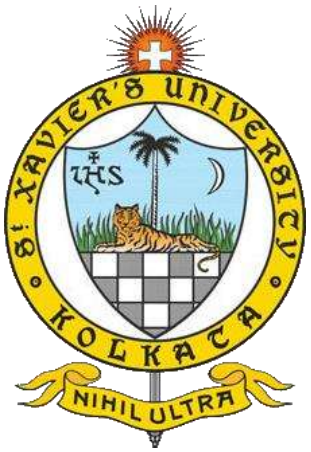

Syllabus of
B.Sc. (Hons.) in Statistics and Data Science

Department of Statistics

Faculty of Science

St. Xavier's University, Kolkata

w.e.f A.Y. 2025-2026

B.Sc. (Hons.) in Statistics and Data Science

[Semester III to Semester VI]

Total Credit: 160

Semester wise details

Semester- III							
Number of Papers: 6							
Course Code	**Course Title**	**Course Type**	**Credits in each course**				
			Theory	**Practical**	**Tutorial**	**Credits**	**Total Marks**
	Mathematical Analysis-I	Major	4	0	0	4	30(CIA) + 70(T)
	Sampling Distribution and Statistical Inference-I	Major	3	1	0	4	30(CIA) + 45(T) + 25(P)
	Database Management System	Minor				4	
Any one of the following two multidisciplinary courses							
	Financial Technology	Multi-Disciplinary	3	0	0	3	30(CIA) +70(T)
	Basics of Accounting	Multi-Disciplinary	3	0	0	3	30(CIA) +70(T)
Any one of the following two Ability Enhancement courses							
	Modern Indian Language I (Bengali/Hindi)	Ability Enhancement	2	0	0	2	15(CIA) + 35(T)
	Business Communication I	Ability Enhancement	2	0	0	2	15(CIA) +35(T)
	Python	Skill Enhancement	0	3	0	3	30(CIA) + 70(P)
Total						**20**	

Semester-IV							
Number of Papers: 6							
Course Code	**Course Title**	**Course Type**	**Credits in each course**				
			Theory	**Practical**	**Tutorial**	**Credits**	**Total Marks**
	Statistical Inference-II	Major	3	1	0	4	30(CIA) + 45(T) + 25(P)
	Linear Algebra and Linear Statistical Models	Major	3	1	0	4	30(CIA) + 45(T) + 25(P)
	Multivariate Analysis	Major	3	1	0	4	30(CIA) + 45(T) + 25(P)
	Data Analysis with R	Minor		4		4	30(CIA) + 70(P)
Any one of the following two Ability Enhancement courses							
	Modern Indian Language II (Bengali/Hindi)	Ability Enhancement	2	0	0	2	15(CIA)+ 35(T)
	Business Communication II	Ability Enhancement	2	0	0	2	15(CIA)+ 35(T)
	Internship		0	2	0	2	15(CIA) + 35(P)*
Total						**20**	

***35 = 10(Internal) + 25(External)**

Semester-V							
Number of Papers: 5							
Course Code	**Course Title**	**Course Type**	**Credits in each course**				
			Theory	**Practical**	**Tutorial**	**Credits**	**Total Marks**
	Numerical Methods and Optimization Techniques	Major	3	1	0	4	30(CIA) + 45(T) + 25(P)
	Large Sample Theory and Nonparametric Inference	Major	3	1	0	4	30(CIA) + 45(T) + 25(P)
	Regression Analysis	Major	3	1	0	4	30(CIA) + 45(T) + 25(P)
	Statistical Quality Control and Vital Statistics	Major	3	1	0	4	30(CIA) + 45(T) + 25(P)
	Artificial Intelligence	Minor	2	2	0	4	15(CIA) + 35(T)
Total						**20**	

Semester-VI							
Number of Papers:5							
Course Code	**Course Title**	**Course Type**	**Credits in each course**				
			Theory	**Practical**	**Tutorial**	**Credits**	**Total Marks**
	Statistical Inference-III	Major	3	1	0	4	30(CIA) + 45(T) + 25(P)
	Statistical Decision Theory and Bayesian Inference	Major	3	1	0	4	30(CIA) + 45(T) + 25(P)
	Sample Survey-I and Design of experiments-I	Major	3	1	0	4	30(CIA) + 45(T) + 25(P)
	Time Series Analysis-I and Econometrics-I	Major	3	1	0	4	30(CIA) + 45(T) + 25(P)
	Machine Learning with R/Python	Minor	0	4	0	4	30(CIA) + 70(T)
Total						**20**	

[For the Four-Year Credit Framework: https://www.sxuk.edu.in/statistics_programes]

Program Outcomes

PO1 - Critical Thinking: Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.

PO2 - Effective Communication: Speak, read, write and listen clearly in person and through electronic media in English and in one Indian language, and make meaning of the world by connecting people, ideas, books, media and technology.

PO3 - Social Interaction: Elicit views of others, mediate disagreements and help reach conclusions in group settings.

PO4- Effective Citizenship: Demonstrate empathetic social concern and equity centered national development, and the ability to act with an informed awareness of issues and participate in civic life through volunteering.

PO5 - Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions and accept responsibility for them.

PO6 - Environment and Sustainability: Understand the issues of environmental contexts and sustainable development.

PO7 - Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes.

SEMESTER-III

Course Name: **Mathematical Analysis-I**

Course Type: Discipline Specific Core.

Credit: **4** [Lecture: 4, Practical: 0]

Course Outcomes (CO):

CO1: Understand real numbers and analyze the convergence of sequences and series used in statistical theory.

CO2: Apply limits, continuity, and differentiability to study the behavior of statistical functions.

CO3: Evaluate definite and improper integrals and use Beta and Gamma functions in probability and distribution theory.

CO4: Use partial and total derivatives to solve optimization problems in statistics.

CO5: Apply vector differentiation, double integrals, and Lagrange multipliers in multivariate data analysis.

COURSE CONTENT:

Module No.	Module Name	Chapter Topic	CO
I	Real number system, Sequences and Series of real numbers	**Real number system:** Representation of real numbers as points on a line. Algebraic, Order and Completeness properties of R (Concepts only), ε-neighborhood of a point in R. Idea of countable sets, uncountable sets and uncountability of R. **Sequences of real numbers:** Sequences and their convergence, limit of a sequence. Bounded and monotone sequences. Cauchy sequences. Properties and applications. **Series of real numbers:** Infinite series, positive termed series and their convergence, Comparison test, ratio test and root test. Absolute convergence of series, Conditional convergence.	CO1
II	Limit, Continuity and differentiability of real valued functions	Review of limits, continuity and differentiability. Indeterminate form, L' Hospital's rule. Rolle's Theorem. Mean value theorem for derivatives. Taylor's Series expansion. Maxima and Minima of Functions. Successive Differentiation.	CO2
III	Integral Calculus	**Integral Calculus:** Definite integral (definition). Statements of properties, Fundamental Theorem of Integral Calculus. Improper Integral, Beta and	CO2, CO3

		Gamma functions: properties and relationship between them.	
IV	Analysis of functions of two variables	Partial and total differentiation. Vector differentiation. Maxima and Minima of such Functions. Constrained Maximization and minimization, use of Lagrange Multiplier. Double integrals.	CO4, CO5

Reference Texts:

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Robert C. Wrede and Murray R. Spiegel, *Advanced Calculus*, 2nd Ed., Schaum's Outline Series, McGraw-Hill, 2002.
3. T.M. Apostol, Mathematical Analysis, Second Edition, Narosa Publishing House, New Delhi.
4. Walter Rudin, Principles of Mathematical Analysis, 3rd Ed., McGraw-Hill Education (Indian Edition)
5. S.K. Berberian, A First Course in Real Analysis, Springer Verlag, New York, 1994.
6. Malik S.C. and Savita Arora (1994): Mathematical Analysis, Second Edition, Wiley Eastern Limited, New Age International Limited, New Delhi.
7. Shanti Narayan (1987): A course of Mathematical Analysis, 12th revised Edition, S. Chand & Co. (Pvt.) Ltd., New Delhi.
8. S. Narayan and P.K. Mittal, *Integral Calculus*, S. Chand & Company Ltd., New Delhi, 2005.
9. M. Spivak, Calculus on Manifolds: A Modern Approach to Classical Theorems of Advanced Calculus, Westview Press, 1965.
10. S. K. Mapa, Introduction to Real Analysis, 9th Ed., Levant Books/Sarat Book Distributors (India), New Delhi, 2025.

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	No
4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)
CO1	H	L	H	M	--	--	H
CO2	H	L	M	--	--	--	M
CO3	H	L	M	--	--	--	M
CO4	H	L	M	H	--	--	M
CO5	H	H	H	H	--	--	H
Average	3.0	1.4	2.4	1.6	0	0	2.4

***__H__ means High relevance (3), **M** means medium relevance (2), **L** means Low relevance(1)

SEMESTER-III

Course Name: Sampling Distribution and Statistical Inference-I.

Course Type: Discipline Specific Core.

Credit: 4 [Lecture: 4, Practical: 0].

Course Outcomes (CO):

CO1: Understand and derive sampling distributions of statistics from univariate and bivariate distributions.

CO2: Use transformation techniques to derive the distributions of functions of random variables.

CO3: Analyze properties and applications of central and non-central distributions commonly arising in statistical inference.

CO4: Apply order statistics in sampling contexts and understand their distributions.

CO5: Comprehend the foundations of statistical inference, including estimation and hypothesis testing, and apply related techniques in parametric settings.

COURSE CONTENT

Module No.	Module Name	Chapter Topic	CO
I	Basics of Sampling Distribution	Concepts of population and sample, parameter and statistic Notion of sampling distribution of a statistic and its standard error Functions of random variables and their distributions using: ● Distribution function method ● Moment generating function method ● Transformation method with Jacobians Additive property of independent random variables • Orthogonal and polar transformations	CO1, CO3
II	Sampling distributions under univariate and bivariate normal populations	Central χ^2, t, and F distributions – derivation and key properties Idea of non-central distributions: Definitions and simple properties of non-central χ^2, t, and F Sampling distributions of sample mean and variance under univariate normal distribution Sampling distributions of sample means, variances and covariance in bivariate normal distribution Distribution of sample correlation coefficient (Population correlation coefficient=0 case) Distribution of regression coefficients	CO2, CO3
III	Order statistics	● Definition and distribution of sample order statistics (marginal and joint) ● Distribution of sample range	CO1, CO3, CO4

IV	Introduction to estimation and hypothesis testing	Types of inference: Estimation and hypothesis testing Concepts of point estimation: Estimator, mean squared error, unbiasedness, method of moments Interval estimation: Concepts and examples Hypothesis testing: ● Simple vs. composite hypotheses ● Null and alternative hypotheses ● Critical region, Type I and II errors, Level of significance, size, power, and p-value, Application: ● Parametric tests for mean and variance in univariate normal distribution	CO5

Suggested Readings:

Text Books:

1. Goon, A.M., Gupta, M.K., & Dasgupta, B. (2003). *An Outline of Statistical Theory*, Vol. 1, 4th Edn., World Press, Kolkata.

2. Rohatgi, V.K. and Saleh, A.K. Md. E. (2015). *An Introduction to Probability and Statistics (3rd Edition)*, Wiley Series in Probability and Statistics, India.

