K. C. E. Society's
Moolji Jaitha College
An 'Autonomous College' Affiliated to
K.B.C. North Maharashtra University, Jalgaon.
NAAC Reaccredited Grade - A (CGPA : 3.15 - 3rd Cycle)
UGC honoured "College of Excellence" (2014-2019)
DST(FIST) Assisted College

KNOWLEDGE IS POWER
ESTD. 1945

के. सी. ई. सोसायटीचे
मूळजी जेठा महाविद्यालय
क.ब.चौ. उत्तर महाराष्ट्र विद्यापीठ, जळगाव संलग्नित
'स्वायत्त महाविद्यालय'
नॅकद्वारा पुनर्मानांकित श्रेणी – 'ए' (सी.जी.पी.ए. : ३.१५ – तिसरी फेरी)
विद्यापीठ अनुदान आयोगाद्वारा घोषित 'कॉलेज ऑफ एक्सलन्स' (२०१४-२०१९)
डी.एस.टी. (फीस्ट) अंतर्गत अर्थसहाय्य प्राप्त

Date :- 25/04/2025

NOTIFICATION

Sub :- CBCS Syllabi of B. Sc. in Statistics (Sem. V & VI)

Ref. :- Decision of the Academic Council at its meeting held on 22/04/2025.

The Syllabi of B. Sc. in Statistics (Fifth and Sixth Semesters) as per **NATIONAL EDUCATION POLICY – 2020 (2023 Pattern)** and approved by the Academic Council as referred above are hereby notified for implementation with effect from the academic year 2025-26.

Copy of the Syllabi Shall be downloaded from the College Website (www.kcesmjcollege.in)

Sd/-
Chairman,
Board of Studies

To :

1) The Head of the Dept., M. J. College, Jalgaon.
2) The office of the COE, M. J. College, Jalgaon.
3) The office of the Registrar, M. J. College, Jalgaon.

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समर्थ कॉलनी जवळ, जळगांव – ४२५ ००२. (महाराष्ट्र, भारत) । दूरध्वनी क्र. : +९१ २५७–२२३७३६३, २२३४२८१ । ई–मेलः mjcollege@kces.in । वेबसाईटः mjcollege.kces.in

Khandesh College Education Society's

Moolji Jaitha College, Jalgaon

An "Autonomous College"

Affiliated to

Kavayitri Bahinabai Chaudhari

North Maharashtra University, Jalgaon-425001

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STRUCTURE AND SYLLABUS

B.Sc. Honours/Honours with Research (T.Y. B.Sc. Statistics)

Under Choice Based Credit System(CBCS)

and

as per NEP-2020 Guidelines

[w.e.f. Academic Year: 2025-26]

Preface

Welcome to the Bachelor of Science in Statistics program! This syllabus serves as your guide to understand the curriculum and objectives of the program. The field of statistics plays a crucial role in today's data-driven world, and this program is designed to equip you with the necessary knowledge and skills to navigate the ever-expanding realm of statistical analysis. The BSc in Statistics program offers a comprehensive and rigorous study of statistical theory, methodology, and applications. It aims to develop your critical thinking abilities, analytical skills, and problem-solving capabilities, all of which are essential for making informed decisions based on data. Whether you aspire to work in industry, academia, research, or any other sector where data analysis is vital, this program will provide you with a solid foundation in statistical principles and techniques.

The syllabus is structured to cover a wide range of statistical topics, including probability theory, mathematical statistics, statistical modeling, experimental design, regression analysis, multivariate analysis, time series analysis, and more. Throughout the program, you will also have opportunities to enhance your computational skills through the use of statistical software packages widely used in the field.As you progress through this program, you will not only develop a strong statistical foundation but also cultivate essential skills in data collection, data cleaning, data visualization, and effective communication of statistical findings. These skills are highly valued in today's job market, where organizations across industries are seeking professionals who can harness the power of data to drive evidence-based decision-making.

Hence, Board of Studies in Statistics in its meeting held on 22 March, 2025 resolved to accept therevised syllabus for T. Y. B. Sc. (Statistics) based on Choice Based Credit System (CBCS) ofUGC, NEP-2020 and the Government of Maharashtra guidelines.

Program Outcomes (PO) for B.Sc. Program:

Program outcomes associated with a B.Sc. degree are as follows:

PO No.	PO
1	Graduates should have a comprehensive knowledge and understanding of the fundamental principles, theories, and concepts in their chosen field of study.
2	Graduates should possess the necessary technical skills and competencies related to their discipline, including laboratory techniques and data analysis.
3	Graduates should be able to identify, analyze, and solve complex problems using logical and critical thinking skills. They should be able to apply scientific methods and principles to investigate and find solutions.
4	Graduates should be proficient in effectively communicating scientific information, both orally and in writing.
5	Graduates should have a basic foundation in research methods and be capable of designing and conducting scientific investigations.
6	Graduates should be able to work effectively as part of a team, demonstrating the ability to collaborate with others, respect diverse perspectives, and contribute to group projects.
7	Graduates should recognize the importance of ongoing learning and professional development. They should be equipped with the skills and motivation to engage in continuous learning, adapt to new technologies and advancements in their field, and stay updated with current research.

Programme Specific Outcome (PSO) for B.Sc. Statistics Honours/Honours with Research:
After completion of this program, students are expected to learn/understand the:

PSO No.	PSO
1	Serve as a statistician with sound theoretical, practical and computational skills.
2	Work as researcher for formulation and solution of mathematical, scientific, societal and industrial problems.
3	Understand the role of statistics in science, society and for National Development.
4	Apply some discrete and continuous distributions which are highly useful in modelling real life.
5	Investigate the relationship between a variable of interest (the response) and a set of related predictor variables and formulate and fit the appropriate regression model to the given dataset.
6	Serve as Administrators/Investigators in the private as well as government sectors and worked as Analyst in Manufacturing (SQC Unit), Pharmaceutical industries.

Multiple Entry and Multiple Exit options:

The multiple entry and exit options with the award of UG certificate/ UG diploma/ or three-year degree depending upon the number of credits secured;

Levels	Qualification Title	Credit Requirements		Semester	Year
		Minimum	Maximum		
4.5	UG Certificate	40	44	2	1
5.0	UG Diploma	80	88	4	2
5.5	Three Year Bachelor's Degree	120	132	6	3
6.0	Bachelor's Degree- Honours **Or** Bachelor's Degree- Honours with Research	160	176	8	4

Credit distribution structure for Three/ Four year Honors/ Honors with Research Degree Programme with Multiple Entry and Exit

F.Y. B.Sc.

Year (Level)	Sem	Subject-I (M-1)	Subject-II (M-2)	Subject-III (M-3)	Open Elective (OE)	VSC, SEC (VSEC)	AEC, VEC, IKS	CC, FP, CEP, OJT, RP	Cumulative Credits/Sem	Degree/ Cumulative Credit
I (4.5)	I	DSC-1(2T) DSC-2(2P)	DSC-1(2T) DSC-2(2P)	DSC-1(2T) DSC-2(2P)	OE-1(2T)	---	AEC-1(2T) (Eng) VEC-1(2T) (ES) IKS(2T)	CC-1(2T)	22	**UG Certificate**
	II	DSC-3(2T) DSC-4(2P)	DSC-3(2T) DSC-4(2P)	DSC-3(2T) DSC-4(2P)	OE-2(2T) OE-3(2P)	---	AEC-2(2T) (Eng) VEC-2(2T) (CI)	CC-2(2T)	22	
	Cum. Cr.	**8**	**8**	**8**	**6**	**---**	**10**	**4**	**44**	
Exit option: Award of UG Certificate with 44 credits and an additional 4 credits core NSQF course/ Internship OR Continue with Major and Minor.										

S.Y. B.Sc.

Year (Level)	Sem	Subject-I (M-1) Major*		Subject-II (M-2) Minor #	Subject-III (M-3)	Open Elective (OE)	VSC, SEC (VSEC)	AEC, VEC, IKS	CC, FP, CEP, OJT/Int/RP	Cumulative Credits/Sem	Degree/ Cumulative Credit
		Mandatory (DSC)	Elective (DSE)	(MIN)							
2 (5.0)	III	DSC-5(2T) DSC-6(2T) DSC-7(2P)	---	MIN-1(2T) MIN-2(2T) MIN-3(2P)	---	OE-4(2T)	SEC-1(2T)	AEC-3(2T) (MIL)	CC-3(2T) CEP(2)	22	**UG Diploma**
	IV	DSC-8(2T) DSC-9(2T) DSC-10(2P)	---	MIN-4(2T) MIN-5(2P)	---	OE-5(2T)	SEC-2(2T) SEC-2(2P)	AEC-4(2T) (MIL)	CC-4(2T) ۞FP(2)	22	
	Cum. Cr.	**12**	**---**	**10**	**---**	**4**	**6**	**4**	**8**	**44**	
	Exit option: Award of UG Diploma in Major and Minor with 88 credits and an additional 4 credits core NSQF course/ Internship OR Continue with Major & Minor.										

***** Student must choose one subject as a Major subject out of M-1, M-2 and M-3 that he/she has chosen at First year
#Student must choose one subject as a Minor subject out of M-1, M-2 and M-3 that he/she has chosen at First year (Minor must be other than Major)
۞ OJT/Internship/CEP should be completed in the summer vacation after 4th semester

T.Y. B.Sc.

Year (Level)	Sem	Subject-I (M-1) Major		Subject-II (M-2) Minor	Subject-III (M-3)	Open Elective (OE)	VSC, SEC (VSEC)	AEC, VEC, IKS	CC, FP, CEP, OJT/Int/RP	Cumulative Credits/Sem	Degree/ Cumulative Credit
		Mandatory (DSC)	Elective (DSE)	(MIN)							
3 (5.5)	V	DSC-11(2T) DSC-12(2T) DSC-13(2T) DSC-14(2P) DSC-15(2P)	DSE-1A/B (2T) DSE-2A/B (2P)	---	---	---	VSC-1(2T) VSC-2(2P)	---	OJT/Int (4)	22	UG Degree
	VI	DSC-16(2T) DSC-17(2T) DSC-18(2T) DSC-19(2T) DSC-20(2T) IKS DSC-21(2P) DSC-22(2P)	DSE-3A/B (2T) DSE-4A/B (2P)	---	---	---	VSC-3(2T) VSC-4(2P)	---	---	22	
	Cum. Cr.	**24**	**8**	**---**	**---**	**---**	**8**	**---**	**4**	**44**	
	Exit option: Award of UG Degree in Major with 132 credits OR Continue with Major and Minor										

Fourth Year B.Sc. (Honours)

Year (Level)	Sem	Major Core Subjects		Research Methodology (RM)	VSC, SEC (VSEC)	OE	AEC, VEC, IKS	CC, FP, CEP, OJT/Int/RP	Cumulative Credits/Sem	Degree/ Cumulative Credit
IV (6.0)	VII	DSC-23(4T) DSC-24(4T) DSC-25(4T) DSC-26(2P)	DSE-5A/B (2T) DSE-6A/B (2P)	RM(4T)	---	---	---	---	22	UG Honours Degree
	VIII	DSC-27(4T) DSC-28(4T) DSC-29(4T) DSC-30(2P)	DSE-7A/B (2T) DSE-8A/B (2P)	---	---	---	---	OJT/Int (4)	22	
	Cum. Cr.	**28**	**8**	**4**	**---**	**---**	**---**	**4**	**44**	
Four Year UG Honors Degree in Major and Minor with 176 credits										

Fourth Year B.Sc. (Honours with Research)

Year (Level)	Sem	Major Core Subjects		Research Methodology (RM)	VSC, SEC (VSEC)	OE	AEC, VEC, IKS	CC, FP, CEP, OJT/Int/RP	Cumulative Credits/Sem	Degree/ Cumulative Credit
IV (6.0)	VII	DSC-23(4T) DSC-24(4T) DSC-26(2P)	DSE-5A/B (2T) DSE-6A/B (2P)	RM(4T)	---	---	---	RP(4)	22	UG Honours with Research Degree
	VIII	DSC-27(4T) DSC-28(4T) DSC-30(2P)	DSE-7A/B (2T) DSE-8A/B (2P)	---	---	---	---	RP(8)	22	
	Cum. Cr.	**20**	**8**	**4**	**---**	**---**	**---**	**12**	**44**	
Four Year UG Honours with Research Degree in Major and Minor with 176 credits										

Sem- Semester, **DSC**- Department Specific Course, **DSE**- Department Specific Elective, **OE/GE**- Open/Generic elective, **VSC**- Vocational Skill Course, **SEC**- Skill Enhancement Course, **VSEC**- Vocation and Skill Enhancement Course, **AEC**- Ability Enhancement Course, **IKS**- Indian Knowledge System, **VEC**- Value Education Course, **T**- Theory, **P**- Practical,**CC**-Co-curricular **RM**- Research Methodology, **OJT**- On Job Training, **FP**- Field Project, **Int**- Internship, **RP**- Research Project, **CEP**- Community Extension Programme, **ENG**- English, **CI**- Constitution of India, **MIL**- Modern Indian Laguage

- Number in bracket indicate credit
- The courses which do not have practical 'P' will be treated as theory 'T'
- If student select subject other than faculty in the subjects M-1, M-2 and M-3, then that subject will be treated as Minor subject, and cannot be selected as Major at second year.

