Dr. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, AURANGABAD

CIRCULAR NO.SU/Sci. & Tech./University Deptt./NEP/15/2023

It is hereby inform to all concerned that, the syllabi prepared by the Departmental Committee and recommended by the Dean, Faculty of Science & Technology, the Hon'ble Vice-Chancellor has accepted **the following curriculum of All Post Graduate Degree Courses as per Norms of National Education Policy – 2020 under the Faculty of Science & Technology run at University Department, Dr.Babasaheb Ambedkar Marathwada University, Aurangabad** in his emergency powers under section 12(7) of the Maharashtra Public Universities Act, 2016 on behalf of the Academic Council as appended herewith.

Sr.No.	Syllabi of Department of BAMU, Aurangabad.	Semester
1.	M.Sc.Chemistry specialization Inorganic Chemistry, Organic Chemistry, Physical Chemistry and self supported Analytical Chemistry	Ist and IInd Semester
2.	M.Sc.Statistics	Ist and IInd Semester
3.	M.Sc.Mathematics	Ist and IInd Semester
4.	M.Sc.Physics	Ist Semester
5.	M.Sc.Food Technology	Ist and IInd Semester
6.	M.Sc.Drug Intermediates Technology	Ist and IInd Semester
7	M.Sc. Information Technology	Ist to IVth Semester
8.	M.Sc.Computer Science	Ist to IVth Semester
9.	M.Sc.Botany	Ist and IInd Semester
10.	M.Sc.Enviornmental Science	Ist and IInd Semester
11.	M.Sc.Artificial Intelligence.	Ist to IVth Semester
12.	M.Sc.Biochemistry	Ist and IInd Semester

This is effective from the Academic Year 2023-24 and onwards.

All concerned are requested to note the contents of this circular and bring the notice to the students, teachers and staff for their information and necessary action.

University Campus,
Aurangabad-431 004.
REF.NO.SU/NEP/2023/ 8743-51
Date:- 08.08.2023.

★★★★★

Deputy Registrar,
Academic Section

Copy forwarded with compliments to :-

1] **Head of the Department, All Departments, Dr.Babasaheb Ambedkar Marathwada University, Aurangabad.**
2] **The Director, University Network & Information Centre, UNIC, with a request to upload this Circular on University Website.**

Copy to :-

1] The Director, Board of Examinations & Evaluation, Dr.BAMU,A'bad.
2] The Section Officer,[M.Sc.Unit] Examination Branch,Dr.BAMU,A'bad.
3] The Programmer [Computer Unit-1] Examinations, Dr.BAMU,A'bad.
4] The Programmer [Computer Unit-2] Examinations, Dr.BAMU,A'bad.
5] The In-charge,[E-Suvidha Kendra], Rajarshi Shahu Maharaj Pariksha Bhavan, Dr.BAMU,A'bad.
6] The Public Relation Officer, Dr.BAMU,A'bad.
7] The Record Keeper, Dr.BAMU,A'bad.

DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, AURANGABAD

FACULTY OF SCIENCE & TECHNOLOGY

2 Years P.G. Programme in Science (M.Sc.)

In

Subject: STATISTICS

(Effective from 2023-24)

As per National Education Policy-2020

(To be implemented from Academic Year -2023-24)

Course Structure and Curriculum

(Outcome Based Credit System)

Dean
Faculty of Science & Technology
Dr. Babasaheb Ambedkar Marathwada
University, Aurangabad

Two-Year Post-graduate Program

Course and Credits Distribution of Two Years PG/Master's Degree Program With Entry &Exit Option.

Faculty of Science & Technology

<table>
<tr><th rowspan="2">Year/ Leavel</th><th rowspan="2">Sem.</th><th colspan="2">Major Subject</th><th rowspan="2">RM</th><th rowspan="2">OJT / FT</th><th rowspan="2">RP</th><th rowspan="2">Credits</th><th rowspan="2">Degree</th></tr>
<tr><th>DSC Core Mandatory</th><th>DSE (Elective)</th></tr>
<tr><td rowspan="2">First Year 6.0</td><td>I</td><td>3(4)+2=14</td><td>4</td><td>4</td><td></td><td></td><td>22</td><td rowspan="3">PG Diploma (After 3 years Degrre)</td></tr>
<tr><td>II</td><td>3(4)+2=14</td><td>4</td><td></td><td>4</td><td></td><td>22</td></tr>
<tr><td colspan="2">Cum. Cr. For PG Diploma</td><td>28</td><td>08</td><td>4</td><td>4</td><td></td><td>44</td></tr>
<tr><td colspan="9">Exit option with Post-graduate Diploma (44 credits) after first yesr or two semester with complection of courses equivalent to 44 Credis</td></tr>
<tr><td rowspan="2">Second Year 6.5</td><td>III</td><td>3(4)+2=14</td><td>4</td><td></td><td></td><td>4</td><td>22</td><td rowspan="5">PG Degree after 3 years UG Or PG Degree after 4 years UG</td></tr>
<tr><td>IV</td><td>3(4)=12</td><td>4</td><td></td><td></td><td>6</td><td>22</td></tr>
<tr><td colspan="2">Cum.Cr.For 1year PG Degree</td><td>26</td><td>8</td><td></td><td></td><td>10</td><td>44</td></tr>
<tr><td colspan="2">Cum.Cr.For 2year PG Degree</td><td>54</td><td>16</td><td>4</td><td>4</td><td>10</td><td>88</td></tr>
<tr><td colspan="8">2 years -4 Sem.PG Degree (88 Credits) after three year UG Degree or 1 Year-2 sem.PG Degree (44 Credits) after four year UG Degree.</td></tr>
<tr><td colspan="2">8.0</td><td></td><td>Course work Min.12 Credits 3(4)</td><td colspan="2">Training in teaching /education/ Pedogogy:4</td><td>16+ Ph.D. Work</td><td>Ph.D in Subject</td></tr>
</table>