Reference Books:

3. Casella, G. & Berger, R.L. (2021). *Statistical Inference*, Cengage Learning.

4. Hogg, R.V. & Tanis, E.A. (2009). *A Brief Course in Mathematical Statistics*, Pearson Education.

5. Johnson, R.A. & Bhattacharya, G.K. (2001). *Introduction to the Theory of Statistics*, 3rd edition, Tata McGraw-Hill.

6. Mood, A.M., Graybill, F.A., & Boes, D.C. (1974). *Introduction to the Theory of Statistics*, McGraw-Hill.

7. Freund, J.E. (2021). *Mathematical Statistics with Applications*, 8th edition, Pearson.

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	Yes
4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)
CO1	H	M	H				H
CO2	H	L					H
CO3	H	L					H
CO4	H	M	M		L		H

CO5	H	M	M	M	M		H
Average	3.0	1.6	1.4	0.4	0.6	0.0	3.0

*** **H** means High relevance, **M** means medium relevance, **L** means Low relevance

SEMESTER-III

Course Name: **Database Management System**

Credit: 4, [Lecture: 2, Practical: 2]

Course Outcomes (CO):
CO1: Understand the basic concepts and appreciate the applications of database systems.
CO2: Comprehend the fundamentals of design principles for the logical design of relational databases.
CO3: Apply query writing skills and optimize queries effectively.
CO4: Understand the basic issues of transaction processing and concurrency control.
CO5: Analyze and evaluate database storage structures and indexing techniques for efficient data retrieval.

COURSE CONTENT:

Module No.	Module Name	Chapter Topic	CO
I	Introduction	Concept &Overview of DBMS, Applications, Data Models, Database Languages, Database Administrator, Database Users, Three Schema architecture of DBMS, Basic concepts, Design Issues, Mapping Constraints,	CO1

		Keys, Entity-Relationship Diagram, Weak Entity Sets, Extended E-R features Structure of relational Databases, Relational Algebra, Relational Calculus, Extended Relational Algebra Operations, Views, Modifications of the Database	
II	SQL and Integrity Constraints & Index Structures,	Concept of DDL, DML, DCL. Basic Structure, Set operations, Aggregate Functions, Null Values, Domain Constraints, Referential Integrity Constraints, assertions, views, Nested Sub queries, Database security application development using SQL, Stored procedures and triggers. Necessity of index structures, Types of Single-Level Index (primary, secondary, clustering), Multi level Indexes, Dynamic Multi level Indexes using B tree and B+ tree	CO2
III	Normalization & Transaction processing	Functional Dependency, Anomalies in a Database, The normalization process: Conversion to first normal form, Conversion to second normal form, Conversion to third normal form and BCNF, Fourth Normal form and fifth normal form, normalization and database design, De-normalization, Loss-less join decomposition, Dependency preservation Introduction of transaction processing, advantages and disadvantages of transaction processing system, online transaction processing system, serializability and recoverability, view serializability	CO3
IV	Concurrency Control & Database recovery management	Serializability: Enforcing, Serialize ability by Locks, Locking Systems With Several, Lock Modes, Architecture for a Locking Scheduler Managing Hierarchies of Database Elements, Concurrency Control by Timestamps, Concurrency Control by Validation Deferred database modification Vs. Immediate Database modification, Checkpoint technique	CO4
V	Query Optimization & Distributed Database (DDB)	Heuristics in Query Optimization, Converting Query Tree to Query Evaluation Plan Introduction of DDB, DDBMS architectures, Homogeneous and Heterogeneous databases, Distributed data storage, Advantages of Data Distribution, Disadvantages of Data Distribution Distributed transactions, Commit protocols, Data Replication, Data Fragmentation. Distributed database transparency features	CO5

Suggested Readings:

Text Books:

1. An Introduction to Database Systems",C.J Date, Pearson Education.
2. Database System Concepts",Abraham Silberschatz,Henry F. Korth and S. Sudarshan, McGraw-Hill.
3. Distributed Databases Principles & Systems", Stefano Ceri and Giuseppe Pelagatti, McGraw-Hill International Editions.

ReferenceBooks:

1. Fundamentals of Database Systems",Ramez Elmasri and Shamkant B. Navathe,Addison-Wesley.

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)

1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	No
4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)
CO1	M	H	M	H	H		
CO2	M	H		M		H	M
CO3	M	H	M	M	M		M
CO4	H	M	M				M
CO5	M	M	M	M		M	M
Average	2.2	2.6	1.6	1.8	1	1	1.6

SEMESTER-III

Course Name: **Financial Technology**

Course Type: Multi-Disciplinary Course.

Credit: 3 [Lecture: 4, Practical: 0].

Course Outcomes (COs) (Tentative):

CO#	COGNITIVE ABILITIES	COURSE OUTCOMES
CO1	REMEMBERING	To relate the concept of financial technology
CO2	UNDERSTANDING	To describe financial technology based on different business models and strategies.

CO3	APPLYING	To practice, classify and compare between different modes of electronics payment mechanisms.
CO4	ANALYSING	To analyze functions, scopes and risks involved in fintech Industry.
CO5	EVALUATING AND CREATING	Assess and evaluate emerging technologies related to fintech

COURSE CONTENT

Module Number	Module Name	Topics	CO
I	**Introduction**	1.1 Meaning and scope of finance, financial technology, Evolution of financial services, Major FinTech domains, Drivers of digital transformation, FinTech ecosystem and players. 1.2 Top fintech trends (only basic concept): Embedded finance, open banking, Digital only banking, chatbots and virtual assistants (robotic process automation), Big data analytics	**CO1, CO 2**
II	**Digital Transactions**	2.1 E-Payment System: Payment systems overview, Methods of e–payment (Debit Card, Credit Card, Smart Cards, e-money), Mobile payments & e-wallets, Real-time payments, QR-based payments, payment gateways. Online banking (concept, importance, electronic fund transfer – RTGS, NEFT). Basic concept of CBS. Risks involved in e-payments (Tax evasion, Fraud, Impulse buying, Payment conflict). Introduction of Mobile Commerce, – Global Mobile E-Commerce – Secure Mobile Commerce, Challenges of E-commerce 2.2 SEO-Basics, onsite and offsite optimization techniques, Alternative Lending & Crowdfunding.	**CO3**
III	**Security and Technology Solution**	3.1 Dimensions of security, Security threats in the fintech environment – malicious codes (virus, Trojan, worm), hacking, spoofing, sniffing, phishing, cyber-vandalism. Encryption, Decryption, Symmetric & Asymmetric Encryption, Secured Electronic Transaction (https, SSL), protecting networks (Firewall, DMZ)). RegTech tools & automation, Fraud detection using AI.	**CO4**
IV	**Recent Development in Fintech**	4.1 Basics of AI and ML technology, AI-driven finance & GenAI in banking, How AI is Transforming the Future of FinTech – AI & Governance – New Challenges of AI and Machine Learning – Challenges of Data Regulation, Algorithmic investment management, Robo-advisors. 4.2 Blockchain Technology, Distributed Ledger Technology (DLT), Basics of Cryptocurrency & Tokenization	**CO3, CO4**

Suggested Reading: (Theory)

1. Amalia, Fitri., THE FINTECH BOOK: THE FINANCIAL TECHNOLOGY HANDBOOK FOR INVESTORS, ENTREPRENEURS AND VISIONARIES.. 31. 345. 10.22146/jieb.23554
2. Chisti, S., and Barberis, J. The FINTECH Book: The Financial Technology Handbook for

Investors, Entrepreneurs and Visionaries. John Wiley & Sons Ltd: West Sussex.
3. Chris Skinner, Digital Human, Wiley

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	Yes
4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)
CO1	H	M	H				H
CO2	H	L	H				
CO3	H	L					H
CO4	H	M	M		L		H
CO5	H	M	M	M	M		H
Avg	3.0	1.6	2	0.4	0.6	0.0	2.4

*** **H** means High relevance, **M** means medium relevance, **L** means Low relevance

SEMESTER-III

Course Name: **Basics of Accounting**

Course Type: Multi-Disciplinary Course.

Credit: 3 [Lecture: 4, Practical: 0]

Course Outcomes (COs) (Tentative):

CO#	COGNITIVE ABILITIES	COURSE OUTCOMES
CO1	REMEMBERING	Familiarizing students with the mechanics of fundamentals of accounting
CO2	UNDERSTANDING	Acquainting the accounting system and prepare necessary books of accounts.
CO3	APPLYING	Applying the accounting principles, rules and procedures in recording different types of transactions.
CO4	ANALYSING	Analyzing and interpreting the financial statements using accounting ratios.
CO5	EVALUATING AND CREATING	Creating financial statements and evaluating financial positions will enable students to take informed decisions

COURSE CONTENT

Module Number	Module Name	Topics	CO
I	**Introduction to Financial Accounting**	1.3 Introduction to Financial Accounting, Accounting Principles, Understanding Assets, Liabilities, Revenues, and Expenses, Bases of Accounting 1.4 Accounting cycle, Accounting Equation, Transaction analysis 1.5 Nature of Accounts and Rules of Debit and Credit. 1.6 Recording transactions in General Journal. Preparation of Ledger Accounts. Preparation of Trial Balance.	**CO1, CO 2**
II	**Financial Statement Preparation and Presentation**	2.1Financial Statements: Objective, Importance and Limitations; Capital Expenditure, Revenue Expenditure, Deferred Revenue Expenditure, Capital Receipts, and Revenue Receipts. 2.2 Preparing Trading Account, Profit & Loss Account and Balance Sheet for a Sole Proprietor with simple adjustments (Trading Concern). 2.3Corporate Financial Reporting, Understanding the contents of a Corporate Annual Report (Actual latest annual reports to be used).	**CO3, CO4**
III	**Financial Statement Analysis**	3.1 Objectives of Financial Statement Analysis; Sources of information; Standards of Comparison. 3.2 Techniques of Financial Statement Analysis (Through a case study of real company) - Ratio analysis (computation and interpretation), Cash flow analysis (structure, presentation and interpretation), Trend analysis, Common size statement analysis, Comparative statement analysis, Use of ratios to predict financial crisis of a company by using Altman Z –score, introduction to Earnings Management	**CO 4, CO5**

Suggested Reading: (Theory)

4. Robert N. Anthony, David Hawkins, Kenneth A. Merchant, Accounting: Text and Cases, McGraw-Hill
5. Gupta, R. L. and Radhaswamy, M: Financial Accounting; S. Chand & Sons
6. Maheshwari: Introduction to Accounting; Vikas Publishing
7. P.C. Tulsian, Financial Accounting, Pearson Education.
8. V.K. Goyal & Ruchi Goyal, Financial Accounting, PHI Learning.
9. Hanif and Mukherjee - Financial Accounting –McGraw –Hill Education India Pvt.Ltd

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	Yes
4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)
CO1	H	M	H				H
CO2	H						H
CO3	H						
CO4	H	M	M		L		H
CO5	H	M	M	M	M		H
Avg	3.0	1.2	1.2	0.4	0.6	0.0	2.4

*** **H** means High relevance, **M** means medium relevance, **L** means Low relevance

SEMESTER-III

Course Name: Modern Indian Language (MIL I) – Hindi I

Course Type: Ability Enhancement Course.

Credit: 2 [Lecture: 2, Practical: 0].

COURSE CONTENT

UNIT-1 साहित्य (LITERATURE) (Marks allotted : 20)

कथा साहित्य

(1) त्रिशंकु (मन्नू भंडारी)
(2) सिक्का बदल गया (कृष्णा सोबती)
(3) ब्लैक होल (संजीव)
{ तर्कसम्मत एवं समीक्षात्मक प्रश्न पूछे जाएंगे। }

UNIT-2 भाषा (LANGUAGE) (Marks allotted : 20)

अनुवाद विज्ञान

(1) अनुवाद की परिभाषा, भेद , महत्व एवं प्रासंगिकता।
(2) हिंदी अनुवाद का भविष्य ।
(3) व्यवहारिक अनुवाद में आने वाली समस्याएँ ।
(4) अंग्रेजी से हिंदी का व्यावहारिक अनुवाद ।
{ तर्कसम्मत एवं समीक्षात्मक प्रश्न पूछे जाएंगे। }

UNIT-3 दक्षता (SKILL) (Marks allotted : 10)

वर्तनी

(1) वर्तनी की अशुद्धियों का संक्षिप्त ज्ञान ।
(वर्तनी क्या है, हिंदी में कितने प्रकार की वर्तनी की अशुद्धियाँ होती हैं एवं उन्हें कैसे सुधारा जा सकता है।)
(2)प्रूफ संशोधन ।
{ वस्तुनिष्ठ प्रश्न पूछे जाएंगे। }

SEMESTER-III

Course Name: **Modern Indian Language I- Bengali I**

Course Type: Ability Enhancement Course.