Details of T.Y. B.Sc. (Statistics)

Course	Course Type	Course Code	Course Title	Credits	Teaching Hours/ Week			Marks			
					T	P	Total	Internal		External	
								T	P	T	P
Semester V, Level – 5.5											
DSC-11	DSC	STA-DSC-351	Distribution Theory-I	2	2	---	2	20	---	30	---
DSC-12	DSC	STA-DSC-352	Statistical Inference	2	2	---	2	20	---	30	---
DSC-13	DSC	STA-DSC-353	Design of Experiments	2	2	---	2	20	---	30	---
DSC-14	DSC	STA-DSC-354	Statistics Practical-VII	2	---	4	4	---	20	---	30
DSC-15	DSC	STA-DSC-355	Statistics Practical-VIII	2	---	4	4	---	20	---	30
DSE-1A	DSE	STA-DSE-351A	Introduction to Regression Analysis	2	2	---	2	20	---	30	---
DSE-1B	DSE	STA-DSE-351B	Distribution Theory-II	2	2	---	2	20	---	30	---
DSE-2A	DSE	STA-DSE-352A	Practical on Regression Analysis	2	---	4	4	---	20	---	30
DSE-2B	DSE	STA-DSE-352B	Practical on Distribution Theory-II	2	---	4	4	---	20	---	30
VSC-1	VSC	STA-VSC-351	C-Programming	2	2	---	2	20	---	30	---
VSC-2	VSC	STA-VSC-352	Practical on C-Programming	2	---	4	4	---	20	---	30
OJT/Int	OJT	STA-OJT-351	On Job Training/Internship	4	---	8	8	---	40	---	60
Semester VI, Level – 5.5											
DSC-16	DSC	STA-DSC-361	Statistical Quality Control	2	2	---	2	20	---	30	---
DSC-17	DSC	STA-DSC-362	Sampling Theory	2	2	---	2	20	---	30	---
DSC-18	DSC	STA-DSC-363	Optimization Techniques	2	2	---	2	20	---	30	---
DSC-19	DSC	STA-DSC-364	Applied Statistics	2	2	---	2	20	---	30	---
DSC-20	DSC/IKS	STA-DSC-365	India's Statistical Heritage and Official Statistics	2	2	---	2	20	---	30	---
DSC-21	DSC	STA-DSC-366	Statistics Practical-IX	2	---	4	4	---	20	---	30
DSC-22	DSC	STA-DSC-367	Statistics Practical-X	2	---	4	4	---	20	---	30
DSE-3A	DSE	STA-DSE-361A	Elements of Clinical Trials	2	2	---	2	20	---	30	---
DSE-3B	DSE	STA-DSE-361B	Basic Linear Algebra	2	2	---	2	20	---	30	---
DSE-4A	DSE	STA-DSE-362A	Practical on Clinical Trials	2	---	4	4	---	20	---	30
DSE-4B	DSE	STA-DSE-362B	Practical on Basic Linear Algebra	2	---	4	4	---	20	---	30
VSC-3	VSC	STA-VSC-361	Introduction to Python	2	2	---	2	20	---	30	---
VSC-4	VSC	STA-VSC-362	Practical on Python	2	---	4	4	---	20	---	30

Examination Pattern

Theory Question Paper Pattern:

- 30 (External) +20 (Internal) for 2 credits
    - External examination will be of 1½ hours duration
    - There shall be 3 questions: Q1 carrying 6 marks and Q2, Q3 carrying 12 marks each. The tentative pattern of question papers shall be as follows;
    - Q1 Attempt any 2 out of 3 sub-questions; each 3 marks
    - Q 2 and Q3 Attempt any 3 out of 4 sub-question; each 4 marks.

Rules of Continuous Internal Evaluation:

The Continuous Internal Evaluation for theory papers shall consist of two methods:

1. Continuous & Comprehensive Evaluation (CCE): CCE will carry a maximum of 30% weightage (30/15 marks) of the total marks for a course. Before the start of the academic session in each semester, the

subject teacher should choose any three assessment methods from the following list, with each method carrying 10/5 marks:

i. Individual Assignments
ii. Seminars/Classroom Presentations/Quizzes
iii. Group Discussions/Class Discussion/Group Assignments
iv. Case studies/Case lets
v. Participatory & Industry-Integrated Learning/Field visits
vi. Practical activities/Problem Solving Exercises
vii. Participation in Seminars/Academic Events/Symposia, etc.
viii. Mini Projects/Capstone Projects
ix. Book review/Article review/Article preparation
x. Any other academic activity
xi. Each chosen CCE method shall be based on a particular unit of the syllabus, ensuring that three units of the syllabus are mapped to the CCEs.

2. Internal Assessment Tests (IAT): IAT will carry a maximum of 10% weightage (10/5 marks) of the total marks for a course. IAT shall be conducted at the end of the semester and will assess the remaining unit of the syllabus that was not covered by the CCEs. The subject teacher is at liberty to decide which units are to be assessed using CCEs and which unit is to be assessed on the basis of IAT.The overall weightage of Continuous Internal Evaluation (CCE + IAT) shall be 40% of the total marks for the course. The remaining 60% of the marks shall be allocated to the semester-end examinations.The subject teachers are required to communicate the chosen CCE methods and the corresponding syllabus units to the students at the beginning of the semester to ensure clarity and proper preparation.

Practical Examination Credit 2: Pattern (30+20)

External Practical Examination (30 marks):

- Practical examination shall be conducted by the respective department at the end of the semester.
- Practical examination will be of 3 hours duration and shall be conducted as per schedule.
- Practical examination shall be conducted for 2 consecutive days for 2 hr/ day where incubation conditionis required.
- There shall be 05 marks for journal and viva-voce. Certified journal is compulsory to appear for practical examination.

Internal Practical Examination (20 marks):

- Internal practical examination of 10 marks will be conducted by department as per schedule given.
- For internal practical examination student must produce the laboratory journal of practicals completed along with the completion certificate signed by the concerned teacher and the Head of the department.
- There shall be continuous assessment of 30 marks based on student performance throughout the semester. This assessment can include quizzes, group discussions, presentations and other activities assigned by the faculty during regular practicals. For details refer internal theory examination guidelines.
- Finally 40 (10+30) marks performance of student will be converted into 20 marks.

SEMESTER-V

T.Y. B.Sc. Statistics (Major)
Semester-V
STA-DSC-351: Distribution Theory-I

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To continue study of standard discrete and continuous probability distributions and their applications. ▪ To introduce Chebychev's inequality, WLLN, CLT . ▪ To introduce order statistics.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Use Chebychev's inequality and WLLN to solve statistical problem. ▪ Compute various events probability using Central Limit Theorem. ▪ Apply hyper geometric and negative binomial distribution in real life situations. ▪ Obtain distributions of order statistics.	
Unit	**Contents**	**Hours**
Unit I	**Chebychev's Inequality and Central Limit Theorem** ▪ Chebychev's theorem: If g(X) is a non-negative function of a r.v. X , $E\{g(X)\} < \infty$ and if $k > 0$ then $P\{g(X) \geq k\} \leq E\{g(X)\}/k^2$. ▪ Chebychev's inequality for discrete & continuous distribution in the forms $P\{\lvert X - \mu \rvert \geq k\sigma\} \leq 1/k^2$ and $P\{\lvert X - \mu \rvert < k\sigma\} \geq 1-1/k^2$, where $\mu = E(X)$ and $\sigma^2 = V(X)$. ▪ Concept of convergence in probability. ▪ Statement and proof of WLLN based on Chebychev's theorem. ▪ Statement and proof of the central limit theorem for i.i.d.r.v.s. based on mgf. ▪ Examples and problems.	**9**
Unit II	**Hyper geometric distribution** ▪ Probability mass function $P(X = x) = \dfrac{\binom{M}{x}\binom{N-M}{n-x}}{\binom{N}{n}},\ x = 0,1,2,\ldots,n;\ n \leq M$ Notation X~H(N, M, n) ▪ Applications of hyper geometric distributions ▪ Binomial approximation to hyper geometric distribution ▪ Conditional distribution of X given (X+Y), where X and Y are independent binomial random variables with parameters (n_1, p) and (n_2, p) respectively. ▪ Raw moments, factorial moments, mean and variance ▪ Examples and problems	**5**

Unit III	**Negative binomial distribution** ▪ Probability mass function $P(X=x)=\binom{x+k-1}{x}p^k q^x$; x = 0,1,2,…. 0< p < 1, q = 1-p. Notation X~ NB(k, p), k ≥ 1. ▪ Probability Generating function (pgf), mgf, cgf, fmgf, first four moments and cumulants, factorial moments, recurrence relation for probabilities. ▪ Additive property. ▪ NB distribution as a waiting time distribution. ▪ NB(k, p) as the distribution of sum of k i.i.d. geometric r.v.s. with common parameter p. ▪ NB distribution obtained from Poisson distribution with gamma distributed parameter. ▪ Poisson approximation to NB distribution. ▪ Examples and problems.	**8**
Unit IV	**Order Statistics** ▪ Order statistics for a random sample from a continuous distribution. ▪ Distribution of the i^{th} order statistics $X_{(i)}$ (distribution function and probability density function). ▪ Joint distribution of $(X_{(i)}, X_{(j)})$. ▪ Distribution of the smallest order statistics $X_{(1)}$, distribution of largest order statistics $X_{(n)}$ ▪ Distribution of the sample median, distribution of the sample range $X_{(n)} - X_{(1)}$. Distribution of $X_{(1)}$ and $X_{(n)}$ for uniform and exponential distributions. ▪ Examples and problems.	**8**
Study Resources	▪ Gupta S.C. and Kapoor V. K. (2017). Fundamentals of Mathematical Statistics. S. Chand and Sons, New Delhi. ▪ Rohatgi V. K. (1976). An Introduction to Probability theory and Mathematical Statistics. John Wiley and Sons, New York. ▪ Hogg. R. V., M. McKean J. W. and Craig. A. J. (2019). Introduction to Mathematical Statistics. Pearson Education, Inc. ▪ Weatherburn C. E. (1968). A first course in Mathematical Statistics. Cambridge University Press. ▪ Kulkarni M.B. and Ghatpande S.B. (2007). Introduction to Discrete Probability and Probability Distributions. SIPF Academy. ▪ Mood A. M. and Graybill F. A and Boes D. C. (2001). Introduction to the Theory of Statistics, third edition. Mc Graw Hill Education. ▪ Dudewicz E.J. and Mishra S.N. (1988). Modern Mathematical Statistics, (WileySons). ▪ Biswas S. and Sriwastav G. L. (2011). Mathematical Statistics; Narosa Pub.	

