VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF ADVANCED SCIENCES

DEPARTMENT OF MATHEMATICS

M.Sc. Integrated Computational Statistics & Data Analytics (5yr.) (CS&DA)

Curriculum & Syllabi

(2020–2021 Admitted Students)

VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

- **World class Education**: Excellence in education, grounded in ethics and critical thinking, for improvement of life.
- **Cutting edge Research**: An innovation ecosystem to extend knowledge and solve critical problems.
- **Impactful People**: Happy, accountable, caring and effective workforce and students.
- **Rewarding Co-creations**: Active collaboration with national & international industries & universities for productivity and economic development.
- **Service to Society**: Service to the region and world through knowledge and compassion.

VISION STATEMENT OF SCHOOL OF ADVANCED SCIENCES

To be an internationally renowned science school in research and innovation by imparting futuristic education relevant to the society.

MISSION STATEMENT OF SCHOOL OF ADVANCED SCIENCES

- To nurture students from India and abroad by providing quality education and training to become scientists, technologists, entrepreneurs and global leaders with ethical values for a sustainable future.

- To enrich knowledge through innovative research in niche areas.

- To ignite passion for science and provide solutions for national and global challenges.

M.Sc. Integrated Computational Statistics & Data Analytics (5yr.)

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO_01: Graduates will be practitioners and leaders in their chosen field.

PEO_02: Graduates will function in their profession with social awareness and responsibility.

PEO_03: Graduates will interact with their peers in other disciplines in their work place and society and contribute to the economic growth of the country.

PEO_04: Graduates will be successful in pursuing higher studies in their chosen field.

PEO_05: Graduates will pursue career paths in teaching or research.

M.Sc. Integrated Computational Statistics & Data Analytics (5yr.)

PROGRAMME OUTCOMES (POs)

PO_01: Having a clear understanding of the subject related concepts and of contemporary issues .

PO_02: Having an ability to design and conduct experiments, as well as to analyze and interpret data .

PO_03: Having an ability to use techniques, skills and modern tools necessary for solving scientific problems .

PO_04: Having problem solving ability- solving social issues and societal problems Having cross cultural competency exhibited by working in teams.

PO_05: Having adaptive thinking and adaptability.

PO_06: Having a clear understanding of professional and ethical responsibility .

PO_07: Having cross cultural competency exhibited by working in teams .

PO_08: Having a good working knowledge of communicating in English .

PO_09: Having a good cognitive load management [discriminate and filter the available data] skills.

PO_10: Having interest in lifelong learning.

M.Sc. Integrated Computational Statistics & Data Analytics (5yr.)

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M.Sc. Integrated Computational Statistics and Data Analytics (5 yr.) Programme, graduates will be able to

PSO_01: Apply knowledge of quantitative aptitude, computing techniques, programming knowledge to analyse real-world problems and requirements.

PSO_02: Provide solutions to the computing problems and reaching conclusions using principles of statistics, computational Science and data analytic tools.

PSO_03: Create, select, adapt and apply suitable Statistical techniques and modern computing tools for Data Analysis.

M.Sc. Integrated Computational Statistics & Data Analytics (5yr.)

CREDIT STRUCTURE

Category-wise Credit distribution

Category	Credits
University core (UC)	68
Programme core (PC)	71
Programme elective (PE)	59
University elective (UE)	12
Total credits	210

M.Sc. Integrated Computational Statistics & Data Analytics (5yr.)