Credit: 2 [Lecture: 2, Practical: 0].

Paper Structure – Continuous Internal Assessment (30%) + End Semester Examination (70%)

Continuous Internal Assessment – Project/assignment/test, Mid-semester Examination, attendance

End Semester – Written exam

Credit Division – Unit 1: One credit, Unit II & III: One credit, Total: 2 credits

Unit – I, Literature সাহিত্যপাঠ (20 Marks: Q1, A রবীন্দ্র কবিতা / B রবীন্দ্র ছোটগল্প)

A) **রবীন্দ্রকবিতা পাঠ: নৈবেদ্য কাব্য**

১। তোমার পতাকা যারে দাও

২। শতাব্দীর সূর্য আজি

৩। চিত্ত যেথা ভয়শূন্য, উচ্চ যেথা শির

B) **রবীন্দ্র ছোটগল্প পাঠ:**

১। পোস্টমাস্টার

২। মণিহারা

Unit – II, Language ভাষাপাঠ (20 Marks: Q2, A বোধপরীক্ষণ / B প্রতিবেদন লিখন / C সংলাপ লিখন)

Comprehension

A) **বোধপরীক্ষণ** – নির্বাচিত কোনো বাংলা সাহিত্য প্রবন্ধ থেকে নির্বাচিত অংশ বোধ-পরীক্ষণের জন্য উদ্ধৃত করে প্রশ্ন করা হবে।

Writing Skill

B) **প্রতিবেদন রচনা:** সংবাদপত্রে প্রকাশের উপযোগী সাম্প্রতিক কোনও ঘটনার প্রতিবেদনের খসড়া রচনা করতে হবে।

অথবা

C) **সংলাপ লিখন:** গল্পাংশ অথবা উপন্যাসের অংশ থেকে সংলাপ ভিত্তিক পুনর্নির্মাণ করতে হবে।

Unit – III, Skill দক্ষতা (10 marks: Q3, A পরিভাষা / B বাংলা বানান)

A) **পরিভাষা** – বাংলা পরিভাষার নির্বাচিত তালিকা থেকে ৫টি লিখতে হবে, প্রশ্নে ৮টি দেওয়া থাকবে।

B) **বানানবিধি** – পশ্চিমবঙ্গ বাংলা আকাদেমি প্রণীত 'আকাদেমি বানান অভিধান' অনুসারে বাংলা বানান বিষয়ক সিদ্ধান্তগুলি ক্লাসে আলোচিত হবে, এন্ড সেম পরীক্ষায় ৮টি অশুদ্ধ বানান দেওয়া হবে, ৫টি শুদ্ধ করে লিখবে।

SEMESTER-III

Course Name: **Business Communication I**

Course Type: Ability Enhancement Course.

Credit: 2 [Lecture: 2, Practical: 0].

Course Outcomes (CO):

CO1. Develop proficiency in speaking, reading, writing, and listening in both English and one Indian language.
CO2. Facilitate constructive dialogue and mediate disagreements to reach consensus in group settings.
CO3. Develop an understanding of grammatical conventions and principles in English writing.
CO4. To create effective communicators with the ability to express themselves in the workplace and elsewhere
CO5. Demonstrate the ability to integrate language and communication skills to produce clear, coherent, and context-appropriate presentations and documents.

COURSE CONTENT

Sno	Module Name	Description	CO
I	**Vocabulary and English for**	Students are expected to read newspapers, business news, magazines to build vocabulary for business	CO1, CO4

	Business Communication	communication. The reading material is provided by the faculty as and when required.	
II	**Communicative English**	Students participate in group activities to understand the purpose and responses in interpersonal communication from personal to professional situations. Stanford University's Business School after a lot of research work has come up with these role-playing activities to help learners become good speakers and overcome their anxiety of communicating in public. Following their research work, students are made to do certain exercises in the class helping them overcome their stage-fear. To understand the dynamics of group communication, students are made to participate in various team activities followed by their experience sharing and learning. Students make Group Presentations which are part of their internal evaluation.	CO2, CO3
III	**Theories of Communication**	Importance of Communication, Communication Process, Channels of communication, Significance of Feedback, Barriers to Effective Communication, Ways to overcome the Barriers.	CO4, CO5
IV	**Formal Letter and E-Mail Writing**	Students learn how to write formal letters; more than the format, in this unit the focus is on the style of language used in a formal letter which has an authority of the message to be conveyed yet not offensive. Students are taught how to generally introduce a formal letter and conclude it following a narrative which avoids any kind of exaggeration and jargon. Following the same style of language and narration they are taught about the usage of e-mail in today's world. The importance of it and the way they should use it, eg. the usage of 'CC', 'BCC', how to attach files and what to write before they attach any document.	CO1, CO3, CO4

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	Yes

4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)
CO1	H	M	H				H
CO2	H						H
CO3	H						
CO4	H	M	M		L		
CO5	H	M	M	M	M		H
Avg	3.0	1.2	1.2	0.4	0.6	0.0	1.8

*** **H** means High relevance, **M** means medium relevance, **L** means Low relevance

SEMESTER-III

Course Name: Python

Course Type: Skill Enhancement.

Credit: 3 [Lecture: 0, Practical: 3].

Course Outcomes (CO):

CO1: Set up and navigate Python environments (Anaconda, Jupyter, Spyder), and understand fundamental syntax and operations.

CO2: Use Python's built-in data structures and libraries for data manipulation and basic programming

tasks.

CO3: Perform descriptive statistical analysis and create visualizations using libraries like Matplotlib and Seaborn.

CO4: Apply inferential statistical techniques in Python, including hypothesis testing, correlation, ANOVA, and regression.

CO5: Develop and analyze statistical models using Python and present results in a meaningful way.

COURSE CONTENT

Module No.	Module Name	Chapter Topic	CO
I	Python Fundamentals and Data Handling	● Introduction to Python & Environments: Installing Anaconda (Individual Edition), using Python Shell, introduction to Spyder and Jupyter Notebook. ● Python Basics: Numbers, variables, comparisons, logic, strings, lists, tuples—with examples. ● Control Structures: Loops (for, while), conditional statements (if, elif, else), file input/output. ● Functions: Defining functions, lambda functions, using map() and filter(), working with lists, tuples, and dictionaries. ● Simple Plotting: Introduction to Matplotlib—basic plots, labels, legends, customization. ● Advanced Data Structures: Sets and dictionaries, error and exception handling, useful idioms in Python. ● Introduction to Libraries: NumPy (arrays, functions, matrix operations), reading/writing arrays, descriptive stats with NumPy, polynomial fitting, root-finding, sampling (Uniform, Normal, Binomial, Poisson, with/without replacement), permutations.	CO1, CO2

II	Descriptive Statistics and Data Visualization	Descriptive Statistics: Frequency, mean, median, mode, range, quartiles, max, min, percentiles, correlation. Data Exploration: Summarizing univariate/multivariate data, handling missing values, basic EDA with Pandas. Data Visualization Techniques: ● Univariate: Histogram, bar plot, pie chart, box plot, stem-leaf plot. ● Multivariate: Scatter plot, heatmap, line plot. Using Matplotlib & Seaborn for visual summaries and plot customization.	CO5
III	Basic Inferential Statistics and Statistical Modeling in Python	● Inferential Statistics: Confidence intervals, hypothesis testing (Z-test, t-test, chi-square), left/right/two-tailed tests, one-sample, two-sample, and paired-sample tests. ● Regression & ANOVA: Simple/multiple linear regression, ANOVA (one-way), residual analysis, model diagnostics. ● Introduction to SciPy & Statsmodels for statistical analysis. ● Pandas: DataFrames, reading/writing text, CSV, Excel; web scraping; data cleaning and grouping; statistical functions.	CO4, CO5

IV	Case Study and Group Project	● Hands-on Case Study: Real-world dataset analysis using learned tools. ● Model Fitting and Evaluation: Linear and logistic regression with interpretation, visualization, and reporting. ● Plotting and Communication: Custom visualizations using Matplotlib and Seaborn; presenting results using Pandas DataFrames. ● Project Work: Group-based project involving EDA, modeling, interpretation, and presentation.	CO5

Suggested Readings:

Text Books:

1. *Learning Scientific Programming with Python* – Christian Hill, Cambridge University Press (2020).

2. *Foundations of Statistics for Data Scientists with R & Python* – Alan Agresti, Maria Kateri; CRC Press (2022).

Reference Manuals:

3. Anaconda Distribution Documentation – https://www.anaconda.com/products/distribution

4. Spyder IDE Documentation – https://docs.spyder-ide.org/current/index.html

5. Interactive statistics platform – http://stat4ds.rwth-aachen.de

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes

3	Case Study	Yes
4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)
CO1	H	L					H
CO2	H	L					H
CO3	H	M					H
CO4	H	M	L		L		H
CO5	H	H	M	L	M	L	H
Avg	3.0	1.8	0.6	0.2	0.6	0.2	3.0

*** **H** means High relevance, **M** means medium relevance, **L** means Low relevance

SEMESTER-IV

Course Name: Statistical Inference-II.

Course Type: Discipline Specific Core.

Credit: 4 [Lecture: 3, Practical: 1].

Course Outcomes (CO):

CO1: Explain and apply core concepts of point estimation including unbiasedness, consistency, efficiency, and sufficiency.

CO2: Use classical estimation techniques such as the Method of Moments and Maximum Likelihood Estimation and evaluate their statistical properties.

CO3: Understand and implement fundamental principles of hypothesis testing including the Neyman-Pearson Lemma, MP, UMP, and UMPU tests.

CO4: Apply the theory and methods of Likelihood Ratio Tests to simple and composite hypotheses.

CO5: Construct and interpret confidence intervals and uniformly most accurate (UMA) confidence sets and understand their relationship to hypothesis tests.

COURSE CONTENT

Module No.	Module Name	Chapter Topic	CO
I	Theory of estimation	● Concepts: Estimator, Estimation, Bias, Mean Squared Error, Unbiasedness ● Sufficiency and Factorization Theorem (Proof in discrete case), Minimal Sufficiency ● Uniformly Minimum Variance Unbiased Estimators (UMVUE): conditions and properties ● Fisher's Information ● Cramér-Rao inequality and Minimum Variance Bound (MVB) ● Completeness; Ancillary Statistic, Basu's Theorem – statement and application ● Rao-Blackwell Theorem and applications; Lehmann Scheffe Theorem	CO1

II	Methods of estimation	● Method of Moments – formulation, examples, properties ● Maximum Likelihood Estimation (MLE): likelihood function, examples ● Minimum Chi-square method	CO2
III	Hypothesis Testing	● Review: Simple vs. composite hypotheses, null/alternative, errors, power ● Notion of p-value and its application ● Test functions: Randomized and non-randomized tests ● Neyman-Pearson Lemma: statement and proof (sufficiency part); applications to MP and UMP tests ● UMPU tests (definition only) ● Likelihood Ratio Tests (LRT): concept, examples ● Tests on bivariate normal distribution – mean, correlation, regression coefficients	CO3, CO4
IV	Confidence Intervals and UMA Confidence Sets	● Concepts: Interval estimation and confidence level ● Uniformly Most Accurate (UMA) confidence sets: concept and examples ● Relationship between hypothesis tests and confidence intervals ● Confidence intervals for means, variances, proportions (Under univariate/bivariate normal distribution)	CO5

Suggested Readings:

Text Books:

1. Goon, A.M., Gupta, M.K., Dasgupta, B. (2005). Outline of Statistics, Vol. I & II, World Press.
2. Rohatgi, V.K., Saleh, A.K. Md. E. (2009). An Introduction to Probability and Statistics, Wiley.