T.Y. B.Sc. Statistics (Major)
Semester-V
STA-DSC-352: Statistical Inference

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To acquaint the students with point estimation. ▪ To introduce properties of estimators such as unbiasedness, relative efficiency, sufficiency, consistency. ▪ To explain methods of estimation.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Understand problem of estimation of parameters. ▪ Test whether estimator is unbiased or not. ▪ Find efficiency of estimator relative to another estimator. ▪ Find estimator of unknown parameter using maximum likelihood estimation and method of moments.	
Unit	**Contents**	**Hours**
Unit I	**Point Estimation** ▪ Concept of random sample from a distribution, Notion of a Parameter, Parameter space, general problem of estimation. Types of estimation: Point estimation and interval estimation. ▪ Point estimation: Definition of estimator, distinction between estimator and estimate, illustrative examples. ▪ Unbiasedness: Definition of unbiased estimator, biased estimator, positive and negative biases. Illustrative examples (These should include unbiased and biased estimators for the same parameters) ▪ Proofs of the results regarding unbiased estimator: (a) Two distinct unbiased estimators of $f(\theta)$ give rise to infinitely many unbiased estimators of $f(\theta)$. (b) If T is an unbiased estimator of θ, then f (T) is an unbiased estimator $f(\theta)$, provided f(T) is linear function of T. ▪ Discussion of the following results:- (a) If T is an unbiased estimator of θ, then f(T) need not be an unbiased estimator of $f(\theta)$, illustrative examples. (b) Sample standard deviation is a biased estimator of population standard deviation. ▪ Relative efficiency of unbiased estimator T_1 with respect to another unbiased estimator T_2, use of mean square error to define relative efficiency of biased estimators. ▪ Examples and Problems.	**10**

Unit II	**Sufficiency and Consistency** ▪ Concept and definition of sufficiency ▪ Statement of Neyman's factorization theorem (proof for discrete case only). ▪ Proofs of the following properties of sufficient statistics: o If T is sufficient for θ, f (T) is also sufficient for f(θ) provided f is one to one and onto function. o If T is sufficient for θ then T also sufficient for f (θ). ▪ Definition of likelihood as a function of the parameter for a random sample from (i) discrete, (ii) continuous distribution. Definition of Fisher's information function. Amount of information regarding parameter contained in a statistic T and a sufficient statistic T. ▪ Consistency: Definition of consistent estimator. Statement of the theorem: Biased estimator is consistent if its bias and variance both tend to zero as the sample size tends to infinity. ▪ Examples and problems.	**8**
Unit III	**Methods of Estimation** ▪ Method of maximum likelihood, derivation of maximum likelihood estimators (m.l.e.) for parameters of only standard distributions: binomial, normal. Invariance property of m.l.e., relation between m.l.e. and sufficient statistics. ▪ Method of moments: Derivation of moment estimators for standard distributions: binomial, Poisson, normal, exponential and uniform, illustration of situations where m.l.e. and moment estimators are distinct and their comparison using mean square error. ▪ Examples and problems.	**7**
Unit IV	**Interval Estimation** ▪ Notion of interval estimation, definition of confidence interval, confidence bounds. ▪ Relation between confidence interval and testing of hypothesis, definition of pivotal quantity and its use in obtaining confidence interval and bounds. ▪ Interval estimation for the following cases: o Mean (μ) of normal distribution (when σ known and σ unknown) o Variance (σ^2) of normal distribution (when μ known and μ unknown) ▪ Examples and problems.	**5**
Study Resources	▪ Gupta S.C. and Kapoor V. K. (2017). Fundamentals of Mathematical Statistics. S. Chand and Sons, New Delhi. ▪ Rohatgi V. K. (1976). An Introduction to Probability theory and Mathematical Statistics. John Wiley and Sons, New York. ▪ Hogg. R. V., M. McKean J. W. and Craig. A. J. (2019). Introduction to Mathematical Statistics. Pearson Education, Inc. ▪ Mood A. M. and Graybill F. A and Boes D. C. (2001). Introduction to the Theory of Statistics, third edition. Mc Graw Hill Education. ▪ Kale B. K. and Muraridharan. (2015). Parametric Inference: An Introduction, Alpha Science Intl Ltd. ▪ Dudewicz E.J. and Mishra S.N. (1988). Modern Mathematical Statistics, (WileySons). ▪ Biswas S. and Sriwastav G. L. (2011). Mathematical Statistics; Narosa Pub.	

T.Y. B.Sc. Statistics (Major)
Semester-V
STA-DSC-353: Design of Experiments

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To introduce concept of design of experiments. ▪ To make student aware about standard designs of experiments such as CRD, RBD and LSD. ▪ To introduce efficiency of design, missing plot technique.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Plan the experiment, obtain relevant information from it. ▪ Understand basic principles of Design of Experiments. ▪ Study Standard designs: CRD, RBD, LSD etc. ▪ Identify real life situations where the above designs are useful.	
Unit	**Contents**	**Hours**
Unit I	**Introduction to Design of Experiments** ▪ Concept of Design of Experiment (DOE), Introduction to basic terms of Design of Experiments, Experimental unit, treatments, layout of an experiment, factor, level, run of experiment, control experiment, test experiment. ▪ Basic principles of Design of Experiments, Randomization, Replication and Local control. ▪ Uniformity trials. ▪ Choice of size and shape of a plot. ▪ The empirical formula for the variance per unit area of plots. ▪ Examples and problems	**5**
Unit II	**Standard Designs of Experiments** ▪ Completely Randomized Design (CRD). Definition and model, Preparation of Analysis of Variance (ANOVA) table, testing of equality of treatment effects, testing equality of two specified treatment means, critical differences. Merits and demerits of CRD. ▪ Randomized Block Design (RBD). Definition and model, Preparation of ANOVA table, testing of equality of treatment effects and block effects, testing for equality of two specific treatment means, critical differences. Merits and demerits of RBD. ▪ Latin Square Design (LSD) : definition, model: $Y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + \varepsilon_{ijk}$ $i = 1, 2, \ldots, m;$ $j = 1,2, \ldots, m; (i, j, k) \varepsilon S$ $k = 1, 2, \ldots, m$ Assumptions and interpretation, Estimation of parameters, Expectedvalue of Mean sum of squares, components of variance.	**15**

	Hypothesis for the model: H_{01}: $\alpha_1 = \alpha_2 = \ldots = \alpha_m$ H_{02}: $\beta_1 = \beta_2 = \ldots = \beta_m$ H_{03}: $\gamma_1 = \gamma_2 = \ldots = \gamma_m$ and its interpretation. Justification of use of F-test for H01, H02 and H03, (independence of Chi-squares is to be assumed), Preparation of ANOVA table and F-test for H01, H02 and H03. Testing for equality of two specified treatments effects, use of critical difference, testing for equality of two row effects, two column effects and treatment effects. Merits and demerits of LSD. ▪ Linear treatment contrasts, orthogonal contrasts. Scheffe's method for comparing contrasts, Tuckey's procedure for comparing pairs of treatment means (applicable to C.R.D., R.B.D. and L.S.D.) ▪ Identification of real life situations where the above designs are useful. ▪ Applications of principles of Design of Experiments in CRD, RBD and LSD. ▪ Simple numerical problems.	
Unit III	**Efficiency of a Design** ▪ Concept and definition of efficiency of a design. ▪ Comparison of efficiencies between CRD and RBD. ▪ Comparison of efficiencies between LSD and RBD, LSD and CRD. ▪ Simple numerical problems.	**4**
Unit IV	**Missing Plot Technique** ▪ Situations where missing plot technique is applicable. ▪ Estimation of missing plots by minimizing error sum of squares in RBD and LSD with one or two observations are missing. ▪ Derivation of exact treatments sum of squares, preparing analysis of variance table and writing report. ▪ Iterative procedure in case of missing observations. ▪ t-test for comparing any two treatment effects.	**6**
Study Resources	▪ Federer W.T. (1963). Experimental Designs, Oxford & IDH Publishing Co., New Delhi. ▪ Cochren W.G. & Cox G,M. (1992). Experimental Designs, Second Edition, John Wiley & Sons Inc., New Delhi. ▪ Montgomery D.C. (2001). Design & Analysis of Experiments, John Wiley & Sons Inc., New Delhi. ▪ Das M. N. and Giri N.C. (1986). Design & Analysis of Experiments, Second edition, Wiley Eastern Ltd., New Delhi. ▪ Snedecor G.W. and Cochran W.G. (1989). Statistical Methods, 8th edition, Affiliated East West Press, New Delhi. ▪ Goon A. M., Gupta M. K. and Dasgupta B. (1986). Fundamentals of Statistics, Vol-II, The World Press Pvt. Ltd., Calcutta. ▪ Gupta S.C. and Kapoor V.K. (2007). Fundamentals of Applied Statistics, S. Chand and Sons, New Delhi. ▪ Parimal Mukhopadhyay (2005). Applied Statistics, Books and Allied(P) Ltd, Kolkata.	

T.Y. B.Sc. Statistics (Major)
Semester-V
STA-DSC-354: Statistics Practical-VII

Total Hours: 60 **Credits: 2**

General instructions	▪ All Practical of this paper are to be carried out by using R/MS-Excel/MINITAB software. ▪ Student must complete all the practical to the satisfaction of concerned teacher. ▪ Students must be encouraged to collect live data from real life situations for practical.	
Course Objectives	▪ To develop skill to solve distributions problems. ▪ To develop abilities to solve statistical inference problems. ▪ To introduce truncated distributions.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Solve distribution theory problems. ▪ Explain properties of estimators. ▪ Estimate parameters of standard distributions. ▪ Apply distributions to real life situations.	
Sr. No.	**Contents**	**Hours**
1	Continuous uniform distribution-I	**4**
2	Continuous uniform distribution-II	**4**
3	Point Estimation	**4**
4	Model sampling and applications of hypergeometric distribution	**4**
5	Sufficiency	**4**
6	Consistency	**4**
7	Fitting of negative binomial Distribution	**4**
8	Model sampling and applications of negative binomial distribution	**4**
9	Order Statistics	**4**
10	Estimation of parameters by the method of Maximum Likelihood Estimation-I	**4**
11	Estimation of parameters by the method of Maximum Likelihood Estimation-II	**4**
12	Estimation of parameters by the method of moments-I	**4**
13	Interval estimation	**4**
14	Truncated binomial distribution	**4**
15	Truncated Poisson distribution	**4**
Study Resources	▪ Gupta S.C. and Kapoor V. K. (2017). Fundamentals of Mathematical Statistics. S. Chand and Sons, New Delhi. ▪ Rohatgi V. K. (1976). An Introduction to Probability theory and Mathematical Statistics. John Wiley and Sons, New York. ▪ Hogg. R. V., M. McKean J. W. and Craig. A. J. (2019). Introduction to Mathematical Statistics. Pearson Education, Inc. ▪ Weatherburn C. E. (1968). A first course in Mathematical Statistics. Cambridge University Press. ▪ Kulkarni M.B. and Ghatpande S.B. (2007). Introduction to Discrete Probability and Probability Distributions. SIPF Academy. ▪ Mood A. M. and Graybill F. A and Boes D. C. (2001). Introduction to the Theory of Statistics, third edition. Mc Graw Hill Education. ▪ Dudewicz E.J. and Mishra S.N. (1988). Modern Mathematical Statistics,	

	(WileySons). ▪ Biswas S. and Sriwastav G. L. (2011). Mathematical Statistics; Narosa Pub. ▪ Purohit S.G., Gore S.D. and Deshmukh S.R. (2008). Statistics Using R. Narosa Pub.	