DETAILED CURRICULUM

University Core (UC)							
S. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**J**	**C**
1	CHY1003	Environmental Studies	2	0	0	4	3
2	CHY1005	Allied Chemistry	3	0	0	0	3
3	CSE1012	Introduction to Computers and their Applications	2	0	2	0	3
4	MAT1023	Computational Thinking for Data Analytics	3	0	0	0	3
5	ENG3000	English for Beginners	1	0	2	0	2
6	ENG1911	General English - I	1	0	2	0	2
7	ENG1912	General English - II	1	0	2	0	2
7	HUM1032	Ethics and Values	1	0	0	4	2
8	MAT1001	Fundamentals of Mathematics	3	1	0	0	4
9	MAT1024	Real Analysis and its Applications	3	0	0	0	3
10	MGT1022	Lean Start-up Management	1	0	0	4	2
11	PHY1003	Physics	3	0	2	4	5
12	FLC4097	Foreign Language Course Basket	0	0	0	0	2
13	SET4001	Science, Engineering and Technology Project – I	0	0	0	0	2
14	SET4002	Science, Engineering and Technology Project – II	0	0	0	0	2
15	EXC4097	Co-Extra-Curricular Basket	0	0	0	0	2
16	STS5097	Soft Skills Course Basket	0	0	0	0	8
17	MIY4098	Comprehensive Examination	0	0	0	0	2
18	MIY6099	Master’s Thesis	0	0	0	0	16

M.Sc. Integrated Computational Statistics & Data Analytics (5yr.)

DETAILED CURRICULUM

Programme Core (PC)							
S. No	**Course Code**	**Course Title**	**L**	**T**	**P**	**J**	**C**
1	MAT1005	Fundamentals of Statistics	3	0	2	0	4
2	MAT1018	Probability and Random Variables	3	2	0	0	4
3	MAT1019	Statistical Methods for Data Analysis	3	2	0	0	4
4	MAT1020	Sampling Techniques	3	0	0	0	3
5	MAT1025	Data base management systems	3	0	2	0	4
6	MAT1026	Discrete Mathematics	3	2	0	0	4
7	MAT1027	Design and analysis of algorithms	3	0	2	0	4
8	MAT1028	Operation Research for Data Analysis	3	2	0	0	4
9	MAT1029	Statistical Quality Control	3	0	2	0	4
10	MAT1030	Statistical Computing for Data Analysis	0	0	4	0	2
11	MAT2006	Distribution Theory and its applications	3	0	2	0	4
12	MAT2007	Linear Algebra and Numerical Methods	3	0	0	0	3
13	MAT5013	Statistical Inference	3	0	2	0	4
14	MAT5016	Time Series Analysis and Forecasting	3	0	2	0	4
15	MAT5017	Multivariate Data Analysis	3	0	2	0	4
16	MAT6002	Regression Analysis and Predictive Models	3	0	2	0	4
17	MAT6004	Computational Statistics for Data Science	0	0	4	0	2
18	MAT6009	Design and Analysis of Experiments	3	0	2	0	4
19	MAT6012	Programming for Data Analysis	2	0	4	0	4

M.Sc. Integrated Computational Statistics & Data Analytics (5yr.)

DETAILED CURRICULUM

Programme Elective (PE)							
S. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**J**	**C**
1	CSE1030	Introduction to IoT	3	0	2	0	4
2	CSE1031	Web Technologies	2	0	2	0	3
3	CSE1032	Cloud Computing Techniques	3	2	0	0	4
4	CSE1008	Programming in C	3	0	2	0	4
5	CSE2037	Object Oriented Programming	3	0	2	0	4
6	CSE3100	Java Programming	3	0	2	0	4
7	MAT5022	Modelling and Simulation	3	0	2	0	4
8	MAT5024	Decision Support Systems	2	0	0	4	3
9	MAT6005	Machine learning for Data Science	3	0	2	0	4
10	MAT6007	Deep Learning	2	0	2	0	3
11	MAT6008	Artificial Intelligence for Data	2	0	2	0	3
12	MAT6015	Big Data Analytics and	2	0	2	0	3
13	MATXXXX	Econometric Analysis	3	0	2	0	4
14	MAT3010	Total Quality Management	3	0	0	4	4
15	MAT3011	Non-Parametric Tests	3	0	2	0	4
16	MAT1031	Biostatistics	3	0	2	0	4
17	MAT1032	Decision Modelling Techniques	2	0	2	0	3
18	MAT6017	Actuarial Statistics	3	0	0	0	3
19	MAT3012	Data Warehousing and Data	3	0	0	0	3
20	MAT3013	Data Engineering for Analytics	2	0	2	4	4
21	MAT3014	Software Quality and Testing	2	0	0	4	3