ABBREVIATION:

Major- Comprising Mandatory –is based on specialization

DSE- Discipline Specific Elective

OJT- On-the-Job Training

FP- Field Project (Corresponding to the Major (Core) Subject

RP- Research Project (Corresponding to the Major (Core) Subject

Internship/Apprenticeship - (Corresponding to the Major (Core) Subject

As Per NEP 2020

Illustrative Credit distribution structure for Two Years Programme with Multiple Entry and Exit options-

Class: M.Sc. First Year
Semester: I[st] Semester
Subject: Statistics

Course Type	Course Code	Course Name	Teaching Scheme (Hrs./week)		Credits Assigned		Total Credits
			Theory	Practical	Theory	Practical	
Major Mandatory (**DSC**)	STA/MJ/ 501	Distribution Theory	4	--	4	--	4+4+2+ 4=14
	STA/MJ/ 502	Statistical inference	4	--	4	--	
	STA/MJ/ 503	Statistical Computation Using R	2	--	2	--	
	STA/MJ/ 504	Practical - I	--	4	--	2	
DSE (Choose any one from pool of course)	STA/DSE 505(A)	Operations Research	4	--	4	--	4
	STA/DSE 505(B)	Actuarial Statistics	4	--	4	--	
RM	RM	Research Methodology	4	--	4	--	4
							22 Credits

Class: M.Sc. First Year
Semester: II[nd] Semester
Subject: Statistics

Course Type	Course Code	Course Name	Teaching Scheme (Hrs./week)		Credits Assigned		Total Credits
			Theory	Practical	Theory	Practical	
Major Mandatory (**DSC**)	STA/MJ/ 506	Design & Analysis of Experiments	4	--	4	--	4+4+2+ 4=14
	STA/MJ/ 507	Probability Theory	4	--	4	--	
	STA/MJ/ 508	Statistical Computation Using Python	2	--	2	--	
	STA/MJ/ 509	Practical - II	--	4	--	2	
DSE (Choose any one from pool of course)	STA/DSE 510(A)	Industrial Statistics	4	--	4	--	4
	STA/DSE 510(B)	Clinical Trials	4	--	4	--	
OJT/FP	STA-511		4	--	4	--	4
							22 Credits

STA/MJ-501: Distribution Theory

Max marks – 100

Contact Hours: 60 (Clock hours)
Credit – 04

Unit I: - Basic Distribution Theory: Random experiment and its sample space, events, probability axioms, Random variable, Discrete random variables, continuous random variables, **Convolution of random variables**. Definition of distribution and types of distribution: p.d.f, p.m.f, c.d.f. of random variables, m.g.f, p.g.f., characteristic function of random variables, Moments: raw moments, central moments & factorial moments, joint distribution, conditional distribution, marginal distribution, **mixture distributions.** (12L)

Unit II :- Discrete Distributions : Bernoulli, Binomial, Poisson, geometric, negative binomial, , Hyper geometric, uniform and **multinomial** distribution. Their m.g.f, p.g.f, c.d.f., characteristics function, moments, properties and fitting of above distributions. **Compound Poisson distribution and truncated Poisson distributions**. (12L)

Unit III: - Continuous Distributions: Exponential, Normal, Gamma, Beta, Uniform, Lognormal, Weibull, Cauchy, Pareto distribution, **Dirichlet Distribution,** Their m.g.f, p.g.f, c.d.f., characteristics function, moments and properties of above distributions. (12L)

Unit IV: Sampling distributions: central and non central Chi-square, t- and F-distribution. Their m.g.f, p.g.f, c.d.f., characteristics function, moments and properties. **Bivariate normal distribution:** c.d.f., marginal distribution, conditional distribution and its properties. (12L)

Unit V : Order Statistics:kth order statistics, their density functions, distribution function and its properties. **Inequalities**: Markov, Holder, Jensen and *Lyapunov's*inequality, **Compound and truncated distributions.** (12L)

Text Books

1) Rohtagi V.K. (2012): An Introduction to Probability Theory and Mathematical Statistics, Wiley eastern, 2nd ed.
2) AnirbanDasgupta (2010) Fundamentals of Probability: A First Course. Springer Texts in Statistics
3) Hogg, R.V. and Craig, A.T. (1978). Introduction to Mathematical Statistics, (5th Ed. Pearsons Education).

4) Hogg, R.V. and Tanis E.(2002) An. Probability and Statistical Inference (6th Ed. Pearsons Education).