***Mandatory to perform any 12 practical from above.**

T.Y. B.Sc. Statistics (Major)
Semester-V
STA-DSC-355: Statistics Practical-VIII

Total Hours: 60 **Credits: 2**

General instructions	▪ All Practical of this paper are to be carried out by using R software. ▪ Student must complete all the practical to the satisfaction of concerned teacher. ▪ Students must be encouraged to collect live data from real life situations for practical.	
Course Objectives	▪ To develop skill of the numerical calculations. ▪ To develop abilities to adopt proper DOE. ▪ To introduce analysis of designs using R software.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Analyze standard designs CRD, RBD and LSD using R. ▪ Estimate missing observations and then analyze design. ▪ Compare designs and analyze BIBD and factorial experiments. ▪ Analyze factorial experiment with total confounding.	
Sr. No.	**Contents**	**Hours**
1	Analysis of CRD.	**4**
2	Analysis of RBD.	**4**
3	Analysis of LSD-I	**4**
4	Analysis of LSD-II	**4**
5	Efficiency of Designs	**4**
6	Missing Plot Technique in RBD	**4**
7	Missing Plot Techniques in LSD-I	**4**
8	Missing Plot Technique in LSD-II	**4**
9	Analysis of BIBD-I	**4**
10	Analysis of BIBD-II	**4**
11	Analysis of 2^3 factorial experiment arranged in RBD-I	**4**
12	Analysis of 2^3 factorial experiment arranged in RBD-II	**4**
13	Analysis of 2^3 factorial experiment with total confounding-I	**4**
14	Analysis of 2^3 factorial experiment with total confounding-II	**4**
15	Analysis of 2^3 factorial experiment with partial confounding	**4**
Study Resources	▪ Federer W.T. (1963). Experimental Designs, Oxford & IDH Publishing Co., New Delhi. ▪ Cochren W.G. & Cox G,M. (1992). Experimental Designs, Second Edition, John Wiley & Sons Inc., New Delhi. ▪ Montgomery D.C. (2001). Design & Analysis of Experiments, John Wiley & Sons Inc., New Delhi. ▪ Das M. N. and Giri N.C. (1986). Design & Analysis of Experiments, Second edition, Wiley Eastern Ltd., New Delhi. ▪ Snedecor G.W. and Cochran W.G. (1989). Statistical Methods, 8th edition, Affiliated East West Press, New Delhi. ▪ Goon A. M., Gupta M. K. and Dasgupta B. (1986). Fundamentals of Statistics, Vol-II, The World Press Pvt. Ltd., Calcutta.	

	▪ Gupta S.C. and Kapoor V.K. (2007). Fundamentals of Applied Statistics, S. Chand and Sons, New Delhi. ▪ Parimal Mukhopadhyay (2005). Applied Statistics, Books and Allied (P) Ltd, Kolkata. ▪ Purohit S.G., Gore S.D. and Deshmukh S.R. (2008). Statistics Using R. Narosa Pub.	

***Mandatory to perform any 12 practical from above.**

T.Y. B.Sc. Statistics (Elective)
Semester-V
STA-DSE-351A: Introduction to Regression Analysis

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To discuss in detail simple linear regression model. ▪ To introduce in detail multiple linear regression model and logistic regression model. ▪ To make student aware about applications of these models in real life situations.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Investigate the relationship between a variable of interest (the response) and the set of related predictor variables. ▪ Formulate and fit the appropriate regression model to the given dataset. ▪ Analyze statistical data using regression in various real-life situations. ▪ Compare AIC and BIC criteria for model selection in regression analysis.	
Unit	**Contents**	**Hours**
Unit I	**Simple Linear Regression Model** ▪ Review of simple linear regression model: $Y = \beta_0 + \beta_1 X + \varepsilon$, where ε is a continuous random variable with E(ε) =0, V(ε) = σ^2. ▪ Estimation of β_0 and β_1 , by the method of least squares. ▪ Properties of estimators of β_0 and β_1 Estimation of σ^2 ▪ Assumption of normality of ε. Tests of hypothesis of β_1 ▪ Interval estimation in simple linear regression model ▪ Coefficient of determination.	**8**
Unit II	**Multiple linear Regression Model** ▪ Review of multiple linear regression model $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots . \beta_p X_p + \varepsilon$, where ε is a continuous random variable with E(ε) =0, V(ε) =σ^2. ▪ Estimation of regression parameters $\beta_0, \beta_1 \ldots..$and $\beta_p$by the method of least squares, obtaining normal equations, solutions of normal equations. ▪ Estimation of σ^2 ▪ Assumption of normality of ε. Tests of hypothesis of regression parameters. ▪ Interval estimation in simple linear regression model ▪ Variable selection and model building ▪ Residual diagnostics and corrective measures such as transformation of response variable, weighted least squares method ▪ Polynomial regression models	**8**
Unit III	**Logistic Regression Model** ▪ Binary response variable, Logit transform, estimation of parameters, interpretation of parameters. ▪ Tests of hypotheses of model parameters, model deviance, LR test. ▪ AIC and BIC criteria for model selection ▪ Interpretation of output produced by glm command in R ▪ Multiple logistic regression	**6**

Unit IV	**Model Adequacy Checking** ▪ Introduction ▪ Residual Analysis: Definition of Residuals ▪ Standardized residuals, Studentized residuals, ▪ Residual plots ▪ Detection and treatment of outliers ▪ Interpretation of four plots produced by lm() command in R	**8**
Study Resources	▪ Draper, N. R. and Smith, H. (1998). Applied Regression Analysis, John Wiley, 3 rd Ed. ▪ Hosmer, D. W. and Lemeshow, S. (1989). Applied Logistic Regression, Wiley. ▪ Montgomery, D. C., Peck, E. A. and Vining, G. G. (2003). Introduction to Linear • Regression Analysis, Wiley. ▪ Neter, J., W., Kutner, M. H.; Nachtsheim, C.J. and Wasserman, W.(1996). Applied ▪ Linear Statistical Models, fourth edition, Irwin USA.	

T.Y. B.Sc. Statistics (Elective)
Semester-V
STA-DSE-351B: Distribution Theory-II

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To make student aware about uniform, lognormal, Weibull, Laplace and Cauchy distributions. ▪ To discuss derivations of distributions of functions of random variables. ▪ To acquaint students with the applications of probability distributions.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Use continuous uniform distribution in real life situations. ▪ Apply lognormal and Weibull distribution in real life situations. ▪ Identify situations where Cauchy and Laplace distribution is applicable. ▪ Use multinomial distribution in real life situations.	
Unit	**Contents**	**Hours**
Unit I	**Rectangular (Uniform) distribution** ▪ P.d.f. $f(x) = \frac{1}{b-a} \qquad -\infty < a < x < b < \infty$ $= 0 \qquad Otherwise$ ▪ Distribution function, mean, variance, mgf, r^{th} raw moment. ▪ Standard form: U(0,1). ▪ U(0,1) as the distribution of F(X), where X is a continuous type r.v. with d.f. F(.), application to model sampling, Use of U(0,1) to generate integer valued random numbers. ▪ Distributions of X+Y, X-Y, XY, X/Y for X and Y are independent U(0,1) random variables. ▪ Real life situations. ▪ Examples and problems.	**8**
Unit II	**Weibull distribution** ▪ P.d.f.: $f(x) = \frac{\beta}{\alpha}\left(\frac{x-\gamma}{\alpha}\right)^{\beta-1} \exp\left\{-\left(\frac{x-\gamma}{\alpha}\right)^{\beta}\right\};\ \gamma \le x < \infty,\ -\infty < \gamma < \infty,\ \alpha, \beta > 0$ $= 0 \qquad otherwise.$ Notation : X ~ W (γ,α,β) ▪ Distribution function, quartiles. ▪ r^{th} Moment about x = γ, mean and variance. ▪ Relation with exponential distribution. ▪ Examples and problems.	**7**
Unit III	**Cauchy Distribution**	**7**

	▪ P.d.f.: $$f(x) = \frac{\lambda}{\pi} \frac{1}{1+\left(\frac{x-\mu}{\lambda}\right)^2} ; -\infty < x < \infty, -\infty < \mu < \infty, \lambda > 0$$ $= 0$ *otherwise.* Notation : X~ C(μ, λ) ▪ Nature of probability curve. ▪ Distribution function, quartiles, non-existence of moments. ▪ Additive property for two independent Cauchy variates (Statement only), Statement of distribution of the sample mean. ▪ Relationship with uniform and Student's 't' distribution. ▪ Examples and problems.	
Unit IV	**Multinomial Distribution** ▪ Joint p.m.f. $$P(X_1 = x_1, X_2 = x_2, \ldots\ldots X_k = x_k) = \frac{n!\, p_1^{x_1} p_2^{x_2} \ldots p_k^{x_k}}{x_1!\, x_2! \ldots\ldots x_k!} ; x_i = 0,1,2,\ldots n ;$$ $i=1,2,\ldots,k ; x_1+x_2+\ldots+x_k = n; p_1+p_2+\ldots+p_k = 1; 0<p_i<1$ $=0,$ *otherwise* Notation $(X_1,X_2,\ldots X_k)' \sim MD(n,p_1, p_2,\ldots p_k)$ ▪ Joint mgf of $X_1 X_2 \ldots X_k$ ▪ Use of joint mgf to obtain means, variances, covariances, total correlation coefficients, multiple and partial correlation coefficients for k = 3, univariate marginal distributions. ▪ Variance covariance matrix, Rank of Variance-Covariance matrix and its interpretation. ▪ Real life situations. ▪ Examples and problems.	**8**
Study Resources	▪ Gupta S.C. and Kapoor V. K. (2017). Fundamentals of Mathematical Statistics. S. Chand and Sons, New Delhi. ▪ Rohatgi V. K. (1976). An Introduction to Probability theory and Mathematical Statistics. John Wiley and Sons, New York. ▪ Hogg. R. V., M. McKean J. W. and Craig. A. J. (2019). Introduction to Mathematical Statistics. Pearson Education, Inc. ▪ Weatherburn C. E. (1968). A first course in Mathematical Statistics. Cambridge University Press. ▪ Mood A. M. and Graybill F. A and Boes D. C. (2001). Introduction to the Theory of Statistics, third edition. Mc Graw Hill Education. ▪ Dudewicz E.J. and Mishra S.N. (1988). Modern Mathematical Statistics, (WileySons). ▪ Biswas S. and Sriwastav G. L. (2011). Mathematical Statistics; Narosa Pub.	

T.Y. B.Sc. Statistics (Elective)
Semester-V
STA-DSE-352A: Practical on Regression Analysis

Total Hours: 60 **Credits: 2**

General instructions	▪ All Practical of this paper are to be carried out by using R/MS-Excel/MINITAB software. ▪ Student must complete all the practical to the satisfaction of concerned teacher. ▪ Students must be encouraged to collect live data from real life situations for practical.	
Course Objectives	▪ To provide an in-depth discussion on the simple linear regression model. ▪ To offer a detailed introduction to multiple linear regression and logistic regression models. ▪ To enhance students' understanding of real-life applications of these regression models.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Explore the relationship between a response variable and its associated predictor variables. ▪ Develop and apply suitable regression models to analyze given datasets. ▪ Assess the significance of regression parameters through appropriate testing methods. ▪ Evaluate and compare model selection criteria, such as AIC and BIC, in regression analysis.	
Sr. No.	**Contents**	**Hours**
1	Introduction to Scatter diagram.	**4**
2	Simple regression analysis and diagnostics by graphical method	**4**
3	Simple regression analysis.	**4**
4	Multiple regression analysis and diagnostics by graphical method	**4**
5	Multiple linear regression I	**4**
6	Multiple linear regression II	**4**
7	Multiple Correlation coefficient	**4**
8	Partial Correlation coefficient	**4**
9	Logistic Regression Model I	**4**
10	Logistic Regression Model II	**4**
11	Detection of outliers using graphical method	**4**
12	Detection of outliers.	**4**
13	Real life data analysis I	**4**
14	Real life data analysis II	**4**
15	Real life data analysis III	**4**
Study Resources	▪ Draper, N. R. and Smith, H. (1998). Applied Regression Analysis, John Wiley, 3 rd Ed. ▪ Hosmer, D. W. and Lemeshow, S. (1989). Applied Logistic Regression, Wiley. ▪ Montgomery, D. C., Peck, E. A. and Vining, G. G. (2003). Introduction	

	to Linear • Regression Analysis, Wiley. ▪ Neter, J., W., Kutner, M. H.; Nachtsheim, C.J. and Wasserman, W.(1996). Applied ▪ Linear Statistical Models, fourth edition, Irwin USA.	