University Core

Course code	Environmental Studies	L	T	P	J	C
CHY1003		3	0	0	0	3
Pre-requisite	None	Syllabus version				
		1.1				

Course Objectives:

The course is aimed at

- To make students understand and appreciate the unity of life in all its forms and the implications of lifestyle on the environment.
- To broaden the understanding of global climate changes and the importance of renewable sources of energy.
- To give students a basic understanding of the major causes of environmental degradation on the planet, with specific reference to the Indian situation.
- To inspire students to find ways in which they can contribute personally and professionally to prevent and rectify environmental problems.

Course Outcomes: (CO):

At the end of the course, the student should be able to

- Know the importance of environment and awareness on natural resources to find the causes, effects, and consequences if not protected.
- Acquire knowledge of renewable and non-renewable energy resources to solve future problems on energy demand.
- Enriching the understanding of the need for eco-balance and the importance of biodiversity conservation.
- Identify the numerous causes for environmental pollutions, hazards, their management, and control methods.
- Find ways to protect the environment on global climatic changes and their mitigation.
- Recognise some of the social issues and gaining knowledge on the protection of the environment.
- Develop adequate knowledge of population, which enabling them to make better in life decisions as well as enter a career in an environmental profession or higher education.

Module:1	Environment and Natural Resources	7 hours

Definition, scope, importance, the need for public awareness on natural resources Forest resources – use, exploitation, causes, and consequences of deforestation. Water resources – use of surface and subsurface water; dams - effect of drought, water conflicts. Land resources - Land degradation, soil erosion, and desertification. Indian Case studies. Food resources – Definition, world food problems, Traditional and modern agriculture, and its impacts and remedies.

Module:2	Energy Resources	7 hours

Definition of renewable and non-renewable energy resources. Non-renewable energy resources - oil, Natural gas, Coal, Nuclear energy. Renewable energy - Solar energy, Hydroelectric power, Ocean thermal energy, wind, and geothermal energy. Biomass energy and Bio Gas.

Module:3	Ecosystem and Biodiversity	5 hours

Concept of ecosystem, Structure, and functions of an ecosystem, Food chains, food webs. Energy flow in an ecosystem, ecological pyramids, and ecological succession. Case studies: Bio magnification of DDT. Biodiversity-Bio-geographical classification of India, hotspots, values of biodiversity. Threats to biodiversity - a Case study. Conservation of biodiversity. GM Crops

Module:4	Environmental changes and Remediation	6 hours

Air, water, soil, Thermal Pollution: Causes, effects and control measures; Nuclear hazard. Solid waste

Management- Causes, Effects and control measures. Floods, earthquakes, cyclones, tsunami and landslides, Case studies.		
Module:5	**Global Climatic Change and Mitigation**	**5 hours**
Global climate change and the greenhouse effect – Kyoto Protocol, Carbon sequestration, Acid rain, Ozone depletion problem – Montreal Protocol.		
Module:6	**Social Issues and the Environment**	**6 hours**
Urban problems related to energy and sustainable development, Water conservation, Rainwater harvesting, Wasteland Reclamation. Environment Protection Act - Prevention and control of Pollution of Air and Water. Wildlife protection and Forest Conservation Acts.		
Module:7	**Human Population and the Environment**	**7 hours**
Population growth, variation among nations, population explosion, Family Welfare Programme, Environment, Women and Child Welfare, Human rights, HIV/AIDS, Role of information technology on the environment and human health. Discussion on current environmental issues/topics by an Industrial expert or faculty		
Module:8	**Contemporary issues**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**45 hours**