Reference Books

1) Mukhopadhy .P (1996): Mathematical Statistics, New central book agency,

2) DudewiczE.J.and Mishra S.N. (1988): Modern Mathematical statistics, Wiley Int.

student's Edition.

3) Johnson, S. and Kotz, (1972). Distributions in Statistics, (Vol..I, II and III, Houghton and Miffin).

STI/MJ-502: Statistical Inference

Max marks – 100

Contact Hours: 60 (Clock hours)
Credit – 04

Unit-I :Theory of estimation: Introduction, Characteristics of estimators : unbiasedness, Consistency, Efficiency, Sufficiency. factorization theorem, minimal sufficiency , minimal sufficient statistic, construction of minimal sufficient statistics, special classes of distributions admitting complete sufficient statistics. Consistent Asymptotic Normal(CAN) estimator, invariance of CAN estimator under differentiable transformation. CAN property of estimators obtained by moment and MLE method in one (12L)

Unit-II :, Concept of completeness, bounded completeness, MVUE Uniqueness Rao – Blackwell theorem. Lehman –scheffs theorem. Application to standard families of distribution Regular families, Fisher information, Cramer Rao inequality. Testing of hypothesis : Concept of critical regions, types of hypothesis, test functions, two kinds of errors, level of significance, power function, Neyman- Pearson lemma (with Proof) for test function, MP and UMP test, UMP test for one sided alternative for one parameter exponential class of densities and extension to the distribution having monotone likelihood ratio property. One parameter exponential family, multi parameter exponential family. parameter exponential family. (12 L)

Unit-III : Likelihood function, Examples from standard discrete and continuous distributions (such as Bernoulli, Poisson, Negative Binomial, Normal, exponential, Gamma, Pareto etc.), Methods of estimation : Maximum likelihood method, Methods of moments. MLE in censored and truncated distributons. Likelihood Ratio Test(LRT), Asymptotic distribution of LRT statistic, Wald's Test, RAO's Score test , Pearson's chi-square test of Goodness of fit, Bartlett's test for homogeneity of variances. Variancestabilizing transformations. (12 L)

Unit-IV: Interval estimation, confidence level, construction of confidence intervals using pivots, shortest expected length confidence interval, uniformly most accurate one sided confidence interval. Types of scales. Non – parametric tests: Sign test, Run test, Mann- Whitney Wilcoxon U test, Median test.Kruskal-Wallis Test. (12 L)

Unit V : one-parameter Cramer family, Method of maximum likelihood CAN estimators for one-parameter Cramer family, Cramer-Huzurbazar theorem (statement only), Solution of likelihood equations, method of scoring, Newton-Raphson and other interactive procedures, Fisher lower Bound to Asymptotic variance, extension to multiparameter case (without proof) multinomial distribution with cell probabilities depending on a parameter. (12 L)

Text Books :

1) Kale B.K. and Murlidharan(2015) : A first course on parametric inference, Narosa Publishing House.
2) Rohatgi V. and Ehsanes Saleh A. K. MD (2012): An introduction to Probability and Mathematical Statistics, Wiley Eastern Ltd., New Delhi Student Edition.
3) Casella G. &beregar R.L.(2002) : Statistical Inference,2nd edition.
4) Dudewitz E.J. and Mishra S.N. (1988) : Modern Mathematical Statistics, John Wiley.

Reference Books :

1) George Casella, Roger L. Berger(2001): Statistical Inference,2nd edition, Duxbury Advanced Press.
2) Lehmann E.L. (1988) : (latest) Theory of Point Estimation (Student edition),John Wiley.
3) Lehmann E.L. (1986) :Testing Statistical hypothesis (Student edition),John Wiley.
4) Rao C.R. (2012) : Linear Statistical Inference and its Application, Wiley series, John Wiley & Sons, Inc.

Zacks.S.(1971) : Theory of Statistical Inference, John Wiley and sons, New York.

STA/MJ-503: Statistical Computation Using R

Max marks – 50

Contact Hours: 30 (Clock hours)
Credit – 02

Unit-I : Introduction to R-Programming :History of R- Programming, Installation of R- Programming, Starting and ending R, Getting help in R, R Commands and Case Sensitivity, Data Types (Modes), Vector and Vector Arithmetic, Data frames, Various Logical and relational loops, Resident data sets, Using R as calculator. (12 L)

Unit-II : Descriptive Statistics & Sampling Methods using R-Programming

Classification of Data. Diagrammatic representation of data-Simple & Multiple bar diagram, Subdivided bar diagram, Pie chart, Box Plot, Steam &Leaf plot, Histogram & Frequency Polygon. Measure of Central Tendency- A.M. , G.M. , H.M. , Mode, Median, Partition Values. Measures of Dispersion – Range, Coeff. Of Range, Quartile deviation, Coeff. of Q.D. , Mean deviation , Variance, Standard deviation, Coeff. of variation. Moment.Skewness. Kurtosis, Scatter Plot, Product Moment Correlation Coefficient, Least square regression line, Fit a second degree parabola, Multiple Regression, SRS, Stratified Random Sampling , Systematic Random Sampling , Generations of random numbers. (12 L)