***Mandatory to perform any 12 practical from above.**

T.Y. B.Sc. Statistics (Elective)
Semester-V
STA-DSE-352B: Practical on Distribution Theory-II

Total Hours: 60 **Credits: 2**

General instructions	▪ All Practicals of this paper are to be carried out by using R/MS-Excel/MINITAB software. ▪ Student must complete all the practicals to the satisfaction of concerned teacher. ▪ Students must be encouraged to collect live data from real life situations for practicals.	
Course Objectives	▪ To enhance numerical calculations skills. ▪ To develop the abilities to apply appropriate probability distributions. ▪ To introduce built-in functions in R software for specified distributions.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Use built-in functions in R software to interpret probability distributions ▪ Apply numerical and statistical techniques using R to solve practical problems. ▪ Identify and apply suitable probability distributions. ▪ Obtain model samples from Cauchy and Bivariate normal distributions.	
Sr. No.	**Contents**	**Hours**
1	Left truncated normal distribution	**4**
2	Right truncated normal distribution	**4**
3	Weibull distribution	**4**
4	Applications of lognormal distribution	**4**
5	Fitting of lognormal distribution	**4**
6	Model Sampling and applications of Cauchy distribution	**4**
7	Fitting of Cauchy distribution	**4**
8	Model Sampling and applications of Laplace distribution	**4**
9	Fitting of Laplace distribution	**4**
10	Multinomial distribution-I	**4**
11	Multinomial distribution-II	**4**
12	Model Sampling from bivariate normal distribution	**4**
13	Applications of bivariate normal distribution-I	**4**
14	Applications of bivariate normal distribution-II	**4**
15	Double truncated normal distribution	**4**
Study Resources	▪ Gupta S.C. and Kapoor V. K. (2017). Fundamentals of Mathematical Statistics. S. Chand and Sons, New Delhi. ▪ Rohatgi V. K. (1976). An Introduction to Probability theory and Mathematical Statistics. John Wiley and Sons, New York. ▪ Hogg. R. V., M. McKean J. W. and Craig. A. J. (2019). Introduction to Mathematical Statistics. Pearson Education, Inc. ▪ Weatherburn C. E. (1968). A first course in Mathematical Statistics. Cambridge University Press. ▪ Kulkarni M.B. and Ghatpande S.B. (2007). Introduction to Discrete Probability and Probability Distributions. SIPF Academy.	

	▪ Mood A. M. and Graybill F. A and Boes D. C. (2001). Introduction to the Theory of Statistics, third edition. Mc Graw Hill Education. ▪ Dudewicz E.J. and Mishra S.N. (1988). Modern Mathematical Statistics, (WileySons). ▪ Biswas S. and Sriwastav G. L. (2011). Mathematical Statistics; Narosa Pub. ▪ Purohit S.G., Gore S.D. and Deshmukh S.R. (2008). Statistics Using R. Narosa Pub.	

***Mandatory to perform any 12 practical from above.**

T.Y. B.Sc. Statistics (Vocational)
Semester-V
STA-VSC-351: C-Programming

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To make student aware about C programming. ▪ To illustrate inbuilt and user defined functions in C. ▪ To explain statistical problem solving using C.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Create algorithm and flowchart to solve simple problems using C. ▪ Understand procedural language, middle level language, higher level language, general language structure. ▪ Design and implement programs that uses loops. ▪ Solve statistical computational problems using C program.	
Unit	**Contents**	**Hours**
Unit I	**Introduction to C** ▪ Algorithms and flowcharts. ▪ Introduction to procedural language, middle level language, higher level language, general language structure, character set, keywords, identifiers. ▪ Data types: Numeric and character data types, Numeric and character constants, string constants, symbolic constants. ▪ Operators: Numeric, logical, arithmetic, unary, relational, equality, decrement, increment, conditional assignments, precedence of operator expressions and their evaluation. ▪ Data input/output, numeric and character data, printf ( ), scanf ( ), getchar ( ), putchar ( ), gets ( ), puts ( ). ▪ Formatted output	**10**
Unit II	**Control Structures** ▪ If, if else, while, do....while, for, switch, goto, break, continue, nested loops. ▪ programs using control structures.	**5**
Unit III	**Arrays** ▪ Concept, declaration, definition, initialization of array, problem using arrays, passing to function, arrays and string operations, string functions like strcpy(), strcat(), strlen(), strcmp(), strrev(). ▪ List of programs using arrays. o To find mean, median, variance and coefficient of variation of frequency distribution. o To find correlation coefficient and least square regression line of Y on X for a given bivariate data. o To arrange the given data in increasing/decreasing order of magnitude. o To obtain median of given n observations. o To obtain addition of two matrices, multiplication of two matrices.	**10**

Unit IV	**Functions** ▪ Declaration, definition, recursion, user defined functions, library function, calling a function by reference and by value, local and global variables. ▪ List of writing functions: o To find factorial of integer number (both recursive and non-recursive) o To find the value of Xnwhere n is integer.(both recursive and non-recursive) o To find GCD of two integer numbers(both recursive and non-recursive) o To find maximum/minimum of n numbers.(non-recursive)	**5**
Study Resources	▪ Gottfried, B.S. (1996). Programming with C (Schaum Outline series), McGraw Hill co., London ▪ Kanitkar, Y (2008). Let us C, BFB publishers, New Delhi. ▪ Karnighan, B. W. and Ritchi, M. (1988). The C programming language, Second edition, Prentice Hall. ▪ Rajaraman V. (2007). Computer programming in C, Prentice Hall of India.	

T.Y. B.Sc. Statistics (Vocational)
Semester-V
STA-VSC-352: Practical on C-Programming

Total Hours: 60 **Credits: 2**

General instructions	▪ All Practicals of this paper are to be carried out by using C software. ▪ Student must complete all the practicals to the satisfaction of concerned teacher. ▪ Students must be encouraged to collect live data from real life situations for practicals.
Course Objectives	▪ To develop hands-on programming skills in C with a focus on statistical problem-solving. ▪ To enhance logical thinking and algorithm design through practical implementation of C concepts. ▪ To apply C programming techniques, including arrays, and functionsto solve statistical and mathematical problems.
Course Outcomes	After successful completion of this course, students are expected to: ▪ Demonstrate proficiency in writing C programs using control structures, loops, and functions. ▪ Use C programming to perform statistical calculations such as mean, median, variance, and regression analysis. ▪ Write well-structured programs using functionsand recursion for efficient problem-solving. ▪ Implement C-based solutions for data handling, matrix operations, and basic statistical modeling.

Sr. No.	Contents	Hours
1	Introduction to C and Basic I/O Operations	**4**
2	Working with Operators	**4**
3	Control Structures: If-Else and Switch Case	**4**
4	Looping Constructs: While and Do-While Loops	**4**
5	Looping Constructs: For Loop and Nested Loops	**4**
6	Introduction to Arrays	**4**
7	Working with One-Dimensional Arrays	**4**
8	Statistical Computations Using Arrays	**4**
9	Matrix Operations Using Two-Dimensional Arrays	**4**
10	String Manipulation in C	**4**
11	Linear Regression and Correlation in C	**4**
12	Recursive and Non-Recursive Functions	**4**
13	Finding Maximum and Minimum Using Functions	**4**
14	Real Life Data Analysis-I	**4**
15	Real Life Data Analysis-II	**4**

Study Resources	▪ Gottfried, B.S. (1996). Programming with C (Schaum Outline series), McGraw Hill co., London ▪ Kanitkar, Y (2008). Let us C, BFB publishers, New Delhi. ▪ Karnighan, B. W. and Ritchi, M. (1988). The C programming language, Second edition, Prentice Hall. ▪ Rajaraman V. (2007). Computer programming in C, Prentice Hall of India.	

***Mandatory to perform any 12 practical from above.**

T.Y. B.Sc. Statistics (On Job Training)
Semester-V
STA-OJT-351: On Job Training/Internship

Total Hours: 120 **Credits:4**

Course Objectives	▪ To equip students with practical work experience. ▪ To familiarize students with prescribed workplace standards and guidelines. ▪ To enhance the employability skills of participating students.
Course Outcomes	After successful completion of this course, students are expected to: ▪ Gain hands-on work experience through office and virtual exposure to diverse management styles, technical, industrial, and procedural systems. ▪ Develop an understanding of working hours, workplace protocols, and guidelines. ▪ Comprehend employee roles, responsibilities, and the importance of teamwork. ▪ Align job experiences with individual potential, skills, and competencies.

Internship:
An internship is a professional learning experience that offers meaningful, practical work related to a student's field of study or career interest. An internship gives a student the opportunity for career exploration and development, and to learn new skills.

On the job training:
On the job training is a form of training provided at the workplace. During the training, employees are familiarized with the working environment they will become part of. Employees also get a hands-on experience using machinery, equipment, tools, materials, etc.

Internship / OJT Mechanism:

1. **Pre-Approval**: Students should seek approval from the college before starting the Internship / OJT. This ensures that the Internship / OJT aligns with the curriculum and meets the necessary criteria.
2. **Mentor and Supervisor**: Each student should have an assigned mentor at the organization/industry where they are interning. Additionally, anInternship / OJT supervisor from the college will be appointed to guide and monitor the progress.
3. **Regular Reporting:** Students should maintain regular communication with their supervisor and mentor, providing progress reports and seeking feedback.
4. **Professional Conduct**: Students must adhere to professional conduct throughout the Internship / OJT, including punctuality, respect for colleagues, and adherence to the organization's/industry's policies and guidelines.
5. **Student Diary**: Students should maintain a diary to document their experiences, challenges faced, and lessons learned during the Internship / OJT.
6. **Final Report**: At the end of the Internship / OJT, students should submit a comprehensive final report, summarizing their accomplishments, contributions, and key takeaways.
7. **Evaluation**: The Internship / OJT is worth 4 credits (equivalent to 100 marks), and the evaluation will be divided into two categories: one by the mentor and the other by the Internship / OJT supervisor. The mentor's evaluation (internal examination) will carry 40 marks, and it will be based on the student's performance during the Internship / OJT. External examination will be conducted by mentor and supervisor which will be based on the student's diary, the final report prepared by the student, and their performance in the final viva voce, and will carry60 marks. The total marks

obtained by the students in both evaluations will be added together for the purpose of final evaluation. The evaluation of the students will be conducted by the mentor using the evaluation sheet provided by the college.

Internal Evaluation Criteria for Students by the Mentor:

1. **Quality of Work** (10 marks): How well did the student perform their assigned tasks during the Internship / OJT? Evaluate the accuracy, thoroughness, and attention to detail in their work.
2. **Initiative and Proactiveness**(10 marks): Did the student show initiative in taking on additional responsibilities or tasks beyond their assigned role? Did they demonstrate a proactive attitude towards problem-solving?
3. **Communication Skills** (10 marks): Assess the student's ability to communicate effectively with colleagues, superiors, and clients (if applicable). Consider both written and verbal communication.
4. **Problem-Solving SkillsandTime Management** (10 marks): Evaluate the student's ability to analyze problems, propose solutions, and implement effective strategies to overcome challenges.How well did the student manage their time during the Internship / OJT? Were they able to meet project deadlines and handle multiple tasks efficiently?

External Evaluation Criteria for Students by the Supervisor and Mentor:

1. **Student Diary** (15 marks): Review the student's diary to understand their reflections, insights gained, and self-assessment of their performance during the Internship / OJT.
2. **Final Report** (15 marks): Evaluate the quality and comprehensiveness of the student's final report, including the clarity of their achievements and contributions.
3. **Presentation of Student in Viva Voce** (30 marks): Evaluate the responses given by the student to the questions asked by the faculty in the Viva Voce.