Text Book(s)	
•	Anubha Kaushik and C.P. Kaushik, Environmental Science and Engineering, 2016, 5th Edition, ISBN: 978-81-224-4013-3, New Age International.
•	G. Tyler Miller Jr and Scott E. Spoolman, Living in the Environment, 2012. 17th Edition, ISBN-13: 978-0-538-73534-6, Brooks / Cole.
Reference Books	
•	Environmental Science and Engineering by Anjali Bagad, 2014, 1st Edition, ISBN-10: 9350997088, Technical Publications.
•	Introduction to Environmental Engineering by Masters, 2015, 3rd Edition, ISBN-10: 9332549761, Pearson Education India.
•	Basic Environmental Sciences For Undergraduates by Dr. Tanu Allen, Dr. Richa K. Tyagi Dr. Sohini Singh, 2014, 1st Edition, ISBN-10: 938375827, Vayu Education of India.

Mode of Evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & FAT			
Recommended by Board of Studies	12-8-2017		
Approved by Academic Council	No.47	Date	05-10-2017

Course code	Allied Chemistry	L	T	P	J	C
CHY1005		3	0	0	0	3
Pre-requisite	Chemistry at 12th standard or equivalent	Syllabus version				
		2.0				

Course Objectives

The course is aimed at

- To understand the interdependency of chemistry and biological systems and the relationship between chemical structure and biological activity.
- To introduce analytical and separation techniques essential for biologists.

Expected Course Outcomes:

At the end of the course, the students will

- be able to acquire knowledge about the stereochemistry of organic and biomolecules.
- be able to acquire knowledge on various electronic effects in biological systems.
- be familiar with the fundamental chemistry of the biomolecules.
- be familiar with the fundamental chemistry of chlorophyll and Haemoglobin.
- be able to acquire knowledge on the various functions of several metal ions and the complexes in the biological systems.
- be able to acquire knowledge about the uses, mechanism of action of essential drugs, and their SAR.
- Demonstrate basic knowledge of the separation and analytical techniques.

Module:1	**Introduction to Stereochemistry**	**6 hours**
Isomerism in organic compounds – structural, stereo, geometrical and optical isomerism-Chirality-Racemisation–Specific optical rotation-Enantiomeric Excess-Optical purity-Resolution–R-S notation–E-Z nomenclature		
Module:2	**Electronic effects**	**6 hours**
Intermolecular bonding forces-ionic bonds, hydrogen bonds, Van der Waals interactions, Dipole-dipole and Ion-dipole interactions, Repulsive interactions, water, and hydrophobic interactions – Importance of these effects in biological systems.		
Module:3	**Chemistry of Biomolecules**	**6 hours**
Amino acids, Proteins, and Enzymes - Chemical structure and function.		
Module:4	**Molecules of Life**	**4 hours**
Structure and functions of Haemoglobin and Chlorophyll.		
Module:5	**Role of metal ions in Biology**	**6 hours**
Essential and toxic metals – metal ions deficiency and its treatment – metal ion toxicity – Fe, Cu, Cr, Pb, As, Hg, Cd – Natural detoxification – chelating drugs for detoxification – examples for Chelating drugs – Anti-arthritic gold drugs – psychiatric drug – Lithium – Anticancer drugs - Platinum complexes.		
Module:6	**Antibiotics, Anti-ulcer and Analgesic drugs**	**9 hours**
Structure-activity relationship (SAR) – cell wall synthesis inhibitors - Penicillins, Cephalosporin-Protein synthesis inhibitors– tetracycline, chloramphenicol. SAR–H_2 antagonist–Ranitidine–Proton pump inhibitors – Pantoprazole –Omeprazole. NSAID- SAR – paracetamol – diclofenac sodium – ibuprofen.		