Unit-III : Probability Distribution and Test of Hypothesis using R-Programming

Problems on finding basic probabilities, Discrete distribution – Binomial distribution, Poisson distribution, Hypergeometric distribution. Continuous distribution – Normal distribution, Exponential distribution,Large sample test – Proportion test , t-test. Small sample test – t-test, Paired t-test, Chi-square test. (12 L)

Unit- IV : Experimental Design and Matrix Operations using R-Programming

Completely Randomized Design , Randomized Block Design, Addition , Subtraction and Multiplication. Inverse of matrix, eigen values and eigenvectors .other basic operations. (12 L)

Text Books :

1. **Python Crash Course,** Eric Matthes *(No Starch Press, 2016.*
2. **Think Python: How to Think Like a Computer Scientist, 2nd edition**

Allen B. Downey *(O'Reilly, 2015)*

STA/PR-504: Practical-1

Max marks – 50

Contact Hours: 04 hr/Practical
Credit – 02

List of practical (Mathematical and Statistical Analysis)

Sr. No.	Title of Practical
1	Basics of R-Programming.
2	Fitting of discrete distributions (Binomial, Poisson, Geometric, Negative Binomial)
3	Fitting of Continuous distributions (Normal, Exponential, Lognormal, Uniform, Gamma, Beta)
4	Testing of Hypotheses (based on t,F,Z and Chi square distribution)
5	Testing of Normality using Shapiro-Wilk test, Kolmogorov Smirnoff test
6	Non-Parametric Testing: Sign, run, Mann Whitney
7	Non-Parametric Testing: Wilcoxon Signed Rank Test, median, Kruskal-Wallis Test
8	MLE Method, Method of Moments
9	Construction of confidence interval, UMP Test
10	Newton Raphson , Rao-score method for estimation of parameters

STA/PR-504: Practical-2 (Based on Electives)

Max marks - 50

Credit – 02

Practical Based On Operations Research

Sr. No.	Title of Practical
1	Simplex , Big-M, Two phase Method
2	Transportation Problem , Assignment Problem
3	Inventory models- deterministic, price break models
4	Sequencing Problem
5	Queuing theory
6	Game theory
7	Replacement problem
8	Network problem – PERT/CPM
9	Non-linear programming
10	Goal programming

Practical Based On Acturial Statistics

Sr. No.	Title of Practical
1	Computation of Premiums
2	Benefit payable at end of year of death
3	Discrete life Annuities
4	Construction of Life Tables
5	Actuarial present values of benefit payable at the moment of death
6	Programming in Python
7	Programming in Python
8	Programming in Python
9	Programming in Python
10	Programming in Python

STA/ME -505(A): Operations Research

Max marks – 100

Contact Hours: 60 (Clock hours)
Credit – 04

Unit I : Overview of LPP, transportation problem, Assignment problem, Nonlinear programming problem: General Nonlinear programming problem, Lagrange's method for optimality, Kuhn-Tucker condition, Quadratic programming problem- Wolfes algorithm for solving Q.P.P.
(12L)

Unit II : Inventory Problem: Introduction, Reason for carrying inventory, EOQ formula of Haris, Inventory models with and without shortages, Inventory models with uniform and instantaneous demand, EOQ formula for single price break, two price break Multi item inventory subject to constraint. Probabilistic inventory models: Single period probabilistic inventory model with a) Instantaneous demand and discrete units, b) Instantaneous demand and continuous units, c) continuous demand and discrete units, d) continuous demand and continuous units, (12L)

Unit III: Game theory : Introduction and assumptions, two person zero sum game, pure and mixed strategies existence of solution and uniqueness of value in zero sum game, Dominance property, Finding solution of 2X2 2xm and mxn games non –zero sum game equivalence between game theory and L.P.P, Goal programming. (12L)

Unit IV: Replacement models: Introduction, Types of failures, Bulk and age replacement, Replacement of equipment fails suddenly, replacement for the equipment deteriorates with time and the value of money a)changes with time, b) does not change with time, Dynamic approach for maintenance, Sequencing problem introduction, Assumption processing of n jobs through two machine processing of n jobs through three machines with identical machine sequence for all jobs processing of two jobs m machines. problem, Group replacement policy, Replacement of items with long life.
(12L)

Unit V: Queuing theory: Introduction, Characteristic of system, Probability distribution in queuing system, Steady state solution of M/M/l and M/M/C with

associated distribution such as queue length waiting time, and steady state solution of $M/E_k/1$ and M/G/1,**Networks:** Definition, Concept of network, drawing of network, determination of flow's , critical path method and PERT, max flow min cut theorem, Advantages and limitation of networks.

(12L)

Text books:

1) Hiller and Lieberman Operations Research concepts and cases, Tata macgraw Hill

2) A. Ravindran, D.T. Phillips, J.J. Solberg. (2001) Operations Research Principles and

practices, 2nd ed. John wiley and sons.

3) Taha H.A.(1976) Operations Research, An introduction, 2nd ed., Macmillan, New York.

References:

1) Sharma J.K (2003) Operations Research theory and application, Macmillan business books.
2) Premkumar Gupta and D. S Hira Operations Research, S. Chand Publication
3) Hadely G.(1969) Linear programming, Addison Wesley.