Reference Books:

3. Casella, G., Berger, R.L. (2002). Statistical Inference, 2nd Ed., Duxbury.
4. Miller, I. and Miller, M. (2002). John E. Freund's Mathematical Statistics, Prentice Hall.
5. Dudewicz, E.J., Mishra, S.N. (1988). Modern Mathematical Statistics, Wiley.
6. Mood, A.M., Graybill, F.A., Boes, D.C. (1974). Introduction to the Theory of Statistics, McGraw-Hill.

List of Practicals

1. Estimation using Maximum Likelihood Estimation (MLE)
2. Estimation by Method of Moments and Minimum Chi-square
3. Simulation and interpretation of Type I and Type II errors
4. Construction of Most Powerful (MP) tests
5. Construction of Uniformly Most Powerful (UMP) tests
6. Plotting and interpreting power curves
7. Construction of confidence intervals
8. Likelihood Ratio Tests

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	Yes

4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)
CO1	H	L					H
CO2	H	M					H
CO3	H	M			L		H
CO4	H	L			L		H
CO5	H	M					H
Avg	3.0	1.6	0.0	0.0	0.4	0.0	3.0

*** **H** means High relevance, **M** means medium relevance, **L** means Low relevance

<u>Semester-IV</u>

Course Name: Linear Algebra and Linear Statistical Models
Course Type: Discipline Specific Core.
Credit: 4 [Lecture: 3, Practical: 1].
Course Outcomes (CO):

CO1: Understand the concepts of vector spaces, subspaces, linear independence, basis, dimension; apply them to solve problems in statistical modeling.
CO2: Analyze and apply matrix operations, rank, inverse, and system of linear equations using methods like Gaussian elimination in the context of multivariate statistical data.

CO3: Interpret eigenvalues, eigenvectors, and diagonalization, and use them in principal component analysis and other techniques in multivariate statistics.
CO4: Understand and apply the principles of linear estimation within the Gauss-Markov framework.
CO5: Employ regression models, ANOVA, and ANCOVA techniques for comprehensive data analysis in various contexts.

COURSE CONTENT:

Module No.	Module Name	Chapter Topic	CO
I	**Vector Spaces, Linear Transformation and Matrices**	**Vector Space:** Definition of vectors, operation of vectors (angle, distance etc.). Vector spaces, Subspaces, sum of subspaces, Span of a set, Linear dependence and independence, dimension and basis. Extension of basis. Orthogonal vectors, Gram-Schmidt Orthogonalization. Algebra of matrices. **Linear Transformation:** Definition, The matrix representations of a linear transformation, Rank, Nullity, Dimension Theorem. Elementary matrices and their uses, theorems related to triangular, symmetric and skew symmetric matrices, idempotent matrices, orthogonal matrices. Trace of a matrix. **Determinants of Matrices:** Definition, properties and applications of determinants. Use of determinants in solution to the system of linear equations. Adjoint and inverse of a matrix and related properties. Basic idea of Generalized Inverse of a matrix. Singular and non-singular matrices and their properties.	CO1, CO2, CO3
II	**System of linear equations, Eigen Value and Eigen vectors, Quadratic Forms**	Systems of linear equations: row reduction and echelon forms, rank of a matrix, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems.	CO1, CO2, CO3

		Partitioning of matrices and simple properties. **Eigen vectors and Eigen values:** Characteristic roots and Characteristic vectors, Properties of characteristic roots. Cayley Hamilton Theorem. **Quadratic forms:** Classification & canonical reduction.	
III	**Linear Estimation and Regression Modeling**	Gauss-Markov set up; Gauss-Markov theorem. BLUE. Fundamental Theorems on least squares (statements only), Simple and Multiple Regression: Estimation and hypothesis testing in case of simple and multiple regression models.	CO4
IV	**Linear Models with ANOVA/ANCOVA Applications**	Definitions of fixed, random and mixed effects models. Analysis of variance for one-way classified data for fixed and random effects models. Analysis of variance for two-way classified data (with equal number of observations per cell) for fixed/random/mixed effects models. Analysis of covariance (with one concomitant variable) in one-way and two-way classified data**,** for fixed effects models.	CO5

Suggested Readings:

Text books:

- Hoffmann, K., & Kunze, R. A. (1971). *Linear algebra*. Hoboken, NJ: Prentice-Hall.
- Renchner, A. C. And Schaalje, G. B. (2008). Linear Models in Statistics (Second edition), John Wiley and Sons.
- Strang, G. (2022). *Introduction to linear algebra*. Wellesley-Cambridge Press.
- Scheffe, H. (1999). *The analysis of variance*. John Wiley & Sons.

Reference books:

- Seber, G. A., & Lee, A. J. (2003). Linear regression analysis. John Wiley & Sons.
- Rao, C. R., Rao, C. R., Statistiker, M., Rao, C. R., & Rao, C. R. (1973). *Linear statistical inference and its applications* (Vol. 2, pp. 263-270). New York: Wiley.

- Bapat, R. B. (2012). *Linear algebra and linear models*. Springer Science & Business Media.
- Mapa, S. K. (2003). *Higher Algebra: Abstract And Linear (revised Ninth Edition)*. Sarat Book Distributors.
- Searle, S. R. (1997). *Linear models*. John Wiley & Sons.

List of Suggested Practical:

- Estimability when *X* is a full rank matrix and not a full rank matrix
- Simple Linear Regression
- Multiple Regression
- Tests for Linear Hypothesis
- Bias in regression estimates
- Lack of fit
- Analysis of Variance of a one-way classified data
- Analysis of Variance of a two-way classified data with one observation per cell
- Analysis of Covariance of a one-way classified data
- Analysis of Covariance of a two-way classified data

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	No
4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)
CO1	H	L	H				H
CO2	H	H	M				H
CO3	H	M	M				H
CO4	M	L	M				H
CO5	H	H	L				H
Average	2.8	2.0	2.0	0	0	0	3.0

CO-PO mapping:

***__H__ means High relevance (3), **M** means medium relevance (2), **L** means Low relevance (1)

SEMESTER- IV

Course Name: Multivariate Analysis
Course Type: Discipline Specific Core

Credit: 4 [Lecture: 3, Practical: 1].

Course Outcomes (CO):

CO1: Understand the fundamental concepts of multivariate distributions, including random vectors, mean vectors, dispersion matrices, and conditional/marginal distributions.

CO2: Demonstrate knowledge of multivariate probability distributions such as the multivariate normal, multinomial, Wishart, and Hotelling's T^2 distributions and their properties.

CO3: Analyze the sampling distributions of statistics derived from multivariate normal distributions and interpret the relationships using multiple and partial correlation coefficients.

CO4: Apply dimension reduction techniques such as Principal Component Analysis (PCA) and Factor Analysis in multivariate data analysis.

CO5: Develop the ability to synthesize multivariate statistical knowledge to real-life problems and pursue further study or research independently in this field.

COURSE CONTENT

Module No.	Module Name	Chapter Topic	CO
I	Introduction to multivariate distributions	Multivariate Data: Random Vector: Probability mass/density functions, Distribution function, Mean vector & Dispersion matrix, Marginal & Conditional distributions.	CO1, CO5
II	Multivariate distributions	Multinomial distribution and its properties. Multivariate Normal distribution and its properties (including Fisher-Cochran theorem).	CO2, CO5
III	Sampling distributions of statistics in multivariate normal distribution	Sampling distributions of mean vector and variance- covariance matrix. Wishart distribution and its properties. Hotelling's T^2 distribution.	CO3, CO5
IV	Sampling distributions of multiple and partial correlation coefficients	Sampling distributions of multiple and partial correlation coefficients (without proof) and their properties	CO4, CO5

Suggested Readings:

Text Books:

1 Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rd Edition., John Wiley & Sons, Inc.

2. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley & Sons, Inc.

3. Kshirsagar, A.M. (1972): Multivariate Analysis, 1st Edition Marcel Dekker.

4. Johnson, R.A. and Wichern, D.W. (2007): Applied Multivariate Analysis, 6th Edition., Pearson.

Reference Books:

1. Kotz, Samuel, Balakrishnan, N. and Johnson, Norman L. (2000): Continuous Multivariate Distributions: Models and Applications. Vol. 1. 2nd Edition. John Wiley & Sons, Inc.

2. Johnson, Norman L,. Kotz, Samuel and Balakrishnan, N. (1997): Discrete Multivariate Distributions. John Wiley & Sons, Inc.

List of Practicals:

1. Multiple Correlation
2. Partial Correlation
3. Multivariate Normal Distribution
4. Multinomial distribution
5. Hotelling's T^2

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	No
4	Test/Assignment	Yes
5	Student Seminars/Presentation	No

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)
CO1	H	M	H	H	–	–	–
CO2	H	–	L	–	–	–	H
CO3	H	–	L	–	–	–	H
CO4	H	M	M	L	–	–	H
CO5	H	M	M	M	M	–	H
Avg	3.0	1.6	1.2	0.4	0.6	0.0	3.0

*** **H** means High relevance, **M** means medium relevance, **L** means Low relevance

SEMESTER-IV

Course Name: Data Analysis with R.

Course Type: Minor.

Credit: 4 [Lecture: 0, Practical: 4].

Course Outcomes (CO):

CO1: Understand the R environment, perform basic mathematical operations, and handle various data types in R.

CO2: Create and manipulate data structures like vectors, matrices, data frames, and lists, and apply appropriate data summarization techniques.

CO3: Apply graphical tools in R for effective data visualization using base R and ggplot2 packages.

CO4: Perform statistical analyses including univariate and bivariate statistics, regression modeling, and probability computations in R.

CO5: Write R scripts involving loops, conditionals, user-defined functions, and simulations to solve real-world statistical problems.

COURSE CONTENT

Module No.	Module Name	Chapter Topic	CO
I	Introduction to R and Fundamentals of Data Structures	● Overview of R: History and philosophy (open-source), CRAN, installing R and RStudio, R Console, R Script ● Basic Operations: Arithmetic, assignment, logical expressions, standard functions (log, exp, sqrt, abs, etc.) ● Command History & Help: history(), help(), ?function_name, quit() ● Basic Objects: Scalars, vectors (numeric, character, logical), factors ● Creating Vectors: c(), seq(), rep(), colon operator ● Indexing & Subsetting: Position, condition-based, negative indexing	CO1
II	Linear Algebra and Summary Statistics in R	Algebra of Matrices: ● The 'Matrix' package. ● Obtaining Determinants, Trace, Rank and Inverse of a Matrix. ● Obtaining row reduced forms of matrices, obtaining an orthonormal basis. ● Eigen Values and Eigen Vectors. ● Solving a system of equations. ● Diagonalisation of Matrices. Data Structures in R: ● Matrices: Creation, indexing, operations	CO2

		● Data Frames: Structure, accessing columns, rows; attach()/detach(), $ operator ● Lists: Nested elements, accessing and modifying ● Interconversion between structures Data Import/Export: ● Reading and writing CSV/TSV/Text files: read.table(), read.csv(), write.csv() ● Header options, stringsAsFactors, saving/loading workspaces Summarizing Data: mean(), median(), sd(), var(), range(), summary() Conditional Filtering and logical subsetting Merging and Binding Data: cbind(), rbind(), merge() Handling Missing Values: is.na(), na.omit(), na.exclude()	
III	Data Visualization and Statistical Analysis	Graphics with Base R: ● plot(), lines(), points(), abline(), legend(), title() ● Diagram Types: Line, bar (vertical/horizontal), multiple bar, pie chart, subdivided bar chart ● Histogram, Boxplot, Cumulative Frequency Diagrams ● Setting graphical parameters using par() ● Descriptive Statistics: ● Univariate: Central tendency, dispersion, skewness, kurtosis (moments package)	CO3, CO4