Module:7	**Separation and Analytical Techniques**	**6 hours**
Chromatography – Adsorption, Absorption, Partition- HPLC, GC -Spectroscopy – the interaction of electromagnetic radiation with matter, type of interaction, the origin of IR, UV – Visible, Emission spectroscopy (fluorescence) and applications.		
Module:8	**Contemporary issues:**	**2 hours**
Lecture by Industry Experts		
	Total Lecture Hours:	**45 hours**

Text Book(s):

- An Introduction to Medicinal Chemistry, Graham L. Patrick, VIth edition, Oxford University Press, 2017.
- Organic Chemistry, Solomon, and Fryhle. Eighth Edition, Wiley India (P) Ltd. 2009.
- Bioinorganic Chemistry, Asim K. Das, Books and Allied (P) Ltd, 2010.
- Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, and F. J. Holler, S.R. Crouch,9th Edition, Thomson Asia (P) Ltd., Singapore, 2014.

Reference Book(s):

- Stereochemistry of Organic Compounds by L. Eliel, Samuel H. Wilen, Wiley India (P) Ltd, 2010.
- Instrumental Methods of Chemical Analysis, B. K. Sharma, Goel Publishing House, 24th edition,2005.
- Basic Concepts of Analytical Chemistry, S. M. Khopkar, New Age International Publishers, 2009.

Mode of evaluation: Internal assessment (CAT, Quizzes, Digital Assignment) and FAT

Recommended by Board of Studies		12-08-2017	
Approved by Academic Council	No.46	Date	24-08-2017

Course code	Introduction to Computers and their Applications	L	T	P	J	C
CSE1012		2	0	2	0	3
Pre-requisite	None	Syllabus version				
		1.1				

Course Objectives:

- Gaining foundation in the fundamentals of computers concerning computer components and their usage
- Making students understand different web technologies and computer networks
- Exploring the application suite of software for the betterment of presentation and management of data

Expected Course Outcome:

- The students will have the knowledge and skills to describe the software and hardware components
- Explain some of the web technologies and illustrate how these can be used to manage scientific data
- Obtain and analyse information and data relating to specific word applications for fine document preparation and report writing.
- Data computation using spreadsheet application and presentation application for scientific findings.
- Perform practical data management techniques, including DDL and DML and database querying.

Module:1	History of Computers	4 hours

History of Computers, Basic Components of Computer Systems, CPU, Memory, I/O Devices, Operating system, DOS and Unix system commands

Module:2	Web Technologies	4 hours

Introduction to Internet - URL, WWW, HTML, Internet Protocols- HTTP, TCP/IP, E-Mail & FTP.

Module:3	Computer Networks	3 hours

Networks and Data Communications: LAN, MAN & WAN – Network Topologies. Basics of Network, Uses of the network, types of networks, Network topologies.

Module:4	Word Processing	4 hours

Word basics, Editing and formatting a document, layout and inserting and managing graphics, formatting tables

Module:5	Spreadsheets	4 hours

Spreadsheet basics, Editing worksheets, Form cells – formatting worksheets, formulas and function, data filtering and sorting, chart, and graphs.

Module:6	Presentation	5hours

Presentation basics, Creation of Presentation, editing presentation, formatting presentation, working with multimedia.

Module:7	Database Management	4 hours

Database basics, advantages of Database, create a database, updating and manipulating data, DDL and DML command, database querying.

Module:8	**Contemporary issues**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**30 hours**

Text Book(s)

- Peter Norton, 2017, Introduction to Computers, 7th Edition, Tata McGraw Hill Publications.
- Joan Lambert, and Curtis Frye, 2017 Microsoft Office 2016 Step by Step, Microsoft Press

Reference Books

- Rajaraman V, and Adabala N, 2014, Fundamentals of Computers, PHI Publication

Mode of Evaluation: Assignments, Continuous assessment tests and Final assessment test.