Wagner H. M. (1975) Principles of Operations Research, 2nd ed. Prentice Hall, Englewood cliffs.

STA/ME -505(B): Acturial Statistics

Max marks – 100

Contact Hours: 60 (Clock hours)
Credit – 04

Unit I : Introduction to insurance business and Utility theory: Introduction to insurance business, working of insurance business. Expected value principle, Utility, Utility Functions, Expected utility, Concepts of reinsurance.
(12 L)

Unit II : Future life time distributions : Introduction, Future lifetime random variable and its distribution and survival function, Force of mortality, Mortality laws: De Moivre's law, Gompertz's law, Makehan"s law and Weibull law.
(12L)

Unit III: Life Tables: Introduction, International actuarial notations, distribution function and survival function of time until death t(x). Curtate future life time random variable, Life tables, construction of life tables.
(12 L)

Unit IV: Interest: Cash flow models, time value of money, Accumulation and amount function. The effective rate of interest, simple and compound interest. Present value, Nominal and effective rates of interest, discounting & accumulating factors, (12L)

Unit V: Annuities: Continuous life annuities, discrete life annuities, life annuities with monthly payments, apportionable annuities. **Premiums:** Fully continuous & discrete premiums, mthly payment premiums apportionable premiums.
(12L)

Text Books:

1) Deshmukh S.R. (2009): Actuarial Statistics: Introduction using R, University press, Hyderabad.
2) Deshmukh S.R. (2012): Multiple decrement models in Insurance, Springer.
3) N.L. Bowers, H.U. Gerber, J.C. Hickman, D.A. jones and C.J. Nesbit(1986), Actuarial mathematics, Society of Actuaries, Itacasa, IIIinois, U.S.A.
4) Dixit S.P. Modi C.S. & Joshi R.V. (2000): Mathematical basis of life Assurance. Published by Insurance Institute of India, Mumbai .
5) Stephen G. Kelison (2007): Theory of Interest, Mc Graw-Hill Irwin Publication. New York.

Reference Books:

1) Neill A. (1977), life contingencies, Hienemann.
2) Donald D.W.A. (1984): Compound interest & Annuities Certain Published for faculty of Actuaries, and the faculties of actuaries London.
3) McCutcheen J.J.& Scott W.F. (1989): Financial Mathematics, Butterworth Heinemann.

STA/RM -506 Research Methodology

Part – 1 (02 credit : 30 Contact Hours)

Unit - I: Research Fundamentals and Identification of Research Problem: (10 Hrs.)

Research Fundamentals

Introduction: Definition, objectives of the research, characteristics of the research, what makes people to do research, importance of research, Qualitative and Quantitative Research: Qualitative research - Quantitative research - Concept of measurement, causality, generalization, and replication. Merging the two approaches.

Identification of Research Problem

Defining the research problem: Identification of research problems, selection of research problem, facts one should know regarding selection of research problem, the process of research problem definition, some facts involved in defining research problem, Research Design: Concept and Importance in Research - Features of a good research design - Exploratory Research Design - concept, types and uses, Descriptive Research Designs - concept, types and uses. Experimental Design: Concept of Independent & Dependent variables, Case Studies,

Unit - II: Formulation of Research Problem (10 Hrs.)

Formulation of the problems: steps involved in defining a problem, formulation of the problems, Formulation of hypothesis: Concept of hypothesis, hypothesis testing, developing the research plan: implementation, interpreting and reporting the findings, Importance of hypothesis in decision making, Case Studies. Interpretation of Data. Measurement: Concept of measurement- what is measured? Problems in measurement in research- Validity and Reliability. Levels of measurement Nominal, Ordinal, Interval, Ratio.

Unit – III : Research Report and Proposal Writing (10 Hrs.)

Introduction, research proposal writing: costing, the research proposal, rationale for the study, research objectives, research methodology, target respondents, research Centres, sample size and sample composition, sampling procedures, research project execution, research units; An insight into research report and proposal, research project synopsis, research report writing : types of research reports, guidelines for writing reports; Steps in writing report, report presentation, typing the report, documentation and bibliography, formatting guidelines for writing a good research report / research paper, Paper Writing- Layout of a Research Paper, Journals in Computer Science, Impact factor of Journals,

When and where to publish ? Ethical issues related to publishing, Plagiarism and Self-Plagiarism. Case Studies.