		● Inferential Statistics: Confidence intervals, hypothesis testing (Z-test, t-test, chi-square), left/right/two-tailed tests, one-sample, two-sample, and paired-sample tests. ● Regression & ANOVA: Simple/multiple linear regression, ANOVA (one-way), residual analysis, model diagnostics.	
IV	Programming, Simulation & Applications in R	Control Structures: ● if, if-else, for, while, repeat User-defined Functions: Creating, arguments, return values Random Sampling and Simulations: ● rnorm(), runif(), rbinom(), set.seed() ● Simulations: Bias, MSE, confidence interval coverage, test power Optimization: ● optim() function and its applications File Handling: Import/export between R and other software formats (CSV, Excel, etc.)	CO5

Suggested Readings:

Text Books:

1. Dalgaard, P. (2008): *Introductory Statistics with R*, Springer
2. Maindonald, J. & Braun, J. (2007): *Data Analysis and Graphics Using R*, Cambridge University Press

Reference Materials:

3. Gardener, M. (2012): *Beginning R: The Statistical Programming Language*, Wiley
4. Faraway, J.J. (2006): *Linear Models with R*, Chapman & Hall/CRC
5. CRAN Manuals and R Documentation – https://cran.r-project.org

Teaching Pedagogy:

S. No.	**Description**	**Used (Yes/No)**
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	Yes
4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)
CO1	H	L					H
CO2	H	M					H
CO3	H	M					H
CO4	H	M			L		H
CO5	H	M					H
Avg	3.0	1.6	0.0	0.0	0.2	0.0	3.0

*** **H** means High relevance, **M** means medium relevance, **L** means Low relevance

SEMESTER-IV

Course Name: Modern Indian Language (MIL II) – Hindi II

Course Type: Ability Enhancement Course.

Credit: 2 [Lecture: 2, Practical: 0].

COURSE CONTENT

UNIT-1 साहित्य (LITERATURE) (Marks allotted : 20)

कविता

(1) प्रतिबद्ध हूँ - नागार्जुन
(2) भूख (सर्वेश्वर दयाल सक्सेना)
(3) धार्मिक दंगो की राजनीति- शमशेर बहादुर सिंह
{ तर्कसम्मत एवं समीक्षात्मक प्रश्न पूछे जाएंगे। }

UNIT-2 भाषा (LANGUAGE) (Marks allotted : 20)

विज्ञापन

(1)विज्ञापन की परिभाषा, महत्व , भेद , उपयोगिता एवं प्रासंगिकता ।
(2) विज्ञापन की भाषा ।
(3) विज्ञापन लेखन ।
{संक्षिप्त एवं व्यावहारिक प्रश्न पूछे जाएंगे। }

UNIT-3 दक्षता (SKILL) (Marks allotted : 10)

चलचित्र

(1) अपठित गद्यांश

अथवा

(2) प्रतिवेदन लेखन

अथवा

(3) फिल्म समीक्षा कैसे की जाती है ?
{संक्षिप्त प्रश्न पूछे जाएंगे।

SEMESTER-IV

Course Name: Modern Indian Language (MIL II) – Bengali-II

Course Type: Ability Enhancement Course.

Credit: 2 [Lecture: 2, Practical: 0].

COURSE CONTENT

Paper Structure – Continuous Internal Assessment (30%) + End Semester Examination (70%)

Continuous Internal Assessment – project/assignment/test, Mid-semester Examination, attendance

End Semester – Written examination

Credit Division – Unit 1: One credit, Unit II & III: One credit, Total: 2 credits.

Unit – I, Literature সাহিত্যপাঠ (20 Marks: Q1, A আধুনিক কবিতা / B আধুনিক ছোটগল্প)

A) **আধুনিক কবিতা পাঠ:**

১। অদ্ভুত আঁধার এক — জীবনানন্দ দাশ

২। মিছিলের মুখ— সুভাষ মুখোপাধ্যায়

৩। বাবরের প্রার্থনা— শঙ্খ ঘোষ

B) **আধুনিক ছোটগল্প পাঠ:**

১। পুঁই মাচা—বিভূতিভূষণ বন্দ্যোপাধ্যায়

২। হারাণের নাতজামাই—মানিক বন্দ্যোপাধ্যায়

Unit – II, Language ভাষাপাঠ (20 Marks: Q2, A বোধপরীক্ষণ / B বিজ্ঞাপন লিখন / C চিত্রনাট্য লিখন)

Comprehension

A) বোধপরীক্ষণ – নির্বাচিত কোনো বাংলা সাহিত্য প্রবন্ধ থেকে নির্বাচিত অংশ বোধ-পরীক্ষণের জন্য উদ্ধৃত করে প্রশ্ন করা হবে।

Writing Skill

B) বিজ্ঞাপনের বয়ান রচনা: সংবাদপত্রে প্রকাশের উপযোগী বিজ্ঞাপনের খসড়া রচনা করতে হবে। (কর্মখালি, পণ্যের বিজ্ঞাপন ইত্যাদি)

অথবা

C) চিত্রনাট্য লিখন: গল্পাংশ অথবা প্রদত্ত পরিবেশ অনুসারে চিত্রনাট্য নির্মাণ করতে হবে, ৫টি দৃশ্য। চিত্রনাট্য নিয়ে সত্যজিৎ রায়ের লেখা ১। সিনেমার কথা, ২। চিত্রনাট্য ৩। চিত্রনাট্যের শৈলী প্রবন্ধগুলি পাঠ্য।

Unit – III, Skill দক্ষতা (10 marks: Q3, প্রুফ সংশোধন)

A) প্রুফ সংশোধন চিহ্ন [মূল পাঠ ও প্রুফ পাঠের মধ্যে মিলিয়ে ভুল সংশোধন করে প্রুফের চিহ্ন দিতে হবে]

SEMESTER-IV

Course Name: **Business Communication II**

Course Type: Ability Enhancement Course.

Credit: 2 [Lecture: 2, Practical: 0].

Course Outcomes (CO):

CO1. Improve vocabulary skills by regularly engaging with newspapers, business news, and magazines to enhance business communication.
CO2. Learn to analyze and present detailed information effectively in various types of business reports relevant to organizational requirements.
CO3. Develop effective group discussion skills including active listening, argument formation, and minute-taking to contribute meaningfully in professional settings.
CO4. Gain practical skills in drafting job applications, resumes, and formal letters, and prepare for interviews through mock sessions and guidance.
CO5. Demonstrate the ability to integrate language and communication skills to produce clear, coherent, and context-appropriate presentations and documents.

COURSE CONTENT

SNo.	Module Name	Description	CO
I	**Academic Vocabulary and English for Business Communication**	Students are expected to read newspapers, business news, magazines to build vocabulary for the business communication. The reading material is provided by the faculty as and when required.	CO1, CO4
II	**Business Report Writing**	How to read the details and present them as a report especially in the organizational set up. Students are exposed to different nature and types of reports.	CO2, CO3
III	**Group Discussion,**	To participate in a group discussion a learner	CO4, CO5

	Types of Official Meetings and Minutes of a Meeting	requires patience to hear out what others are telling. Listening practice helps the students to grow as a good listener. The students are made to understand the nature of discussion in a group, difference between debate and discussion, ways to form and present the arguments and ways to defend themselves. The students are practically told to make groups and take down Minutes of the Meeting on a given topic; in the process they are taught the different types of business meetings, how to call for a meeting, how to organize it, maintain decorum and how to take down Minutes of the Meeting.	
IV	**Job Applications, Resume Writing and Interview Skills**	On the basis of Formal Letters, they are taught how to write applications for jobs with reference to advertisements; how to write offer letters for recruitment of employees and how to write resignation letters. The students are equipped with the entire process of acquiring a job with special reference to preparing a resume. They learn the skills of appearing in an interview and being successful in it.	CO1, CO3, CO4

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	Yes
4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)
CO1	H	M	H				H
CO2	H						H
CO3	H						
CO4	H	M	M		L		
CO5	H	M	M	M	M		H
Avg	3.0	1.2	1.2	0.4	0.6	0.0	1.8

*** **H** means High relevance, **M** means medium relevance, **L** means Low relevance

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SEMESTER-IV

Course Name: **Internship**

Course Type: Internship

Credit: 2

SEMESTER-V

Course Name: Numerical Methods and Optimization Techniques
Course Type: Discipline Specific Core

Credit: 4 [Lecture: 3, Practical: 1].

Course Outcomes (CO):

CO1: Understand numerical approximation of numbers and functions, and apply interpolation techniques such as Newton's and Lagrange's methods.

CO2: Apply numerical differentiation and integration techniques, and solve equations using fixed-point iteration and Newton-Raphson methods with error analysis.

CO3: Formulate and solve linear programming problems using simplex methods and understand duality and artificial variable techniques.

CO4: Solve transportation and assignment problems using methods like Vogel's Approximation, MODI, and the Hungarian algorithm.

CO5: Develop analytical and algorithmic thinking to solve real-life optimization problems using numerical methods and engage in further independent learning.

COURSE CONTENT

Module No.	Module Name	Chapter Topic	CO
I	Introduction to Numerical Methods	Approximation of numbers and functions. Absolute and Relative errors. Interpolation: Polynomial approximation of functions, Weierstrass Theorem (Statement). Factorial, finite differences and interpolation in numerical analysis. Operators, E and divided difference. Difference Table, Newton's forward and backward interpolation formulae. Lagrange's interpolation formula.	CO1, CO5
II	Numerical Differentiation and Integration, and iteration methods	Numerical Differentiation and its applications. Numerical integration. Trapezoidal rule, Simpson's one-third rule, with error terms. Numerical solution of equations: method of fixed-point iteration and Newton-Raphson method in one unknown, Conditions of convergence, rates of convergence. Extension of the iteration method to more than one unknowns (without proof of convergence).	CO2, CO5
III	Linear programming	Linear Programming Problem, Mathematical formulation of the L.P.P, graphical solutions of a L.P.P. in two decision variables. Simplex method for solving L.P.P. Charne's M-technique, two-phase technique. Concept of Duality in L.P.P. Dual simplex algorithm.	CO3, CO5
IV	Transportation and assignment problems	Transportation Problem: Initial feasible solution by North West corner rule, Least cost method and Vogel's approximation method (VAM), MODI's method to find the optimal solution. Assignment problem: Hungarian method to find optimal assignment.	CO4, CO5

Suggested Readings:

Text Books:

1 Mukherjee, Kr. Kalyan (1990): Numerical Analysis. New Central Book Agency, India.

2. Sastry, S.S. (2000): Introductory Methods of Numerical Analysis, 3rd edition, Prentice Hall of India Pvt. Ltd., New Delhi.

3. Hadley, G. (1969): Linear programming. Narosa Publishing House, New Delhi

4. Gass, S.I. (2003): Linear Programming: Methods and Applications: Fifth Edition. Dover Publications Inc.

Reference Books:

1. Jain,M. K., Iyengar, S. R. K. and Jain, R. K. (2003): Numerical methods for scientific and engineering computation, New age International Publisher, India.

2. Mittal, K.V. and Mohan, C. (2020): Optimization Methods in Operations Research and Systems Analysis. Fifth Edition. New Age International Private Limited, India.

3. Sharma, S.D. (2014): Operations Research – Theory, Methods and Applications. KNRN Publications, India.

List of Practicals:

1. Interpolation by Newton's forward and backward formulae, and Lagrange's formula.
2. Solving one- and 2- variable equations using Newton-Raphson method.
3. Trapezoidal and Simpson's 1/3rd rules for numerical integration with convergence.
4. Formulation of linear programming problems, and solving them.
5 Solving transportation and assignment problems.