List of Experiments		**No. of Hours**
1.	Unix and DOS commands	2 hours
2.	Creating and Formatting Word document	2 hours
3.	Creating and Manipulating Tables in a document	2 hours
4.	Inserting any Graphics in a document	2 hours
5.	Create a Personal Resume	2 hours
6.	Using the Excel Formula and Functions	2 hours
7.	Representing Data in a Chart	2 hours
8.	Excel Using Pivot Table	2 hours
9.	Excel Using Functions	2 hours
10.	Working with Design Templates and Auto Content wizards by using PowerPoint	2 hours
11.	Formatting and editing slides	2 hours
12.	PowerPoint Slide design	2 hours
13.	Slide transition effects	2 hours
14.	Creating and querying a recipe database using a database program	2 hours
15.	Updating and manipulating database	2 hours
	Total Laboratory Hours	30 hours

Mode of Evaluation: Assignments, Continuous assessment tests and Final assessment test.

Recommended by Board of Studies	12-8-2017		
Approved by Academic Council	No. 53.	Date	13-12-2018

Course code	Computational Thinking for Data Analytics	L	T	P	J	C
MAT1023		3	0	0	0	3
Pre-requisite	None	Syllabus version				
		1.0				

Course Objectives:

- To provide a working definition for the concept of computational thinking.
- To understand that logic is necessary and how it can be applied to solve a variety of real-world problems
- To understand the central role algorithms play in computational problem solving and explore many forms of algorithms
- To explore many forms of abstraction that are significant to computer science
- To Understand how algorithms are modularized and often involves the repetition of statements
- To be able to create basic activity diagrams for simple algorithms
- To understand how a computing system organizes data in memory

Expected Course Outcome:

At the end of the course students will be able to:

- explain the stored program concept and the role it plays in software execution and the manipulation of data
- describe how the logic of natural language is expressed symbolically
- interpret state diagrams including do, entry, and exit actions
- examine divide and conquer as a key problem-solving strategy, useful in outlining and top-down design
- model sequential algorithms of ten or fewer states
- understand how linking is used to organize data in memory

Module:1	Computational Thinking – Introduction	6 hours

Introduction: What is computational Thinking? - Computational Thinking in real world; Moore's Law; Logical Thinking: Logic – Inductive vs Deductive Arguments – Boolean logic – Propositions – Logical Operators – Symbolic Logic – Venn Diagrams – Applications of Propositional Logic

Module:2	Problem Solving and Decomposition	6 hours

Problem Definition and Devising Solution; Decomposition – Recursion – Tree Structure; Critical Thinking – Solve a concrete instance – Problem of drawing smiley face; Patterns and Generalisation – Complex Patterns – Loops, Subroutines, Rules

Module:3	Abstraction	6 hours

Abstraction: From generalisation to abstraction – Importance – Examples – Class Diagrams – Use Case Diagrams

Module:4	Algorithmic Thinking	6 hours

Algorithmic Thinking: Algorithms – Intuition vs Precision – Defining Algorithms - Control of Algorithm Execution – Example Algorithm - Name Bindings - Selection - Repetition – Modularization

Module:5	Modelling Solutions	7 hours

Modelling: Motivation – Basics – Static vs Dynamic Models – Uses of Models – Koningsberg Bridge Example; Activity Diagrams: Selection – Repetition – Control Abstraction; States and State Diagrams: Including Behaviour in State Diagrams

Module:6	Data Organisation	7 hours

Names, Lists, Arrays, Linking, Graphs, Hierarchies

Module:7	Error Handling	5 hours

Error Handling and Complex Conditionals; Errors: Typos – Poor Grammar and Ambiguities – Inconsistencies – Logical and Mathematical Errors; Mitigating Errors; Testing and Debugging		
Module:8	**Contemporary issues**	**2 hours**
Lecture by Industry Experts		
	Total Lecture Hours	**45 hours**

Text Book(s)

- David D. Riley, Kenny A. Hunt, Computational Thinking For the Modern Problem Solver, CRC Press, 2014

Reference Book(s)

- John V. Guttag, Introduction to Computation and Programming using Python, The MIT Press, 2016
- Paolo Ferragina, Fabrizio Luccio, Compuational Thinking – First Alogorithms, Then Code, Springer, 2018
- Karl Beecher, Computational Thinking – A beginner's guide to problem-solving and programming, BCS Learning & Development Limited, 2017.
- Eric Freeman, Head First - Learn to Code, O'Reilly, 2018

Mode of Evaluation: CAT, Quiz, Digital Assignment and FAT.