Evaluation Criteria for Final Viva Voce:

1. Presentation Skills
2. Knowledge of the Internship / OJT Project
3. Practical Application and Work Experience
4. Problem-Solving and Critical Thinking
5. Communication and Professionalism

References:

1. Chow, Shein-Chung, and Jen-pei Liu. (2008). Design and analysis of clinical trials: concepts and methodologies, John Wiley & Sons.
2. Chen, Ding-Geng Din, Karl E. Peace, and Pinggao Zhang. (2017). Clinical trial data analysis using R and SAS, CRC Press.
3. Purohit S.G., Gore S.D. and Deshmukh S.R. (2008). Statistics Using R. Narosa Pub.
4. Andy Field (2009). Discovering Statistics Using SPSS, Third edition, SAGE
5. Parimal Mukhopadhyay. (2005). Applied Statistics, Books and Allied (P) Ltd, Kolkata.
6. Sprent P. and Smeeton N. C. (2001). Applied Non Parametric Statistical Methods, Chapman & Hall/CRC.
7. Montgomery D. C. (2009). Statistical Quality Control, John Wiley & Sons Inc.
8. Mukhopadhay P. (2002). Theory and Method of Sample Survey, (Chapman and Hall)
9. Montgomery, D. C., Peck, E. A. and Vining, G. G. (2003). Introduction to Linear Regression Analysis, Wiley.
10. Montgomery D.C. (2001). Design & Analysis of Experiments, John Wiley & Sons Inc., New Delhi.

SEMESTER-VI

T.Y. B.Sc. Statistics (Major)
Semester-VI
STA-DSC-361: Statistical Quality Control

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To make student aware about Statistical Process Control Tools. ▪ To introduce process capability indices. ▪ To make student aware about sampling plans.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Judge process capability. ▪ Design and use sampling inspection plan. ▪ Apply tools such as histogram, scatter diagram, cause and effect diagram etc. ▪ Estimate percentage of defective product in a production process.	
Unit	**Contents**	**Hours**
Unit I	**Statistical Process Control** ▪ Introduction ▪ Seven Process Control (PC) Tools of SPC ▪ (i) Check sheet (ii) Cause and Effect Diagram (CED) (iii) Pareto Diagram (iv) Histogram (v) Control chart. (vi) Scatter diagram (vii) Designs of Experiment (DOE). ▪ X chart, MR chart. ▪ CUSUM chart (tabular method). ▪ Examples and problems.	**9**
Unit II	**Capability Studies** ▪ Specification Limits, natural tolerance limits and their comparisons. ▪ Decisions based on these comparisons, estimate of percent defective. ▪ Catching the shift on average, evaluation of probability of catching shift of the first sample or on the subsequent samples after the shift (when process standard deviation is fixed). ▪ Shift in the process fraction defective, Evaluation of probability (using normal approximation only) of catching the shift on the first sample or on the subsequent samples after the shift. ▪ Process Capability Indices C_p, C_{pk}. ▪ Examples and problems.	**6**
Unit III	**Acceptance Sampling for Attributes** ▪ Introduction. Concept of sampling inspection plan, comparison between 100% inspection and sampling inspection. Rectification of single and double sampling plans. ▪ Explanation of the terms: Producer's risk, Consumer's risk, Acceptance Quality Level (AQL), LTFD, Average Outgoing Quality (AOQ), AOQL, Average Sample Number (ASN), Average Total inspection (ATI), Operating characteristic (OC) curve , AOQ curve, ATI curve. ▪ Single Sampling Plan:	**9**

	Evaluation of probability of acceptance using Hypergeometric (ii) Binomial (iii) Poisson and (iv) Normal distributions. ▪ Derivation of AOQ and ATI. Graphical determination of AOQL, Determination of a single sampling plans by lot quality and average quality approaches (numerical problems are not expected). Description of Dodge and Romig tables (numerical problems are not expected) ▪ Example and problems.	
Unit IV	**Double Sampling Plan** ▪ Evaluation of probability acceptance using Poisson approximation, derivation of ASN and ATI (With complete inspection of second sample). Derivation of the approximate formula of AOQ. Description of Dodge Romig Tables. ▪ Comparisons of single sampling plan and double sampling plan. ▪ Example and problems.	**6**
Study Resources	▪ Duncan A.J. (1986). Quality Control & Industrial Statistics, fifth edition, Irwin. ▪ Grant E.L. & Richard Leavenworth. (2005). Statistical Quality Control, Mc-Graw Hill Education India. ▪ Montgomery D. C. (2009). Statistical Quality Control, John Wiley & Sons Inc. ▪ Western Electric. (1982). Statistical Quality Control Handbook, Second Edition. ▪ ISO 9001:2015 Standards, 2015.	

T.Y. B.Sc. Statistics (Major)
Semester-VI
STA-DSC-362: Sampling Theory

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To introduce in detail sampling methods such as SRSWR, SRSWOR, stratified sampling, systematic sampling. ▪ To introduce the problem of estimation of the population mean and population total. ▪ To make student aware about applications of sampling methods in real life situations.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Obtain simple random sample with replacement and without replacement. ▪ Derive variance of unbiased estimator in case of SRSWR and SRSWOR. ▪ Compare various sampling methods. ▪ Construct stratified random sample and systematic random sample in real life situations where these sampling are appropriate.	
Unit	**Contents**	**Hours**
Unit I	**Sample Survey** ▪ Concept of distinguishable elementary units, sampling units, sampling frame. ▪ Objective of a sample survey. ▪ Designing questionnaire, characteristics of good questionnaire. ▪ Planning, execution and analysis of a sample survey. Practical problems in planning, execution and analysis of a sample survey. ▪ Sampling and non-sampling errors with illustrations. ▪ Study of some surveys illustrating the above ideas.	**5**
Unit II	**Simple Random Sampling** ▪ Simple random sampling with and without replacement: Definition, inclusion probabilities. Definitions of population mean, population total and population variance. ▪ Proof of the following results: 1) Sample mean as an unbiased estimator of population mean. 2) N $\bar{y}$ is an unbiased estimator of population total. 3) Sample mean square is an unbiased estimator of population mean square for SRSWOR 4) Var($\bar{y}$)= $\frac{N-n}{Nn}$ S^2 and SE($\bar{y}$) in case of SRSWOR. 5) Var($\bar{y}$)= $\frac{N-1}{Nn}S^2$ and SE($\bar{y}$) in case of SRSWR. ▪ Simple random sampling without replacement for proportions. ▪ Proof of the following results: 1) Sample proportion is an unbiased estimator of Population proportion 2) Np is an unbiased estimator of NP.	**10**

	3) Var(p) = $\frac{(N-n)}{N-1}\frac{P(1-P)}{n}$ and SE(p) ▪ Examples and problems.	
Unit III	**Stratified Random Sampling** ▪ Introduction. ▪ Real life situations. ▪ Stratified random sampling as a sample drawn from individual stratum using SRSWOR in each stratum. ▪ Construction of strata ▪ Proof of the following results. a) $\bar{y}_{st}$ as an unbiased estimator of population mean $\bar{Y}$. b) N $\bar{y}_{st}$ as an unbiased estimator of population total. ▪ Standard error of $\bar{y}_{st}$ & N $\bar{y}_{st}$ and their estimation. ▪ Problem of allocation, proportional allocation, Neyman's allocation, derivation of the expressions for the standard errors of the above estimators when these allocations are used. ▪ Gain in precision due to stratification, comparison amongst SRSWOR, stratification with proportional allocation & stratification with Neyman's allocation. ▪ Cost & variance analysis in stratified random sampling, minimization of variance for fixed cost, minimization of cost for fixed variance, optimum allocation, Neyman's allocation as a particular case of optimum allocation in cost and variance analysis. ▪ Examples and problems.	**10**
Unit IV	**Systematic Sampling** ▪ Real life situation where systematic sampling is appropriate. Technique of drawing a sample using systematic sampling. ▪ Estimation of population mean and population total, standard errors of these estimators. ▪ Distinguishing between stratification and systematic sampling, between SRSWOR and systematic sampling through real life situations. ▪ Examples and problems.	**5**
Study Resources	▪ Cochran W.G. (2007). Sampling Techniques, Third Edition, Wiley ▪ Sukhatme P.V. (1953). Sampling Theory of Surveys with Applications, Indian Society of Agricultural Statistics, New Delhi. ▪ Murty M.N. (1977). Sampling Methods, ISI, Kolkata. ▪ Daroga, Singh & Chaudhary F.S. (2013). Theory & Analysis of Sample Survey Designs, New Age International. ▪ Mukhopadhay P. (2002). Theory and Method of Sample Survey, (Chapman and Hall) ▪ Gupta S.C. and Kapoor V.K. (2007). Fundamentals of Applied Statistics, S. Chand and Sons, New Delhi.	

T.Y. B.Sc. Statistics (Major)
Semester-VI
STA-DSC-363: Optimization Techniques

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To introduce linear programming problems. ▪ To introduce transportation and assignment problems with its solving methods. ▪ To acquaint students with PERT and networking analysis.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Understand the basics of Linear Programming Problems. ▪ Solve LPP by appropriate method such as graphical, simplex etc. ▪ Solve assignment and transportation problem. ▪ Construct network and analyse using CPM and PERT.	
Unit	**Contents**	**Hours**
Unit I	**Linear Programming Problems** ▪ Statement of the linear programming problems. Simple examples and formulation of problems. ▪ Definitions of i) A Slack variable ii) Surplus variable iii) Unrestricted variable iv) Decision variable. ▪ Definition of i) a solution ii) feasible solution iii) a basic feasible solution (b.f.s. degenerate and non-degenerate solution) iv) Optimal solution v) basic and non basic variables vi) objective function vii) non- negativity conditions. ▪ Solutions of L.P.P. by i) graphical method: Solution space unique and non-unique solutions. Obtaining an optimum solution ii) Simplex method: initial b.f.s. is readily available, obtaining the initial basic feasible solution. Criterion for deciding whether obtained solution is optimal, method of improving a solution. ▪ Initial b.f.s. is not readily available, introduction to artificial variable. Big M.method (or penalty method) modified objective function. Modification and applications of simplex method L.P.P. with artificial variable. ▪ Examples and problems.	**9**
Unit II	**Transportation Problem** ▪ Definition of i) a feasible solution, ii) a basic feasible solution and iii) optimal solution. ▪ Statement of transportation problem, balanced and unbalanced transportation problem. ▪ Methods of obtaining initial basic feasible solution: 1) North west corner method. 2) Method of matrix minima (least cost method) 3) Vogel's Approximation Method (VAM). ▪ Optimal solution of transportation problem using uv-method (MODI), uniqueness and non uniqueness of optimal solution. Degeneracy and method of resolving degeneracy. ▪ Variants in transportation problem: No allocation in a particular cell, maximization problem. ▪ Examples and Problems	**7**

Unit III	**Assignment Problem** ▪ Assignment problem: Statement of assignment problem, relation to transportation problem and solution of assignment problem using Hungarian method. ▪ Special cases in the assignment problem: Unbalanced assignment problem, maximization problem, restrictions on assignments and alternate optimal solution. ▪ Examples and problems.	**5**
Unit IV	**C.P.M. And Networking Analysis** ▪ Definition i) Event or node ii) Activity iii) critical activity iv) Project function v) Predecessor and successor activity vi) Predecessor and successor event vii) properties of network viii) numbering by Fulkerson's rule. ▪ Critical path method, constructions of a network ▪ Definition i) Earliest start time ii) Earliest finish time iii) latest start time iv) Latest finish time v) Critical path ▪ Float, Total float, Independent float & Free float, their significance. ▪ PERT : Definition of PERT, i) Pessimistic time ii) Optimistic time iii) Most likely time iv) Forward Pass Calculation v) Backward Pass calculation vi) Slack vii) Critical Path viii) Probability of meeting scheduled date. ▪ Calculation of expected time, S.D. of project duration. ▪ Distinguish between PERT and C.P.M. ▪ Examples and problems.	**9**
Study Resources	▪ Taha H.A. (2007). Operations Research an Introduction, 8th Ed, Pearson Prentice Hall. ▪ Gupta P.K. , Hira D.S. and Kamboj A. (2012). Introduction to Operations Research, S. Chand. ▪ Shrinath L.S. PERT and CPM Principles & Applications, 3rd Edition, Affiliated East West Press Pvt. Ltd. ▪ Kapoor V.K. (2011). Operations Research, S. Chand & Sons, New Delhi. ▪ Sharma S.D. (2002). Operations Research, Kedarnath Ramnath & Co., Meerut. ▪ Kanti Swarup, Gupta P. K. And Man Mohan. (2020). Operations Research, Sultan Chand and Sons.	