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	No
4	Test/Assignment	Yes
5	Student Seminars/Presentation	No

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)
CO1	H	M	H	H	–	–	–
CO2	H	–	L	–	–	–	H
CO3	H	–	L	–	–	–	H
CO4	H	M	M	L	–	–	H
CO5	H	M	M	M	M	–	H
Avg	3.0	1.6	1.2	0.4	0.6	0.0	3.0

*** **H** means High relevance, **M** means medium relevance, **L** means Low relevance

SEMESTER-V

Course Name: Large Sample Theory and Nonparametric Inference.

Course Type: Discipline Specific Core.

Credit: 4 [Lecture: 3, Practical: 1].

Course Outcomes (CO):

CO1: Understand various modes of convergence for sequences of random variables and apply fundamental limit theorems.

CO2: Derive and interpret large sample approximations for distributions and standard errors of key statistics.

CO3: Apply large sample tests for means, proportions, correlations, and Pearsonian χ^2-statistic in practical scenarios.

CO4: Explain and apply basic nonparametric tests for randomness, goodness of fit, and comparisons of location and scale.

CO5: Understand asymptotic properties of estimators and test statistics, including efficiency, likelihood-based methods, and density estimation.

COURSE CONTENT

Module No.	Module Name	Chapter Topic	CO
I	Limit Theorems and Modes of Convergence	Sequence of random variables: Definitions and examples Modes of convergence: ● Almost sure convergence ● Convergence in probability ● Convergence in distribution ● Convergence in mean square ● Interrelations and examples Weak Law and Strong Law of Large Numbers and applications Central Limit Theorem (CLT) for i.i.d. random variables (statement only) and its applications De Moivre–Laplace theorem (statement only)	CO1
II	Large Sample Approximations and Transformations	Delta method (univariate and multivariate (statement only)) and applications Large sample standard errors of: ● Sample moments ● Standard deviation ● Coefficient of variation ● Sample correlation coefficient ● Sample quantile Variance-stabilizing transformations:	CO2, CO3

		● Arcsin ($\sin^{-1}$), square root, log, Fisher's z-transform Large sample tests: ● Binomial proportions (one and two samples) ● Poisson means (one and two samples) ● Correlation coefficient Large sample distribution of Pearsonian χ^2 statistic and applications in goodness of fit	
III	Nonparametric Tests	Concept of nonparametric inference and advantages Run test for randomness Empirical Distribution Function (EDF): definition and use One-sample tests: ● Kolmogorov–Smirnov (K–S) test ● Sign test ● Wilcoxon signed-rank test Two-sample tests: ● Wilcoxon–Mann–Whitney test ● Median test ● Kruskal–Wallis test (for multiple samples)	CO4

IV	Asymptotics	● Concepts of consistency and asymptotic efficiency of estimators ● Large sample properties of Maximum Likelihood Estimators (MLEs) ● Asymptotic confidence intervals based on MLEs ● Likelihood Ratio Test (LRT): asymptotic distribution and properties (simple null) ● Wald's test and Rao's score test	CO5

Suggested Readings:

Text Books:

1. Goon, A.M., Gupta, M.K., Dasgupta, B. (2002). Fundamentals of Statistics, Vol. I, 8th Edn., The World Press, Kolkata.

2. Rohatgi, V.K., Saleh, A.K. Md. E. (2009). An Introduction to Probability and Statistics, 2nd Edn. (Reprint), John Wiley & Sons.

Reference Books:

3. Casella, G., Berger, R.L. (2002). Statistical Inference, 2nd Edn., Duxbury.

4. Dudewicz, E.J., Mishra, S.N. (1988). Modern Mathematical Statistics, Wiley.

5. Mood, A.M., Graybill, F.A., Boes, D.C. (1974). Introduction to the Theory of Statistics, McGraw-Hill.

6. Miller, I., Miller, M. (2002). John E. Freund's Mathematical Statistics, Prentice Hall.

7. R.J. Serfling (1980). Approximation Theorems of Mathematical Statistics, Wiley.

8. E.L. Lehmann (1999). Elements of Large-Sample Theory, Springer.

9. A.W. van der Vaart (1998). Asymptotic Statistics, Cambridge University Press.

10. Hettmansperger, T.P. (1984). Statistical Inference Based on Ranks, Wiley.

11. Gibbons, J.D. and Chakraborti, S. (2011). Nonparametric Statistical Inference, Fourth Edition, Revised and Expanded, CRC Press.

List of Practicals

1. Illustration of convergence modes using simulated sequences
2. Applying CLT to estimate distribution of sample means
3. Estimation and use of large sample standard errors
4. Using transformations to stabilize variance
5. Conducting large sample z-tests for means and proportions
6. Large sample test using Pearsonian χ^2
7. Performing nonparametric tests: sign test, signed-rank, K–S test
8. Wilcoxon-Mann-Whitney and Kruskal-Wallis tests on real datasets
9. Calculating ARE between different tests
10. Demonstration of likelihood ratio, Wald, and score tests

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	Yes
4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)
CO1	H	M					H
CO2	H	M					H
CO3	H	M			L		H
CO4	H	M	L		L		H
CO5	H	L			M		H
Avg	3.0	1.8	0.2	0.0	0.6	0.0	3.0

*** **H** means High relevance, **M** means medium relevance, **L** means Low relevance

Semester-V

Course Name: Regression Analysis

Course Type: Discipline Specific Core

Credits: 4 [Lecture: 3, Practical: 1]

COURSE CONTENT:

Module No.	Module Name	Chapter Topic	CO
I	Introduction to Linear Regression	Review of Simple Linear Regression and Multiple Linear Regression, Transformation of Variables	C01, CO5

		Dummy Variables	
II	Diagnostics and Remedial Measures	Residual Analysis: Residual plots, Scaling residuals: Standardized and Studentized Residuals, Residual plots, Outlier and leverage diagnostics DFBETA, DFFITS and Cook's Distance. Lack-of-fit tests in regression models	C02, CO5
III	Model Building and Selection	Model Building: Problems in model building, model misspecification and its impact. Variable selection techniques: subset selection methods: all possible regressions, stepwise selection. Criteria for evaluating models: R^2, adjusted R^2. Multicollinearity: • Concept of multicollinearity • detection and steps to remove multicollinearity	C03, CO5
IV	Regression models for binary response	Linear Probability Model (LPM), Logit and Probit models. Estimation of parameters for arrayed responses.	C04, CO5

Suggested Readings

Textbooks:

- Draper, N. R. and Smith, H. (1998): *Applied Regression Analysis*, 3rd Ed. John Wiley and Sons.
- Chatterjee, S., & Hadi, A. S. (2006). *Regression analysis by example* (4th ed.). Wiley.
- Belsley, D. W., Kuh, E., & Welsch, R. E. (1980). *Regression diagnostics: Identifying influential data and sources of collinearity*. Wiley.
- Johnston, J. (1984). *Econometric methods* (3rd ed.). McGraw-Hill.

Reference Books:

- Weisberg, S. (2014). *Applied linear regression* (4th ed.). Wiley.
- Montgomery, D.C., Peck, E.A., & Vining, G.G. (2012). *Introduction to Linear Regression Analysis*, Wiley.
- Ryan, T. P. (2008). *Modern regression methods* (2nd ed.). Wiley.
- Faraway, J. J. (2006). *Linear models with R*. CRC Press.

- Kutner, M. H., Nachtsheim, C. J., Neter, J., & Li, W. (2005). *Applied linear statistical models* (5th ed.). McGraw-Hill/Irwin.
- Judge, G. G., Griffiths, W. E., Hill, R. C., Lütkepohl, H., & Lee, T.-C. (1985). *The theory and practice of econometrics* (2nd ed.). Wiley.
- Cook, R. D., & Weisberg, S. (1982). *Residuals and influence in regression*. Chapman and Hall.

List of Suggested Practical:

- Fitting and interpreting linear regression models.
- Diagnostics: residual plots, multicollinearity (VIF), Cook's D, etc.
- Model selection using statistical criteria and stepwise methods.
- Detection and Remedy for Multicollinearity
- Regression with dummy variables.
- Logistic regression with real data.

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	Yes
4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

CO-PO Mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)

CO1	H	M	H				H
CO2	H	L					H
CO3	H	L					H
CO4	H	M	M		L		H
CO5	H	M	H	M	M		H
Avg	3.0	1.6	1.6	0.4	0.6	0.0	3.0

*** **H** means High relevance, **M** means medium relevance, **L** means Low relevance

Semester-V

Course Name: Statistical Quality Control and Vital Statistics

Course Type: Discipline Specific Core

Credit: 4 [Lecture: 3, Practical: 1].

Course Content:

Module No.	Module Name	Chapter Topic	CO
I	Introduction to Quality Control	Definition of quality, dimensions of quality. Quality system and standards: Introduction to ISO quality standards, Statistical Process Control - Seven tools of SPC, chance and assignable causes of quality variation. Statistical Control Charts-Construction and Statistical basis of 3σ Control charts, Rational Sub-grouping. Statistical product control – sampling inspection plans.	CO1, CO2
II	Control charts and sampling inspection plans	Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Control charts for variables: X-bar chart, R-chart, s-chart. Analysis of patterns on control chart. Acceptance sampling plan: Principle of acceptance sampling plans. Single and Double sampling plans, their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation. Use of Dodge and Romig's sampling inspection plan tables.	CO2
III	Measurement of Vital	Vital events, Rates and Ratios, Measurement of Mortality –	CO1,

	Statistics and Demographic Rates	Crude, Specific and Standardized death rates, Measurements of Fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). Measurement of Population Growth: Crude rates of natural increase, Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR)	CO3
IV	Life Table Techniques	Stationary and Stable population, Central Mortality Rates and Force of Mortality. Life (Mortality) Tables: Assumption, description, construction of Life Tables and Uses of Life Tables. Complete Life Table, Abridged Life Tables: Concept and construction of abridged life tables.	CO3, CO4, CO5

Suggested Readings:

Textbooks:

1 Montogomery, D. C. (2020): Introduction to Statistical Quality Control, 8th Edition, Wiley India Pvt. Ltd.

2. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vols. I& II, 8th Edition, The World Press, Kolkata.

3. Montogomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3 rd Edition reprint, Wiley India Pvt. Ltd.

4. Hoyle, David (1995): ISO Quality Systems Handbook, 2nd Edition, Butterworth Heinemann Publication.

5. Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd Edition. Prentice Hall of India Pvt. Ltd.

6. Keyfitz N., Beckman John A.: Demogrphy through Problems S-Verlag New york.

7. Biswas, S. (1988). Stochastic Processes in Demography & Application, Wiley Eastern Ltd.

Reference Books:

1. Mukhopadhyay, P (2011): Applied Statistics, 2nd edition revised reprint, Books and Allied(P) Ltd.

2. Amitava Mitra (2013): Fundamentals of Quality Control and Improvement. 3rd Edition. John Wiley and Sons, Inc.

3. Croxton, Fredrick, E. Cowden, Dudley J. and Klein, S. (1973). Applied General Statistics, 3rd Ed., Prentice Hall of India Pvt. Ltd. 3.

List of Suggested Practicals:

1. Construction and interpretation of statistical control charts: X-bar, R-chart, s-chart, np-chart, p-

chart, c-chart, u-chart.

2. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves

3. To calculate CDR and Age Specific death rate for a given data set.

4. To find standardized death rate by: (i) Direct method (ii) Indirect method.

5. To construct a complete life table.

6. To calculate probabilities of death at pivotal ages and use it to construct abridged life table

8. To calculate CBR, GFR, SFR, TFR for a given data set.

9. To calculate Crude rate of Natural Increase for a given data set.

10. Calculate GRR and NRR for a given set of data and compare them.

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	No
4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)
CO1	H	M					H
CO2	H	M					H
CO3	H	M					H
CO4	H	M			L		H
CO5	H	M		L	M		H
Average	3.0	2.0	0.0	0.2	0.6	0.0	3.0

*** **H** means High relevance, **M** means medium relevance, **L** means Low relevance

Semester-V

Course Name: **Artificial Intelligence**

Credit: 4, [Lecture: 2, Practical: 2]

Course Outcomes (CO):
CO1: Understand the foundational concepts, history, applications, and ethical implications of AI.
CO2: Apply problem-solving and search strategies for AI-based solutions.
CO3: Explain and apply logical and probabilistic knowledge representation techniques.
CO4: Understand fuzzy and rough set theory and apply them in decision-making contexts.
CO5: Implement basic AI algorithms and reasoning systems using Python-based tools.