Part – 2 (02 credit : 30 Contact Hours)

Presentations, case studies, Assignments, Tutorials based on Module I to III **(30 Hrs.)**

Students are expected to do the Followings

i) Select Broad topic of Research Project (to be implemented from second semester onwards)
ii) Read the Basic concepts / fundaments of broad topic
iii) Identify 10 SCOPUS / WEB OF SCIENCE Indexed Journals related to broad topic
iv) Search and download 20 research articles from above research Journals
v) Do systematic review of above 20 research articles
vi) While doing review of each of above mentioned 20 research articles, students are expected prepare notes on following points
   a) What are the objectives of the research article?
   b) What methodology has been adopted?
   c) What are prominent results?
   d) How these results of relevant to the latest development of the subject?
   e) What is novelty of research article?
   f) What are prominent shortcomings of this research a presented in this research article?
   g) What are your plans to address those shortcoming?

vii) Draft the fine-tuned title of research project
viii) Draft hypothesis
ix) Draft Objectives and Methodology
x) Draft expected outcome of the research project

At the end of the assignment, students are expected to prepare a report having following points

i) Fine-tuned title of Research Project
ii) Fundamental aspects of the fine-tuned research topic
iii) Hypothesis
iv) Objectives
v) Methodology
vi) Detailed Experimental plan
vii) Expected outcome
viii) References

References:

1. Research Methodology by Dr. S. L. Gupta, Hitesh Gupta; International Book House Pvt Ltd **(2013),** ISBN-10: 8191064278, ISBN-13: 978-8191064278
2. Basic Research Methods-Gerard Guthrie SAGE Publications, India, Pvt Ltd, New Delhi **(2010),** ISBN-10: 8132104579, ISBN-13: 978-8132104575
3. Research Methodology-methods and techniques By C. R. Kothari, New Age International Publishers **(2011)** ISBN 978-81-224-1522-3
4. Principles of Research Methodology- Phyllis G. Supino, Jeffrey S. Borer; Springer, Verlag New York **(2012),** ISBN-ebook: 1461433592, ISBN (Hardcover): 978-1461433590
5. Research Design Qualitative, Quantitative. and Mixed Methods Approaches- John W. Creswell; SAGE Publications Ltd, UK **(2011),** ISBN-9780857023452
6. Research Methodology -A Step-by-Step Guide for Beginners- Ranjit Kumar; Sage Publications Ltd**(2010)**, ISBN- 1849203016.
7. Scientific Writing and Communication- Angelika Hofmann; Oxford University Press, US **(2010),** ISBN-13-: 978-0 199947560, ISBN-10: 01 99947562
8. Writing Science: How to Write Papers That Get Cited and Proposals That Get Funded- Joshua Schimel, Oxford University Press, **(2011)**, ISBN: 9780199760237
9. Handbook of Scientific Proposal Writing- A.YavuzOruc; CRC Press, Taylor & Francis group **(2011)**, ISBN: 9781439869185

STA/MJ -506: Design and Analysis of Experiment

Max marks – 100 Contact Hours: 60 (Clock hours)
Credit – 04

Unit I : Basic Designs: Introduction to design of experiments, need of design of experiments, fundamental principles of design of experiments, contrast ,orthogonal contrast, BLUE and its related theorems, Gauss Markov theorem. one way and two way ANOVA, Overview of Basic Design (Completely Randomized Design (CRD): Randomized Block Design (RBD): Latin square Design (LSD): (12L)

Unit II: Missing plot techniques in RBD and LSD with one and two missing observations,. Efficiency of RBD related to CRD, Efficiency of LSD related to RBD, **ANOCOVA** for one way and two way, **M**ultiple comparison test: due to Tukey, Scheffe ,Bonferroni Method, Random, fixed and mixed effect models. Estimation of error functions, (12L)

Unit III : Factorial experiments: Concept of factorial experiment, 2^2, 2^3 ,2^n factorial experiments and their Statistical analysis by Yates method and Fishers algebraic method.Symmetrical Factorial Experimentsts of type 3^2 , 3^3 and their layout, Randomization, Yates method for estimation of factorial effect totals in 3^2 , 3^3 Factorial experiments and Statistical Analysis. Asymmetrical factorial experiments of m x n x p types and their layout, Randomization and Statistical Analysis. Situations when these experiments are used.

(12 L)

Unit IV :Confounding in factorial experiments, Complete and Partial confounding, Construction of designs for 2^n and 3^n confounded factorial designs, Analysis of confounded factorial designs. Fractional Factorial Designs, resolution III, IV and V design.

(12 L)

Unit V : Incomplete Block Designs: Balanced Incomplete Block design (BIBD), General block design and its information matrix, Criteria for Connectedness, Balance and Orthogonally, A, D, G, E, V optimality of designs. Construction of Balanced Incomplete Block Designs (BIBD), Relationship among parameters of BIBD, Inter and Intra block analysis of BIBD. Resolvable designs. **Partially Balanced Incomplete Blocks Designs (PBIBD):** Relationships among parameter PBIBD. Construction of PBIBD. Concept of Youden Square Design

(12 L)

Text Books:-

1) Montgomery D.C. (2004): Design and Analysis of Experiments , John and Wiley
2) Das M.N and Giri (2006): Design and Analysis of Experiments, Eastern Wiley
3) Joshi D.D. (1987): Linear Estimators and Design of Experiments, Wiley eastern
4) Kshirsagar A.M. (1983) : A course in Linear Models. Marcel Dekker Inc New York.