T.Y. B.Sc. Statistics (Major)
Semester-VI
STA-DSC-364: Applied Statistics

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To acquaint students with the concept of death rate and birth rate ▪ To explain procedure of construction of life table ▪ To introduce Index numbers,statistics in education and psychology	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Compute and interpret measures of fertility and mortality ▪ Construct life table ▪ Compute and interpret index numbers ▪ Explain statistics in psychology and education.	
Unit	**Contents**	**Hours**
Unit I	**Demography** ▪ Vital Statistics, uses, measurement of population. ▪ Measures of mortality: crude death rate, specific death rates (age wise, sex wise). ▪ Standardized death rates (based on age-specific death rates) direct and indirect method, comparative study of these measures, infant mortality rate. ▪ Measures of fertility, Crude birth rate, specific rate (age and sex), total fertility rate, ▪ Comparative study of these measures. ▪ Reproduction rates: G.R.R., N.R.R., comparison and interpretation. ▪ Simple numerical problems.	**8**
Unit II	**Life Tables** ▪ Introduction and Meaning ▪ Construction of a life table ▪ Uses of a life table ▪ Numerical Problems	**5**
Unit III	**Index Numbers** ▪ Meaning and utility of index numbers ▪ Basic problems involved in the construction of index numbers ▪ Weighted and unweighted index numbers ▪ Various types of index numbers ▪ Construction of consumer price index number ▪ Limitations of index numbers ▪ Examples and problems.	**8**
Unit IV	**Statistics in Psychology and Education** ▪ Introduction ▪ Scaling individual test items ▪ Scaling of scores on a test o Z scores and Z scaling o Standard scores, T scores and percentile scores ▪ Reliability of test scores o Methods of determining test reliability i)Test retest method	**9**

	ii)Parallel forms method iii)Split half method iv)Kuder-Richardson method ▪ Validity of test scores ▪ Comparison of test scores ▪ Advantages and disadvantages of test scores ▪ I.Q. and E.Q. ▪ Examples and problems.	
Study Resources	▪ Gupta S.C. and Kapoor V.K. (2007). Fundamentals of Applied Statistics, S. Chand and Sons, New Delhi. ▪ Goon, Gupta, Dasgupta. (1986). Fundamentals of Statistics, Vol-II, The World Press Pvt. Ltd., Calcutta. ▪ Parimal Mukhopadhyay. (2005). Applied Statistics, Books and Allied (P) Ltd, Kolkata.	

T.Y. B.Sc. Statistics (Major with IKS)
Semester-VI
STA-DSC-365: India's Statistical Heritage and Official Statistics

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To introduce students to the historical evolution of statistics in India. ▪ To familiarize students with significant Indian statisticians and their contributions. ▪ To study the role of official statistics in shaping India's socio-economic landscape.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Understand the historical evolution of statistics in India. ▪ Recognize Indian Statisticians and their contributions. ▪ Understand statistical methods in various domains. ▪ Understand official statistics in India.	
Unit	**Contents**	**Hours**
Unit I	**Introduction to India's Statistical Heritage** ▪ Course Overview and Importance of Statistics in Indian context ▪ Early Beginnings: Ancient Indian Contributions to Statistics ▪ Development of Modern Statistics in India: Pre-Independence Era ▪ Post-Independence Growth and Institutions	**8**
Unit II	**Pioneers of Indian Statistics** ▪ P.C. Mahalanobis and the Indian Statistical Institute (ISI): A Statistical Revolution ▪ C. R. Rao: A Legendary Statistician ▪ Other Notable Statisticians, their Contributions and Honors: Pandurang Vasudev Sukhatme, Vasant Shankar Huzurbazar, Sharadchandra Shankar Shrikhande, Raghu Raj Bahadur, Debabrata Basu, Debabrata Lahiri, Gopinath Kallianpur, Keshava Raghavan Nair, Pesi Rustom Manasi, R.C. Bose, S. N. Roy, Sujit Kumar Mitra	**7**
Unit III	**Official Statistics in India** ▪ Historical perspective of Official Statistics in India ▪ Fundamental principles of Official Statistics ▪ Census and Data Collection in India ▪ Socioeconomic Surveys and their Significance ▪ Role of Statistics in Policy Formulation ▪ Case Studies: Statistical Insights Shaping Indian Policies ▪ Agricultural Statistics, Industrial Statistics, National Income.	**10**
Unit IV	**Indian Statistical Landscape and Key Entities** ▪ Overview of National Statistical System and role of National Statistical offices. ▪ Indian Statistical Institute (ISI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), Ministry of Statistics and Programme Implementation (MoSPI), National Statistical Commission (NSC).	**5**
Study Resources	▪ Anil Gore, Sharayu Paranjpe and Madhav Kulkarni (2009). Statistics for everyone, SIPF academy, Publishers and consultants, Nashik, India. ▪ B.L.S. Prakasa Rao. C.R. Rao: A Life in Statistics. Current Science. 10 Sep. 2014. 107(5): 895–901	

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T.Y. B.Sc. Statistics (Major)
Semester-VI
STA-DSC-366: Statistics Practical-IX

Total Hours: 60 **Credits: 2**

General instructions	▪ All Practical of this paper are to be carried out by using R/MINITAB/SAS software. ▪ Student must complete all the practical to the satisfaction of concerned teacher. ▪ Students must be encouraged to collect live data from real life situations for practical.	
Course Objectives	▪ To enable students to construct and interpret various control charts for process monitoring. ▪ To develop the ability to compute and interpret process capability indices for assessing process performance. ▪ To provide an understanding of different sampling techniques.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Construct and interpret control charts. ▪ Compute and interpret capability indices ▪ Obtain random samples using SRSWR, SRSWOR, Stratified and Systematic sampling. ▪ Estimate population parameters	
Sr. No.	**Contents**	**Hours**
1	Tools of SPC-I.	**4**
2	Tools of SPC-II.	**4**
3	X and MR charts.	**4**
4	CUSUM chart.	**4**
5	Process Capability Indices.	**4**
6	Single Sampling Plans (with OC, AOQ, AOQL, ATI, ASN curves).	**4**
7	Double Sampling Plans-I.	**4**
8	Double Sampling Plans-II.	**4**
9	Simple Random Sampling with Replacement.	**4**
10	Simple Random Sampling without Replacement.	**4**
11	Stratified Random Sampling-I.	**4**
12	Stratified Random Sampling-II.	**4**
13	Systematic Sampling.	**4**
14	Data Collection using Sample Survey and Analysis-I.	**4**
15	Data Collection using Sample Survey and Analysis-II.	**4**
Study Resources	▪ Duncan A.J. (1986). Quality Control & Industrial Statistics, 5th edition, Irwin. ▪ Grant E.L. & Richard Leavenworth. (2005). Statistical Quality Control, Mc-Graw Hill Education India. ▪ Montgomery D. C. (2009). Statistical Quality Control, John Wiley & Sons Inc. ▪ Cochran W.G. (2007). Sampling Techniques, Third Edition, Wiley ▪ Sukhatme P.V. (1953). Sampling Theory of Surveys with Applications, Indian Society of Agricultural Statistics, New Delhi. ▪ Murty M.N. (1977). Sampling Methods, ISI, Kolkata.	

***Mandatory to perform any 12 practical from above.**

T.Y. B.Sc. Statistics (Major)
Semester-VI
STA-DSC-367: Statistics Practical-X

Total Hours: 60 **Credits: 2**

General instructions	▪ All Practical of this paper are to be carried out by using R/TORA/MINITAB/SPSS software. ▪ Student must complete all the practical to the satisfaction of concerned teacher. ▪ Students must be encouraged to collect live data from real life situations for practical.	
Course Objectives	▪ To develop problem-solving skills in operations research techniques. ▪ To equip students with practical knowledge of project management tools. ▪ To provide hands-on experience in statistical methods related to demography, index numbers, socioeconomic surveys, and agricultural statistics.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Formulate and solve Linear Programming, Transportation, and Assignment problems. ▪ Develop proficiency in using PERT and CPM techniques ▪ Gain practical skills in the construction and interpretation of Life Tables, Index Numbers, and demographic measures. ▪ Capable of conducting socioeconomic and agricultural statistical analyses using real-world data.	
Sr. No.	**Contents**	**Hours**
1	Linear Programming Problems-I.	**4**
2	Linear Programming Problems-II.	**4**
3	Transportation Problems-I.	**4**
4	Transportation Problems-II.	**4**
5	Assignment Problems.	**4**
6	PERT.	**4**
7	CPM.	**4**
8	Demography-I.	**4**
9	Demography-II.	**4**
10	Life Tables.	**4**
11	Index Numbers-I.	**4**
12	Index Numbers-II.	**4**
13	Census and Data Collection in India.	**4**
14	Socioeconomic Surveys.	**4**
15	Agricultural Statistics	**4**
Study Resources	▪ Taha H.A. (2007). Operations Research an Introduction, 8th Ed, Pearson Prentice Hall. ▪ Gupta P.K. , Hira D.S. and Kamboj A. (2012). Introduction to Operations Research, S. Chand. ▪ Shrinath L.S. PERT and CPM Principles & Applications, 3rd Edition, Affiliated East West Press Pvt. Ltd. ▪ Kapoor V.K. (2011). Operations Research, S. Chand & Sons, New Delhi.	

	▪ Sharma S.D. (2002). Operations Research, Kedarnath Ramnath & Co., Meerut. ▪ Kanti Swarup, Gupta P. K. And Man Mohan. (2020). Operations Research, Sultan Chand and Sons. ▪ Gupta S.C. and Kapoor V.K. (2007). Fundamentals of Applied Statistics, S. Chand and Sons, New Delhi. ▪ Goon, Gupta, Dasgupta. (1986). Fundamentals of Statistics, Vol-II, The World Press Pvt. Ltd., Calcutta. ▪ Parimal Mukhopadhyay. (2005). Applied Statistics, Books and Allied (P) Ltd, Kolkata. ▪ National Sample Survey Reports ▪ Agricultural Statistics in India (4th Edition) by P.C. Bansil. CBS Publishers and Distributors.	

***Mandatory to perform any 12 practical from above.**

T.Y. B.Sc. Statistics (Elective)
Semester-VI
STA-DSE-361A: Elements of Clinical Trials

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To introduce terminology used in Clinical trials and several common designs used for clinical trials. ▪ To explain techniques of clinical trials and analysis and interpretation of the experiments. ▪ To discuss treatment comparison.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Understand the fundamentals of clinical trials. ▪ Reduce the bias and variability involved during conduction of clinical trials. ▪ Estimate the true therapeutic effect of the drug. ▪ Analyze and interpret the clinical trial data.	
Unit	**Contents**	**Hours**
Unit I	**Introduction to clinical trials** ▪ Definition, need and ethics of clinical trials, ▪ Drug Development Process, ▪ FDA and its guidelines, ▪ Protocol, objectives and end points of clinical trials, ▪ Possible bias and random errors in clinical studies, ▪ Conduct of clinical trials, ▪ Overview of phase I-IV trials.	**8**
Unit II	**Types of Clinical trials** ▪ Single site vs Multi site studies, ▪ Placebo/Active Control, ▪ Dose response and historical controls, ▪ Superiority and non-inferiority trials, ▪ Combination and Equivalence trials ▪ Vaccine Trials	**7**
Unit III	**Designs for Clinical Trials** ▪ Washout and Run-in period, ▪ Cluster Randomized design, ▪ Parallel and Cross-Over Designs, ▪ Factorial Designs. ▪ Balance Incomplete Block Design ▪ Titration Designs	**8**
Unit IV	**Randomization and Blinding** ▪ Needs and Benefits of Randomization and Blinding ▪ Fixed Allocation Randomization: Simple Randomization, Permuted Blocked Randomization, Stratified Randomization. ▪ Adaptive Randomization Procedures: Covariate, Treatment and Response	**7**

	Adaptive Randomization, ▪ Blinding: No, single, double and triple blinding.	
Study Resources	▪ Chow, Shein-Chung, and Jen-pei Liu. (2008). Design and analysis of clinical trials: concepts and methodologies, John Wiley & Sons. ▪ Friedman, Lawrence M., et al. (2015) Fundamentals of clinical trials, springer ▪ Chen, Ding-Geng Din, Karl E. Peace, and Pinggao Zhang. (2017). Clinical trial data analysis using R and SAS, CRC Press.	

