided alternative in one parameter exponential family.

Unit-V

Wald's SPRT, Determinantion of Constants , Approximate OC and ASN functions and their approximate expressions, OC and ASN fuction of Bernoulli. Normal and Exponential distributions. Variance stabilizing transformations. Asymptotic power of large sample tests.

References:

Casella, G and Berger, R.L. : Statistical Inference, Second Edition

Ferguson, T.S.(1967) : Mathematical Statistics, Academic Press.

Kele, B.K. : A First course on Parametric Inference, Second Edition Narosa

Lehmann,E.L.(1986) : Testing Statistical Hypotheses (Student Edition)

Lehmann,E.L.(1986) : Theory of Point Estimation (Student Edition)

Mood, A.M. Graybill, F.A and Bose, D.C: Introduction to theory of Statistics, Mc Graw Hill International Edition

Rao, C.R.(1973 : Linear Statistical Inference and its Application, Wiley Eastern.

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MSTA CC 12 : Multivariate Analysis **Credit : 5**

Unit – I
Multivariate normal distribution, its properties and characterizations, Random sampling from multivariate normal distribution. Maximum likelihood estimators of parameters. Distribution of sample mean vector.

Unit – II
Wishart distribution- its derivation and properties. Distributions of sample generalized variance. Distribution of quadrative form

Unit – III
Null and Non-Null distribution of simple correlation co-efficient. Null distribution of partial and multiple correlation coefficient. Distribution of sample regression coefficients.

Unit – IV
Hotelling's T^2 statistics- its distribution and properties, Applications in test on mean vector for one and more multivariate normal polpulations, Mahalnobis D^2 classification and discrimination procedures for discrimination between two multivariate normal populations, Fisher's Discriminant function tests associated with discriminant functions.

Unit – V
Canonial variates and canonical correlation. Principal Component Analysis. Elements of factor analysis and cluster analysis.

References :

Anderson, T.W. (2003) : An introduction to multivariate statistical analysis 3rd Ed. John Wiley & sons
Johnson, R.A. & Wichern, D.W. (2001) : Applied Multivariate Statistical Analysis 3rd Ed. Pretice- Hall of India, New Delhi.
Kshirsager, A.M. (1972): Multivariate Analysis, Marcel Dekker
Morrison, D.F. (1976) : Multivariate Statistical Analysis 2nd Ed. Mc Graw Hill
Rao, C.R (1973) : Linear Statistical Inference and its application 2nd Ed. Wiley

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MSTA CC 13 : Stochastic Processes **Credit : 5**

Unit – I
Introduction to stochastic process: Classification of stochastic process according to state space and time domain, Continuous state Markov Chain, Chapman- Kolmogorov equations Calculation of n-step transition probability and its limit.

Unit – II
Stationary distribution, classification of states, Markov – chain Random walk and Gambler's ruin problem, applications to social, biological and physical science.

Unit- III
Discrete state space, continuous time, M.C.Kolmogrov –Feller differential equations, Poisson process. Birth and Death process.

Unit- IV
Applications to queues and storage problems, Wiener process as a limit of random walk, first passage time and other problems.

Unit-V
Renewal theory: elementary renewal theorem and application. Statement and uses of Key renewal theorem, study of residual life time process. Branching process: Galton-Watson branching process, probability of ultimate extinction, distribution of population size, Introduction to martingale.

References:

B.R. Bhatt : Stochastic Models, New Age Publishers
Feller, W. (1968) : Introduction of Probability and its Applications, Vol.1 Wiley Eastern
Karlin'S and Taylor, H.M. (1975) : A first Course in Stochastic Process, Vol.1 Academic Press.
Medhi, J (1998): Stochastic Process, Third Edition, New age International (P) Ltd. Publication.
S.K Srinivasan and K.M Mehta: Stochastic Process, Tata McGraw Hill Publishing company
Seldon M Ross : Stochastic Process, Wiley Student Publication
Singh, BM : Measure, Probability and Stochastic Processes, South Asian Publisher, New Delhi.

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MSTA CC 14 : Practical and group discussion **Credit : 5**

There will be one sitting of practical examination of three hours duration based on theory paper CC 10 to CC 13 The distribution of marks will be as follows

Practical : Based on Paper CC 10 to CC 13	20 marks
Field work	30 marks

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Semester – IV

MSTA EC 01 : Demography **Credit : 5**

Unit –I

Coverage and Content errors in demographic data. Use of balancing equation and equations and Chandrasekharan - Deming formula to check completeness of registration data. Adjustment of age data. Use of Whipple, Myer and UN indices. Population composition dependency ratio.

Unit – II

Measures of fertility, Stochastic models for reproduction, distribution of time to first birth, inter-live birth interval and of number of births (for both homogeneous and non-homogeneous groups of women) estimation of parameters; estimation of parity progression ratios from open birth interval data.

Unit – III

Measure of Mortality; construction of abridged life tables, Distribution of life table functions and their estimation.

Unit – IV

Stable and quasi –stable populations, intrinsic growth rate. Models for Population growth and their fitting to population data. Stochastic models for Population growth.

Unit – V

Stochastic models for migration and for social and occupational mobility based on Markov chains. Estimation of measure of mobility. Methods for population projection. Use of Lesile method.

Reference :

Benjamin B. (1969) : Demographic Analysis, Geogre Allen and Unwin

Cox, P.R. (1970) : Demography, Cambridge University Press

Henery. S and Siegel J.S and Associate (1971) : The method and materials of Demography; Washington D.C. US Bureau of Census.

Keyfit, N (1970) : Applied Mathematical Demography,; Springer Verlag

Nathan K. (1968) : Introduction to the Mathematics of Population Reading, Mann : Addison-Wesley

Pathak, K.B. & Ram, F : Techniques of Demographic Analysis; Himalaya Publishing House

Ram Kumar : Technical Demography

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MSTA EC 02 : Operational Research **Credit : 5**

Unit – I

Definition and scope of operations research: Phases in Operations Research: models and their solution; decision-making under uncertainty and risk, use of different criteria: sensitivity analysis

Unit – II

Programming : Linear Programming and Non linear Programming. Review of LP problems, duality theorem transportations and assignment problems; Non-linear programming- Kuhn Tuckey conditions. Wolfe's and Beals's algorithms for solving quadratic programming problem. Bellman's principle of optimality, general formulation computation methods and application of dynamic programming.

Unit – III

Simulation, Analytical structure of inventory problems; EOQ formula of Harris, its sensitivity analysis and extension allowing quantity discounts and shortages. Multi –item inventory subject to constraints. Models with random demand, the static risk model.

Unit – IV

Queuing models- specifications and effectiveness measure. Steady –state solution of M/M/I and M/M/C models with associated distributiom of queue-length and waiting time. M/G/I queue and Pollazcek Khinchine result. Steady-state solutions of $M/E_K/1$ queues. Machine interference problems.

Unit – V

Sequencing and Scheduling problem. 2 machine n-jobs and 3-machine n jobs with identical machine sequence for all jobs; 2 jobs n machine problem. Branch and bound method for solving travelling salesman problems

References:

Chaurchman, C.W, Ackoff R.L. and Arnoff E.L. (1975) : Introduction to Operations Research: John Wiley

Hillier F.S. and Leiberman G.J. (1962) : Introduction to Operations Research; Holden Day

Kanti Swarup, Gupta, P.K and Singh M.M (1985) : Operations Research; Sultan Chand & Sons

Philips D.T, Ravindran A and Solberg J. : Operations Research, Principle and Practice

Taha H.A. (1982) : An introduction of Operations Research; Macmillan

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