Reference Books:-

1) Giri N. (1986): Analysis of Variance, South Asia publication.
2) Peterson R.G. Design and Analysis of Experiments, Marcel Dekker Inc New York
3) AlokDey (1986): Theory of Block Design, Eastern Wiley

STA/MJ -507: Probability Theory

Max marks – 100 Contact Hours: 60 (Clock hours)
Credit – 04

Unit-I: Fields and sigma fields: Random experiment, Sample space and events. Sequence of sets, limit supremum and limit infimum of sequence of sets. Classes of sets, fields, Sigma-fields, Minimal fields, Borel fields. (12L)

Unit-II: Random Variables: Point function and set function, Inverse function. Measurable function, Borel function. **Measures:** Measure (Definition and simple properties). Probability measure, Properties of a measure. Continuity of a probability measure. Caratheodory Extension theorem (without proof). Counting measure, Conditional Probability measure, Counting measure, Lebesgue measure, Lebesguestiltjes measure. (12L)

Unit-III : Distribution Functions: Distribution functions of a r.v. and its properties. Jordan decomposition theorem, Mixture of distribution functions. Distribution functions of vector valued r.v.s. Empirical distribution functions. **Expectation and Moments:** Expectation of a r.v. Properties of expectation, Expectation of Complex r.v. Moments, Moment generating function.

(12L)

Unit-IV :Convergence of Sequence of Random variables: Convergence in distribution, Convergence in probability, Almost sure convergence and convergence in quadratic mean and their inter-relations. Slutsky's theorem, Monotone convergence theorem, Fatou's Lemma, Dominated convergence theorem.

Characteristic function: Definition and simple properties, Some inequalities. Uniqueness theorem (statement only), Levy's continuity theorem (Statement only). **Independence:** Independence of events, sequence of independent events, independent classes of events, independence of r.v.s, Borel zero-one law.

(12L)

Unit V: Law of Large Numbers : Weak law of large numbers (WLLN), Strong law of large numbers (SLLN), Chebyshev's WLLN, Khinchin's WLLN, Kolmogorov's SLLN (only statement), **Central Limit Theorem (CLT) :**CLT, Lindeberg-Levy, Lindeberg-Feller (sufficient condition only) and their applications, Liapounov's theorem, Multivariate CLT.

(12 L)

Text Books:

1. Bhat, B.R. (2000), Modern Probability Theory, New Age International Pub.
2. Basu, A.K. (1999), Measure Theory and Probability , Prentice Hall of India.
3. Athreya K. B. and Lahiri S. (2006). Probability Theory Vol. 41, Trim series, (Hindustan Book Agency).
4. Billingsley, P. (1986). Probability and Measure, John Wiley

Reference Books:

1. Ash, Robert (1972): Real Analysis and Probability, Academic Press.
2. Kingman, J.F.C. and Taylor, S.J. (1996). Introduction to measure and probability, Cambridge University Press.Feller, W. (1969). Introduction to Probability and its Applications Vol.II (Wiley
   Eastern Ltd.)
3. Gnedenko, B. V. (1988). Probability Theory (Mir. Pub.)
4. Gut, Allan (2005), Probability: A Graduate Course. (Springer, New York)

STA/MJ -508: Statistical Computing Using Python

Max marks – 50 Contact Hours: 30

Credit – 02

Lists : Introduction, Accessing list, Operations, Working with lists, Function and Methods.

Tuple: Introduction, Accessing tuples , Operations, Working, Functions and Methods.

Dictionaries: Introduction, Accessing values in dictionaries,

Functions : Defining a function, Calling a function, Types of functions, Function Arguments, Anonymous functions, Global and local variables.

Modules: Importing module, Math module, Random module, Packages, Composition.

Text Books :

1. **Python Crash Course,** Eric Matthes *(No Starch Press, 2016.*
2. **Think Python: How to Think Like a Computer Scientist, 2nd edition**

Allen B. Downey *(O'Reilly, 2015)*

STA/MJ -509: Practical-3

Max marks – 100

Contact Hours: 60 (Clock hours)
Credit – 04

Analysis of variance in CRD, Analysis of variance in RBD
Analysis of variance in LSD
Analysis of variance in (one) missing plot techniques RBD and LSD
Analysis of Covariance
Analysis of asymmetrical factorial experiments
Analysis of 2^n factorial experiments.
Analysis of 3^n factorial experiments.
Analysis of complete and partial confounding
Analysis of BIBD
Analysis of PBIBD

STA/PR -509: Practical-4 (Based on Electives)

Max marks – 100

Credit – 04

Control Chart for variables (X-bar, R)
Control Chart for variables (c,σ)
O.C, A.O.Q.L.
Acceptance sampling plans for Variables
Control Chart for Attributes
Acceptance sampling plans for Attributes
ASN curves and Process Capability
Acceptance sampling plans double sampling
Acceptance sampling plans multiple sampling
CUSUM charts

OR

STA/MJ -509: Practical-4

Max marks – 100

Credit – 04

1	Analysis of Clinical Trials
2	Analysis of Clinical Trials
3	Analysis of Clinical Trials

4	Analysis of Clinical Trials
5	Analysis of Clinical Trials
6	Analysis of Clinical Trials
7	Analysis of Clinical Trials
8	Analysis of Clinical Trials
9	Analysis of Clinical Trials
10	Analysis of Clinical Trials