T.Y. B.Sc. Statistics (Elective)
Semester-VI
STA-DSE-361B: Basic Linear Algebra
(NPTEL course code: noc25_ma14)

Total Hours: 30 **Credits: 2**

Course Objectives	▪ Develop a Strong Foundation in Linear Algebra ▪ Enhance Problem-Solving Skills in Linear Systems ▪ Explore Advanced Concepts like Eigenvalues and Diagonalization	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Perform Matrix Operations and Solve Linear Systems ▪ Analyze Vector Spaces and Determinants ▪ Understand and Apply Linear Transformations ▪ Compute Eigenvalues, Eigenvectors, and Apply Diagonalization	
Unit	**Contents**	**Hours**
Unit I	**Fundamentals of Matrices and Linear Systems** ▪ Matrices and Matrix Operations ▪ Row Echelon Form (REF) ▪ Linear Systems and their Solutions ▪ Gaussian Elimination ▪ Inverse of a Matrix	**8**
Unit II	**Vector Spaces and Determinants** ▪ $\mathbb{R}^n$ and Subspaces ▪ Linear Independence ▪ Rank of a Matrix ▪ Determinants and their Properties ▪ Rank and Invertibility	**8**
Unit III	**Linear Transformations and Inner Product Spaces** ▪ Linear Transformations and their Properties ▪ Rank-Nullity Theorem ▪ Introduction to Inner Product Spaces ▪ Gram-Schmidt Process	**8**
Unit IV	**Eigenvalues, Eigenvectors, and Diagonalization** ▪ Eigenvalues and Eigenvectors ▪ Similarity of Matrices ▪ Diagonalization and its Applications	**6**
Study Resources	▪ Inder K Rana (2010). An Introduction to Linear Algebra, Ane Books Pvt. Ltd. ▪ Rao, A.R. and Bhimasankaram, P. (2000). Linear Algebra, Hindustan Book Agency. ▪ Searle, S. R. (1982). Matrix Algebra Useful for Statistics, John Wiley and Sons Inc.	

T.Y. B.Sc. Statistics (Elective)
Semester-VI
STA-DSE-362A: Practical on Clinical Trials

Total Hours: 60 **Credits: 2**

General instructions	▪ All Practicals of this paper are to be carried out by using R/SAS/MINITAB/SPSS software. ▪ Student must complete all the practicals to the satisfaction of concerned teacher. ▪ Students must be encouraged to collect live data from real life situations for practicals.	
Course Objectives	▪ To familiarize students with the key concepts, ethics, and regulatory guidelines of clinical trials. ▪ To provide hands-on experience in designing, conducting, and analyzing clinical trial data using statistical methods. ▪ To train students in various randomization techniques, blinding methods, and treatment comparison strategies.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Understand and implement different clinical trial designs. ▪ Perform randomization and blinding techniques using statistical software. ▪ Analyze clinical trial data using parametric and non-parametric statistical tests. ▪ Interpret results using statistical approaches.	
Sr. No.	**Contents**	**Hours**
1	Introduction to Clinical Trials-I	**4**
2	Introduction to Clinical Trials-II	**4**
3	Randomization Techniques-I	**4**
4	Randomization Techniques-II	**4**
5	Blinding Techniques	**4**
6	Sample size determination and power calculations for a clinical study.	**4**
7	Conducting treatment comparison using Z tests	**4**
8	Conducting treatment comparison using t-tests	**4**
9	Conducting treatment comparison using ANOVA	**4**
10	Performing non-parametric tests-I	**4**
11	Performing non-parametric tests-II	**4**
12	Performing non-parametric tests-III	**4**
13	Analyzing categorical data	**4**
14	Extracting and analyzing clinical trial data from available datasets	**4**
15	Preparing a clinical trial report with statistical interpretations and conclusions	**4**
Study Resources	▪ Chow, Shein-Chung, and Jen-pei Liu. (2008). Design and analysis of clinical trials: concepts and methodologies, John Wiley & Sons. ▪ Friedman, Lawrence M., et al. (2015) Fundamentals of clinical trials, springer ▪ Chen, Ding-Geng Din, Karl E. Peace, and Pinggao Zhang. (2017). Clinical trial data analysis using R and SAS, CRC Press.	

***Mandatory to perform any 12 practical from above.**

T.Y. B.Sc. Statistics (Elective)
Semester-VI
STA-DSE-362B: Practical on Basic Linear Algebra

Total Hours: 60 **Credits: 2**

General instructions	▪ All Practical of this paper are to be carried out by using R/MINITAB/MATLAB software. ▪ Student must complete all the practical to the satisfaction of concerned teacher. ▪ Students must be encouraged to collect live data from real life situations for practical.	
Course Objectives	▪ Hands-on Experience with Matrix Operations and Linear Systems ▪ Explore Vector Spaces and Transformations ▪ Apply Eigenvalue Problems and Diagonalization in Real-world Scenarios	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Perform Matrix Operations and Solve Linear Systems ▪ Analyze Vector Spaces and Linear Transformations ▪ Compute and Apply Eigenvalues and Eigenvectors ▪ Use Computational Tools for Linear Algebra Applications	
Sr. No.	**Contents**	**Hours**
1	Basic Matrix Operations	**4**
2	Row Echelon Form (REF) and Reduced Row Echelon Form (RREF)	**4**
3	Solving Linear Systems using Gaussian Elimination	**4**
4	Solving Linear Systems using Matrix Inverse Method	**4**
5	Computing Determinants and Their Properties	**4**
6	Rank of a Matrix and Its Applications	**4**
7	Vector Spaces and Subspaces	**4**
8	Linear Independence and Dependence of Vectors	**4**
9	Linear Transformations and Their Matrix Representation	**4**
10	Gram-Schmidt Orthonormalization Process	**4**
11	Computation of Eigenvalues and Eigenvectors	**4**
12	Diagonalization of Matrices	**4**
13	Application of Linear Algebra in Computer Graphics	**4**
14	Solving Real-world Problems using Eigenvalues-I	**4**
15	Solving Real-world Problems using Eigenvalues-II	**4**
Study Resources	▪ Inder K Rana (2010). An Introduction to Linear Algebra, Ane Books Pvt. Ltd. ▪ Rao, A.R. and Bhimasankaram, P. (2000). Linear Algebra, Hindustan Book Agency. ▪ Searle, S. R. (1982). Matrix Algebra Useful for Statistics, John Wiley and Sons Inc.	

***Mandatory to perform any 12 practical from above.**

T.Y. B.Sc. Statistics (Vocational)
Semester-VI
STA-VSC-361: Introduction to Python

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To make student aware about Python programming. ▪ To illustrate inbuilt and user defined functions in Python. ▪ To explain statistical problem-solving using Python.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Create and run Python programs using required tools. ▪ Understand and explain the results of given Python programs. ▪ Use inbuilt data structures and modules in Python. ▪ Solve statistical problems using Python.	
Unit	**Contents**	**Hours**
Unit I	**Introduction to Python and its data types** ▪ Python Shell ▪ Variables ▪ Arithmetic Operators ▪ Assignment Operators ▪ Comparison Operators ▪ Logical Operators ▪ Identity Operators ▪ Membership Operators ▪ Expressions ▪ Data types in Python	**7**
Unit II	**Programming in Python** ▪ if conditional ▪ if...else conditional ▪ if...elif...else conditional ▪ while loop ▪ for loop ▪ User defined functions def	**5**
Unit III	**Inbuilt Functions and Scientific Libraries in Python** ▪ Iteration: range(), len(), enumerate() ▪ Find attributes: dir() ▪ Value: abs(), round() ▪ Check truthiness: all(), any() ▪ Evaluate: eval() ▪ User input: input(), ▪ Operate on collection: min(), max(), sum() ▪ Open files: open() ▪ importing libraries, ▪ Data manipulation: pandas ▪ Numerical Analysis: numpy ▪ Scientific methods: scipy ▪ Plotting graphs: matplotlib	**12**
Unit IV	**Statistical Problem-solving using Python** ▪ Measures of central Tendency ▪ Measures of dispersion ▪ Correlation and Regression	**6**

Study Resources	▪ Al Sweigart (2015). Automate the Boring Stuff with Python, 2nd Edition, No Starch Press ▪ Eric Matthes (2019). Python Crash Course, No Starch Press ▪ Thomas Haslwanter (2016). An Introduction to Statistics with Python, Springer ▪ Jake VanderPlas (2016). Python Data Science Handbook, O'Reilly Media, Inc	

T.Y. B.Sc. Statistics (Vocational)
Semester-VI
STA-VSC-362: Practical on Python

Total Hours: 60 **Credits: 2**

General instructions	▪ All Practical of this paper are to be carried out by using Python. ▪ Student must complete all the practical to the satisfaction of concerned teacher. ▪ Students must be encouraged to collect live data from real life situations for practical.	
Course Objectives	▪ To familiarize students with Python programming and its application in statistical analysis. ▪ To enable students to use Python's inbuilt functions and libraries for data handling, visualization, and computation. ▪ To provide hands-on experience in solving statistical problems using Python.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Write and execute Python programs for statistical computations. ▪ Use Python's built-in functions and libraries for data analysis and visualization. ▪ Implement statistical techniques like descriptive statistics, correlation, and regression using Python. ▪ Work with real-world datasets to analyze and interpret statistical result	
Sr. No.	**Contents**	**Hours**
1	Python Basics (Fundamentals & Operations)-I	**4**
2	Python Basics (Fundamentals & Operations)-II	**4**
3	Python Basics (Fundamentals & Operations)-III	**4**
4	Data Handling in Python-I	**4**
5	Data Handling in Python-II	**4**
6	Data Handling in Python-III	**4**
7	Data Visualization-I	**4**
8	Data Visualization-II	**4**
9	Descriptive Statistics in Python-I	**4**
10	Descriptive Statistics in Python-II	**4**
11	Correlation	**4**
12	Linear Regression	**4**
13	Multiple linear regression	**4**
14	Probability Distributions	**4**
15	Hypothesis Testing	**4**
Study Resources	▪ Al Sweigart (2015). Automate the Boring Stuff with Python, 2nd Edition, No Starch Press ▪ Eric Matthes (2019). Python Crash Course, No Starch Press ▪ Thomas Haslwanter (2016). An Introduction to Statistics with Python, Springer ▪ Jake VanderPlas (2016). Python Data Science Handbook, O'Reilly Media, Inc	

***Mandatory to perform any 12 practical from above.**

Skills acquired and Job prospects for the BSc Statistics students:

B.Sc. Statistics programme emphasizes both theory and applications of statistics and is structured to provide knowledge and skills in depth necessary for the employability of students in industry, other organizations, as well as in academics.

After successful completion of three years degree course in Statistics, student will be well versed with relevant generic skills and global competencies such as

1. **Problem-solving skills** that are required to solve different types of Statistics related problems with well-defined solutions, and tackle open-ended problems that belong to the disciplinary-area boundaries;
2. **Investigative skills**, including skills of independent investigation of Statistics related issues and problems;
3. **Communication skills** involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature;
4. **Analytical skills** involving paying attention to detail and ability to construct logical arguments using correct technical language related to Statistics and ability to translate them with popular language when needed;
5. **ICT skills**;
6. **Personal skills** such as the ability to work both independently and in a group.

Job Opportunities:

- The student who has thoroughly studied this syllabus of T.Y.B.Sc.(Statistics) can join for higher education at PG level towards M.Sc.(Statistics)
- Students with B.Sc.(Statistics) degree are expected to served as Statisticians/ Administrators / Investigators in the private as well as government sections.
- Students with B.Sc.(Statistics) degree under this syllabus will find better opportunities of Statistician/Analyst in Manufacturing (SQC unit), Pharmaceutical Industries, Service Industries such as Banking and Insurance, Railway, Forest, Telecom, Transports, Hotel etc services.