COURSE CONTENT

Module No.	Module Name	Chapter Topic	CO
I	Introduction	Introduction to Artificial Intelligence, Brief History and Application, Definition and Scope of AI, Importance of AI in various fields like education, healthcare, medicine, environment etc., Advantages and disadvantages of AI, AI as a superset of Machine Learning, Data Science and Deep Learning, Ethical and social issues in AI	CO1
II	Problem Solving and Search Techniques	State space search, problem formulation, Uninformed Search: BFS, DFS, Iterative Deepening, Informed Search: Best-First Search, A* Algorithm, Constraint Satisfaction Problems, Game Playing: Minimax and Alpha-Beta Pruning	CO2, CO5
III	Knowledge Representation and Reasoning	Propositional and Predicate Logic, Rule-Based Systems Forward and Backward Chaining, Probabilistic Reasoning and Bayesian Networks (Introductory concepts)	CO3, CO5
IV	Fuzzy and Rough set	Fuzzy sets, application – basic operations, Properties, Fuzzy Relations, Fuzzy inference, Notion of Fuzziness, Operations on Fuzzy sets, composition of fuzzy relation, Different methods of role aggregation and defuzzification. Rough set, positive region, negative region and boundary region, Basic difference between Rough sets and Fuzzy sets	CO4

Suggested Readings:

Text Books:

1. Stuart Russell & Peter Norvig, Artificial Intelligence: A Modern Approach Publisher: Pearson
2. Elaine Rich, Kevin Knight & Shivashankar B. Nair, Artificial Intelligence Publisher: Tata McGraw-Hill
3. George J. Klir & Bo Yuan *Fuzzy Sets and Fuzzy Logic: Theory and Applications* Publisher: Prentice Hall of India
4. Zdzisław Pawlak, Rough Sets: Theoretical Aspects of Reasoning About Data Publisher: Springer
5. Artificial Intelligence and Soft Computing: Behavioral and Cognitive Modeling of the Human Brain, Amit Konar (Jadavpur University) Publisher: Taylor & Francis (CRC Press), 1999

6. Principles of Soft Computing Authors: S. N. Sivanandam & S. N. Deepa Publisher: Wiley India, 2007

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	Yes
4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

Suggested list of Practical's using Python

1. Implement Breadth-First Search (BFS) and Depth-First Search (DFS) algorithms in Python.
2. Write a Python program to implement Iterative Deepening Search.
3. Develop an A* Search algorithm using an appropriate heuristic function for a graph-based problem.
4. Simulate a simple two-player game (e.g., Tic-Tac-Toe) using the Minimax algorithm with Alpha-Beta pruning.
5. Solve a Constraint Satisfaction Problem such as N-Queens or Sudoku using backtracking in Python.
6. Create a Python program that evaluates logical expressions using propositional logic and generates truth tables.
7. Develop a simple Bayesian reasoning model for medical diagnosis or classification using Python.
8. Design a fuzzy inference system to evaluate student performance or weather conditions using Python or MATLAB.
9. Apply defuzzification techniques such as centroid, bisector, and mean of maxima in a fuzzy inference system.
10. Implement a basic rough set model to identify positive, negative, and boundary regions from a sample dataset.

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)
CO1	H	H	H	H	H		
CO2	M	M	H	M		H	M
CO3	M	H	M	M	M		M
CO4	H	M	M	M			M
CO5	M	M	M	M		M	M
Average	2.4	2.4	2.4	2.2	1	1	1.6

SEMESTER-VI

Course Name: Statistical Inference-III.

Course Type: Discipline Specific Core.

Credit: 4 [Lecture: 3, Practical: 1].

Course Outcomes (CO):

CO1: Understand and apply parametric inference techniques such as Neyman–Pearson Lemma and its extensions to construct optimal tests.

CO2: Apply the theory of U-statistics and linear rank statistics in common nonparametric testing problems.

CO3: Analyze the asymptotic properties of statistical tests including LRT, Wald, and Rao's score test.

CO4: Implement and interpret permutation-based methods and understand their role in exact and approximate inference.

CO5: Apply resampling techniques such as jackknife and bootstrap for estimating bias, variance, distribution functions, and constructing confidence intervals.

COURSE CONTENT

Module No.	Module Name	Chapter Topic	CO
I	Parametric Inference	● Review of Fundamental Neyman–Pearson Lemma with detailed proofs. Typical examples ● UMP tests and Monotone Likelihood Ratio (MLR) ● Karlin–Rubin theorem and applications ● Generalized Neyman–Pearson Lemma ● Concepts of α-similarity and α-Neyman structure ● UMPU tests for simple and composite hypotheses	CO1

		● Applications in one-parameter exponential family and k-parameter exponential family	
II	Nonparametric Statistics	U-statistics: definition, properties, asymptotic behaviour Linear Rank Statistics (LRS): introduction and use in hypothesis testing Applications to: ● Single sample location and location with symmetry ● Goodness-of-fit problems ● Two-sample problems: location, scale, homogeneity ● Multi-sample location problem ● Bivariate association problem Connection to earlier known nonparametric tests (Sign, Wilcoxon, Kolmogorov-Smirnov, etc.) Density estimation	CO2

III	Asymptotic Inference and Efficiency	Concepts of asymptotic relative efficiency (ARE). Introduction to permutation tests and their theoretical justification	CO3, CO4
IV	Resampling Techniques	Introduction to resampling-based inference Jackknife method: ● Estimation of bias and standard error ● Examples: sample mean, correlation coefficient, etc. Bootstrap method: ● Estimation of bias, variance, and distribution ● Bootstrap confidence intervals: percentile, bias-corrected, accelerated (BCa) Applications of jackknife and bootstrap in real-life data analysis	CO5

Suggested Readings:

1. Goon, A.M., Gupta, M.K., Dasgupta, B. (2005). Outline of Statistics, Vol. I & II, World Press.
2. Rohatgi, V.K., Saleh, A.K. Md. E. (2009). An Introduction to Probability and Statistics, Wiley.
3. Casella, G., Berger, R.L. (2002). Statistical Inference, 2nd Ed., Duxbury.
4. Dudewicz, E.J., Mishra, S.N. (1988). Modern Mathematical Statistics, Wiley.
5. Mood, A.M., Graybill, F.A., Boes, D.C. (1974). Introduction to the Theory of Statistics, McGraw-Hill.
6. Miller, I., Miller, M. (2002). John E. Freund's Mathematical Statistics, Prentice Hall.
7. B. Efron & R.J. Tibshirani (1993). An Introduction to the Bootstrap, Chapman & Hall/CRC.
8. B. Efron (1982). The Jackknife, the Bootstrap, and Other Resampling Plans, SIAM.
9. J. Shao & D. Tu (1995). The Jackknife and Bootstrap, Springer.
10. Hettmansperger, T.P. (1984). Statistical Inference Based on Ranks, Wiley.
11. Gibbons, J.D. and Chakraborti, S. (2011). Nonparametric Statistical Inference, Fourth Edition, Revised and Expanded, CRC Press.

List of Practicals:

1. Simulation of asymptotic properties of LRT, Wald, and Rao's Score tests
2. Implementation of permutation tests for mean and median
3. Jackknife estimation for bias and variance
4. Bootstrap methods for estimating standard error and constructing confidence intervals
5. Comparing the performance of parametric and nonparametric tests
6. Density estimation via kernel methods

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	Yes
4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)

CO1	H	M					H
CO2	H	M					H
CO3	H	L			M		H
CO4	H	M			L		H
CO5	H	M					H
Avg	3.0	1.6	0.0	0.0	0.6	0.0	3.0

*** **H** means High relevance, **M** means medium relevance, **L** means Low relevance

SEMESTER-VI

Course Name: Statistical Decision Theory and Bayesian Inference.

Course Type: Discipline Specific Core.

Credit: 4 [Lecture: 3, Practical: 1].

Course Outcomes (CO):

CO1: Understand and analyze decision functions, loss functions, risk, and utility in statistical decision-making.

CO2: Evaluate optimality criteria such as admissibility, Bayes and minimax principles, and complete class theorems.

CO3: Apply foundational principles of Bayesian inference for estimation, testing, and prediction in standard statistical models.

CO4: Compare classical and Bayesian paradigms and understand the use of priors, hierarchical models, and real-world implications.

CO5: Implement Bayesian inference using Stan and RStan for practical computation, including writing models and generating posterior summaries.

COURSE CONTENT

Module No.	Module Name	Chapter Topic	CO
I	Foundations of Statistical Decision Theory	● Decision problems, action space, loss and utility functions, risk functions ● Non-randomized vs randomized rules ● Concepts of admissibility, dominance, complete and essentially complete classes ● Sufficiency and convex loss, risk reduction using sufficient statistics ● Decision problems as two-person games ● Sequential and multiple decision problems	CO1, CO2
II	Bayes and Minimax Decision Rules	Bayes rules and generalized Bayes rules Extended and limiting Bayes rules Admissibility of Bayes rules Minimax principles and minimax rules Techniques to find minimax rules Invariant decision rules Applications in estimation and testing	CO1, CO2

III	Foundations of Bayesian Inference	Comparison between classical and Bayesian paradigms Subjective probability and prior beliefs Prior, posterior, and predictive distributions Conjugate priors for standard families: binomial, Poisson, exponential, normal Interval estimation, hypothesis testing, and prediction under Bayesian framework Simple hierarchical Bayes models	CO3, CO4
IV	Bayesian Computation with Stan	Introduction to probabilistic programming and Stan Syntax of Stan: defining models, functions, data blocks Using RStan for Bayesian analysis in R Sampling from posterior distribution Posterior summaries, diagnostics, trace plots, convergence Applications: simple problems from previous units (e.g., coin toss, Poisson rate, regression)	CO4, CO5

Suggested Readings:

1. Berger, J.O. (1985). *Statistical Decision Theory and Bayesian Analysis*, 2nd Ed., Springer.

2. Ferguson, T.S. (1967). *Mathematical Statistics: A Decision Theoretic Approach*, Academic Press.

3. Ghosh, J.K., Delampady, M., Samanta, T. (2006). *An Introduction to Bayesian Inference*, Springer.

4. Lee, P.M. (2012). *Bayesian Statistics: An Introduction*, Wiley.

5. Gelman, A., Carlin, J.B., Stern, H.S., Dunson, D.B., Vehtari, A., Rubin, D.B. (2013). *Bayesian Data Analysis*, 3rd Ed., CRC Press.