STA/ME-510(A): Industrial Statistics

Max marks – 100 Contact Hours: 60 (Clock hours)
Credit – 04

Unit-I: Basic concepts of SPC and SQC,: Concept of quality, Quality improvement , quality philosophy , PDSA cycle . Total Quality Management, Taguchi design. Concept of stable industrial process, Systematic variation, random variation, General theory and review of control charts for attribute and variable data, O.C. and A.R.L. of control charts. Confirming run length(CRL) chart for Attribute. (12L)

Unit-II: Moving average and Exponentially weighted moving average (EWMA) charts. CUSUM charts using V – masks and decision intervals. Comparison of Shewhartcontrol charts with CUSUM chart. General idea on economic designing of control charts. Process capability and performance indices C_p, andC_{pk},. Estimation and confidence intervals of estimation of C_p . (12L)

Unit-III: Acceptance sampling plans for attributes:Problem of lot acceptance - good and bad lots,producer's and consumer's risks; Single, Double and multiple sampling plans of attributes and their properties. O. C. function, concepts of AQL,LTPD, AOQL, ATIand ASN functions. (12 L)

Unit-IV : Acceptance sampling plans for variables: Designing variable acceptance sampling plans . AOQL based sampling plans: Continuous sampling plans of Dodge type and Wald – Walfowitz type and their properties, Lieberman and Solomon plan. Skip lot sampling plan, Shanin lot plot method, chain sampling and sequential sampling plan.AQL based sampling plans: Plans to control process fraction defective, MIL- STD -105E plan and its switching procedure.

(12 L)

Unit-V: Quality systems: Concept of six sigma. Define –measure- anlayze – improve – control (DMAIC)approach. Concepts of leansix sigma. Precision and accuracy in measurement systems . Estimation of measurement uncertainty. Quality management: ISO 9000 standards, 9001, 14001 standards

(12L)

Text Books :

1) Montoegmory, D.C (1985) : Statistical Process Control, John Wiley.
2) Montoegmory, D.C (2007) :Introduction to Statistical Quality Control, Wiley.
3) Logothetis N. (1992) :Managing Total Quality, Prentice Hall of India.
4) Suddhendu Biswas (2003) : Statistics of Quality Control, New Central Book Agency.
5) Wetherill G.B. and Brown D.W. Statistical Process Control, theory and practice chapman and Hall.

Reference Books :

1) Mahajan M. S. (2013) : Statistical Quality Control. DhanpatRai& Co. (P) LTD. Delhi.
2) Phadke, M.S.(1989) : Quality Engineering through Robust Design Pretic Hall.
3) Oakland J.S. (1989) : Total Quality management, Butterworth Heinemann.
4) Mittag H.J. and Rinne.H. (1993) :Statistical process control John Wiley.

STA/ME-510(B): Analysis of Clinical Trial

Max marks – 100 Contact Hours: 60 (Clock hours)

Credit – 04

Unit I: Introduction to clinical trials: The need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, pharmacokinetic parameters, clinically important differences, assessment of bioequivalence, decision rules and regulatory aspects, overview of Phase I-IV trials, classification of clinical trials: multi-center trails, Active control trials, Combination trials, Equivalence trial. (12L)

Unit II: Designs of clinical trials: Parallel Design, Crossover design, cross-over designs, cross-sectional design, longitudinal designs, review of factorial designs and balanced incomplete block design. Randomization techniques for group allocation. (12L)

Unit III: Design of Phase I trials, Design of single-stage and multi-stage Phase II trials, design and monitoring of Phase-II trials with sequential stopping, design of bio-equivalence trials. Statistical Inferences for effects from a standard 2 X 2 cross over design: The carry over effects, the direct drug effect, the period effect.
(12L)

Unit IV: Analysis: Analysis of continuous data**:** Analysis of variance, Analysis of covariance, nonparametric methods, repeated measures.Analysis of categorical outcomes: from Phase I-III trials, analysis of survival data from clinical trials, Interim analysis, motivating intent-to-treat analysis.
(12L)

Unit V: Power Sample Size Determination: Hypotheses and Type I and Type II errors, Power and relative efficiency, sample size determination. **The assessment of Inter and Intra subject variabilities:** Point and Interval estimates, test for equality of variabilities, Equivalence in variability of Bioavailability, CV assessment. (12L)

Text Books:

1. Chow S.C. and Liu J. P.(2009). Design and Analysis of Bioavailability and bioequivalence, 3rd edition, CRC press
2. Chow S.C. and Liu J. P.(2004). Design and Analysis of Clinical Trials, 2nd edition, Marcel Dekkar.
3. L.M. Friedman, C.Furburg, D.L. Demets (1998) Fundamentals of Clinical Trials, Springer Verlag.
4. J.L. Fleiss (1989). The design and Analysis of Clinical Experiments. Wiley and Sons.
5. Daowen Zhang (2009) Statistical Principles of Clinical Trials (Lecture Notes).
6. Fieller Nick (2007). Medical Statistics: Clinical Trials
7. David Machin, Simon Day, Text book of Clinical Trials
8. UmakantSahoo, DiptiSawant. Clinical Trial Monitoring: A professional Handbook

Reference Books :

1. S.Piantadosi (1997) Clinical Trails : A methodological Perspective. Wiley and Sons.
2. C.Jennison and B.W. Turnbull (1999). Group sequential methods with application to Clinical Trails CRC Press.