6. Robert, C.P. (2007). *The Bayesian Choice*, 2nd Ed., Springer.

List of Practicals

1. Perform Bayesian parameter estimation with informative and non-informative priors
2. Simulate posterior distributions in R using basic MCMC
3. Model real-life problems in Stan (e.g., disease incidence, failure rates, Bayesian regression)
4. Build a hierarchical Bayesian model in RStan
5. Compare posterior estimates from Stan with classical estimates

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	Yes
4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)
CO1	H	M	L				H
CO2	H	M	L				H
CO3	H	M	L		M		H
CO4	H	M	L		L		H
CO5	H	M	L				H
Avg	3.0	2.0	1.0	0.0	0.6	0.0	3.0

*** **H** means High relevance, **M** means medium relevance, **L** means Low relevance

Semester-VI

Course Name: Sample Survey-I and Design of experiments-I

Course Type: Discipline Specific Core

Credit: 4 [Lecture: 3, Practical: 1]

COURSE CONTENT:

Module No.	Module Name	Chapter Topic	CO

I	Basics of Sampling and Probability-Based Survey Methods	• Concepts of finite population and sample • Need for sampling and its advantages over complete enumeration • Types of errors: Sampling vs. Non-sampling errors, Bias and variance trade-offs, • Types of sampling techniques: Non-probability and Probability sampling • Basic principles of sample survey, • Different steps involved in a large-scale sample survey • Tables of random numbers and their use in random selection. Simple Random Sampling (SRS): • With and without replacement • Unbiased estimators of population mean, total, and proportion • Variances of these estimators and their unbiased variance estimators Stratified Random Sampling: • Concept, advantages, and method • Estimators of population mean and total, their variances • Proportional and optimum allocation, and their comparison with SRS • Practical challenges in allocation	CO1, CO2
II	Other types of Sampling procedures	Cluster Sampling (Equal-sized clusters): • Definition and method • Estimation of population mean and variance Subsampling Concepts: • Introduction to two-stage sampling • Estimation of population mean and variance when the sizes of the first stage units are equal, and samples are selected by SRS in the two stages	CO2, C04

III	Introduction to Design of Experiments and Basic Designs	Introduction and Fundamental Concepts • Role and importance of Design of Experiments in scientific studies • Key terminologies: Treatments, Experimental Units, Blocks, Experimental Error • Basic principles of experimental design: Replication, Randomization, and Local Control Design Planning in Agricultural and Industrial Settings • Uniformity trials and fertility contour maps • Choice of size and shape of plots and blocks in agricultural experiments • Applications of DOE in industrial experimentation Basic Experimental Designs • Completely Randomized Design (CRD) • Randomized Block Design (RBD) • Latin Square Design (LSD) o Layout, mathematical model, statistical analysis o **Relative efficiency** comparison among CRD, RBD, and LSD **Analysis with one missing observation** in RBD and LSD	CO3
IV	Factorial and Special Experimental Designs	**Factorial Experiments** • Advantages and applications • **Notation and concepts** for factorial designs • **2^n factorial experiments** (n=2,3): layout, design, and analysis • **Confounding in factorials**: o Total and partial confounding o Concept of **factorial experiments in a single replicate**	C05

Suggested Readings:
Textbooks:

- Raj, D. (1968). *Sampling theory*. McGraw-Hill.
- Sukhatme, P. V., Sukhatme, B. V., Sukhatme, S., & Asok, C. (1970). *Sampling theory of surveys with applications* (pp. 27-29). Ames, IA: Iowa state university press.

- Dean, A., & Voss, D. (Eds.). (1999). *Design and analysis of experiments*. New York, NY: Springer New York.
- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8thEdn. World Press, Kolkata.
- Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.

Reference Books:

- Cochran, W. G. (1977). *Sampling techniques*. John Wiley & Sons.
- Murthy, M. N. (1967). *Sampling theory and methods*. Statistical Publishing Society.
- Cochran, W.G. and Cox, G.M. (1959): *Experimental Design*. Asia Publishing House.
- Das, M.N. and Giri, N.C. (1986): *Design and Analysis of Experiments*. Wiley Eastern Ltd.
- Kempthorne, O. (1965): *The Design and Analysis of Experiments*. John Wiley.
- Wu, C. J., & Hamada, M. S. (2011). *Experiments: planning, analysis, and optimization*. John Wiley & Sons.

List of Suggested Practicals:

1. To draw SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WR and WOR and
3. For SRSWOR, estimate mean, standard error, the sample size
4. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods Compare the efficiencies of above two methods relative to SRS
5. Estimation of gain in precision in stratified sampling.
6. Cluster sampling: estimation of mean or total, variance of the estimate.
7. Problems on CRD, RBD, LSD, and 2^2, 2^3 factorial designs.

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	Yes
4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

CO-PO Mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)
CO1	H	M	L		L		M
CO2	H	M	L		M		H
CO3	H	M	M		L		H
CO4	H	M	L		L		M
CO5	H	M	M		M		M
Avg	3.0	2.0	1.4	0.0	1.4	0.0	2.4

*** **H** means High relevance, **M** means medium relevance, **L** means Low relevance

Semester- VI

Course Name: Time Series Analysis-I and Econometrics-I

Course Type: Discipline Specific Core

Credit: 4 [Lecture: 3, Practical: 1]

Course Contents:

Module No.	Module Name	Chapter Topic	CO
I	Descriptive Analysis of Time Series Data	Components of a time series (trend, seasonal, cyclical and irregular variations) Additive and multiplicative models Estimation of trend: • Measurement of trend by method of free-hand curve, method of moving averages, • fitting various mathematical curves (linear, quadratic and modified exponential). Measurement of seasonal variations: • Method of Ratio to Trend	CO1, CO5

		• Method of Simple Averages,	
II	Stochastic Time Series Models and Forecasting Techniques	Introduction to stochastic modelling: • Concept of stationarity. • Illustration of how a stationary time series may show temporal patterns. Box-Jenkins modelling: • Moving-average (MA) process and Autoregressive (AR) process of orders one and two. • ACF and its graphical use in guessing the order of MA processes. • Estimation of the parameters of AR (1) and AR (2) using least square and Yule-Walker equations. Forecasting: Exponential smoothing method	CO2, CO5
III	Introduction to Econometric Modelling	Objective behind building econometric models, nature of econometrics, model building, role of econometrics..	CO3
IV	Diagnostic Testing and Remedial Measures in Econometric Analysis	Autocorrelation: • Concept and consequences of auto correlated disturbances • detection and solution of autocorrelation • Generalized least squares estimation Heteroscedastic disturbances: • Concepts and consequences of heteroscedasticity. • Tests and solutions of heteroscedasticity.	CO4, CO5

Suggested Readings:

Textbooks:

- Chatfield C. (1980): The Analysis of Time Series –An Introduction, Chapman & Hall.
- Box, G. E., Jenkins, G. M., Reinsel, G. C., & Ljung, G. M. (2015). *Time series analysis: forecasting and control*. John Wiley & Sons.
- Johnston, J. (1972): Econometric Methods, 2nd Edition, McGraw Hill International.
- Gujarati, D. and Sangeetha, S. (2007): Basic Econometrics, 4th Edition McGraw Hill Companies

Reference books:

- Koutsoyiannis, A. (2004): Theory of Econometrics, 2nd Edition, Palgrave Macmillan Limited
- Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4th Edition, John Wiley & Sons.
- Brockwell, P. J., & Davis, R. A. (2010). Introduction to time series and forecasting (2nd ed.). Springer.

- Kendall M.G. (1976): Time Series, Charles Griffin.

List of suggested practicals:

- Decomposition of Time Series models
- Estimation of Trend by Moving Averages
- Fitting of Linear and Quadratic Trends
- Estimation of Seasonal Indices
- Exponential Smoothing Techniques
- Fitting AR(1), AR(2), and MA(1) Models
- Estimation of a Simple Linear Regression Model
- Detection and Treatment of Autocorrelation
- Detection and Treatment of heteroscedasticity

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	Yes
4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)

CO1	H	M	M	L		M	H
CO2	H	L	L	L		L	H
CO3	H	L	L	M		M	H
CO4	H	M	M	L	L	L	H
CO5	H	M	M	M	M	L	H
Avg	3.0	1.6	1.6	1.4	0.6	1.4	3.0

*** **H** means High relevance, **M** means medium relevance, **L** means Low relevance

SEMESTER-VI

Course Name: Machine Learning with R/Python.

Course Type: Minor.

Credit: 4 [Lecture: 2, Practical: 2].

COURSE CONTENT

Module No.	Module Name	Chapter Topic	CO
I	Supervised Learning – Regression & Classification	● Supervised vs. Unsupervised learning ● Linear Regression: simple and multiple, cost function, gradient descent ● Polynomial Regression and Feature Engineering ● Logistic Regression for binary classification ● Regularization techniques: Ridge, Lasso ● Evaluation Metrics: MSE, MAE, Accuracy, Precision, Recall, F1	CO1

		● Implementation using scikit-learn (Python) and caret/tidymodels (R)	
II	Machine Learning Algorithms	Discriminant Analysis: Bayes Rule, Minimax Rule, Likelihood Ratio, Multivariate Normal classification; Misclassification rates. LDA/QDA Introduction to Decision Trees and Random Forests Feature selection and model tuning (grid search, cross-validation) Overfitting and underfitting: bias-variance tradeoff Implementation in scikit-learn, and randomForest (R)	CO2
III	Unsupervised Learning and Dimensionality Reduction	Clustering Techniques: ● Hierarchical clustering (agglomerative, divisive) ● K-means clustering, Silhouette Index Introduction to Principal Component Analysis (PCA): ● Population/sample PCs, Biplots, Large sample inference ● Use of cluster, factoextra, recommenderlab (R), and sklearn.decomposition, surprise (Python)	CO3

IV	Case Studies & Project	End-to-end ML workflow: EDA, preprocessing, modeling, evaluation Case studies from health, finance, marketing, sports analytics Recommender Systems (item-based, user-based) Kaggle-style mini-projects using real datasets Best practices for reproducibility and presentation Group project: presentation, code, and report submission	CO4, CO5

Suggested Readings:

1. Hastie, T., Tibshirani, R., Friedman, J. (2009). *The Elements of Statistical Learning*, 2nd Edn., Springer.
2. James, G., Witten, D., Hastie, T., Tibshirani, R. (2013). *An Introduction to Statistical Learning: With Applications in R*, Springer.
3. Guido, S., Müller, A.C. (2016). *Introduction to Machine Learning with Python: A Guide for Data Scientists*, O'Reilly Media.
4. McKinney, W. (2012). *Python for Data Analysis*, O'Reilly Media.
5. Wickham, H., Grolemund, G. (2016). *R for Data Science*, O'Reilly Media.
6. Chollet, F. (2017). *Deep Learning with Python*, Manning Publications.
7. Lantz, B. (2013). *Machine Learning with R*, Packt Publishing.
8. Lesmeister, C. (2015). *Mastering Machine Learning with R*, Packt Publishing.
9. Johnson, R.A., Wichern, D.W. (2007). *Applied Multivariate Statistical Analysis*, 6th Edn., Pearson.
10. Anderson, T.W. (2003). *An Introduction to Multivariate Statistical Analysis*, 3rd Edn., Wiley.
11. Morrison, D.F. (2004). *Multivariate Statistical Methods*, 4th Edn., Duxbury Press.

List of Practicals

1. Linear and logistic regression with visualization
2. Model tuning with cross-validation in caret or sklearn
3. Classification using LDA and QDA on multivariate datasets
4. Clustering with silhouette analysis and PCA visualization
5. Recommender system using real-world e-commerce data
6. Case study: Predicting credit card default / heart disease classification
7. Final project: full pipeline from data preprocessing to final report & model deployment notebook (in RMarkdown/Jupyter)

Teaching Pedagogy:

S. No.	Description	Used (Yes/No)
1	Lecture	Yes
2	Discussion/Demonstration	Yes
3	Case Study	Yes
4	Test/Assignment	Yes
5	Student Seminars/Presentation	Yes

CO-PO mapping:

CO/PO	PO1 (Critical Thinking)	PO2 (Effective Communication)	PO3 (Social Interaction)	PO4 (Effective Citizenship)	PO5 (Ethics)	PO6 (Environment and Sustainability)	PO7 (Self-directed and Life-long Learning)
CO1	H	M					H
CO2	H	M			L		H
CO3	H	M			M		H
CO4	H	H	M				H
CO5	H	H	M				H
Avg	3.0	2.2	1.2	0.0	0.4	0.0	3.0

*** **H** means High relevance, **M** means medium relevance, **L** means Low relevance