Recommended by Board of Studies	24-06-2020		
Approved by Academic Council	No.59	Date	24-09-2020

Course code	Ethics and values	L	T	P	J	C
HUM1021 / HUM1032		2	0	0	0	2
Pre-requisite	None	Syllabus version				
		1.1				

Course Objectives:

- To understand and appreciate the ethical issues faced by an individual in profession, society, and polity
- To understand the negative health impacts of certain unhealthy behaviours
- To appreciate the need and importance of physical, emotional health and social health

Expected Course Outcome:

- Students will be able to:
- Follow sound morals and ethical values scrupulously to prove as good citizens
- Understand various social problems and learn to act ethically
- Understand the concept of addiction and how it will affect the physical and mental health
- Identify ethical concerns in research and intellectual contexts, including academic integrity, use, and citation of sources, the objective presentation of data, and the treatment of human subjects
- Identify the main typologies, characteristics, activities, actors, and forms of cybercrime

Module:1	Being Good and Responsible	5 hours

Gandhian values such as truth and non-violence – Comparative analysis on leaders of past and present – Society's interests versus self-interests - Personal Social Responsibility: Helping the needy, charity and serving the society

Module:2	Social Issues 1	4 hours

Harassment – Types - Prevention of harassment, Violence, and Terrorism

Module:3	Social Issues 2	4 hours

Corruption: Ethical values, causes, impact, laws, prevention – Electoral malpractices;
White collar crimes - Tax evasions – Unfair trade practices

Module:4	Addiction and Health	5 hours

Peer pressure - Alcoholism: Ethical values, causes, impact, laws, prevention – Ill effects of smoking - Prevention of Suicides;
Sexual Health: Prevention and impact of pre-marital pregnancy and Sexually Transmitted Diseases

Module:5	Drug Abuse	3 hours

Abuse of different types of legal and illegal drugs: Ethical values, causes, impact, laws, and prevention

Module:6	Personal and Professional Ethics	4 hours

Dishonesty - Stealing - Malpractices in Examinations – Plagiarism

Module:7	Abuse of Technologies	3 hours

Hacking and other cybercrimes, Addiction to mobile phone usage, Video games and Social networking websites

Module:8	**Contemporary issues:**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**30 hours**

Reference Books

- Dhaliwal, K.K, "Gandhian Philosophy of Ethics: A Study of Relationship between his Presupposition and Precepts,2016, Writers Choice, New Delhi, India.
- Vittal, N, "Ending Corruption? - How to Clean up India?" 2012, Penguin Publishers, UK.
- Pagliaro, L.A., and Pagliaro, A.M, "Handbook of Child and Adolescent Drug and Substance Abuse: Pharmacological, Developmental and Clinical Considerations," 2012Wiley Publishers, U.S.A.
- Pandey, P. K (2012), "Sexual Harassment and Law in India," 2012, Lambert Publishers, Germany.

Mode of Evaluation: CAT, Assignment, Quiz, FAT, and Seminar

Recommended by Board of Studies	26-07-2017		
Approved by Academic Council	No. 46	Date	24-08-2017

Course code	Real Analysis and its Applications	L	T	P	J	C
MAT1024		3	0	0	0	3
Pre-requisite	None	Syllabus version				
		1.0				

Course Objectives:

- To acquaint the students with basic concepts and knowledge of real analysis
- To train the students in problem solving, occurring in the field of science and technology

Expected Course Outcomes(CO's):

- Students are able to understand the real number system and countable concepts in real number system
- Students are expected to recognize the difference between pointwise and uniform convergence of a sequence of functions.
- Students are able to determine the continuity and differentiability of functions defined on subsets of the real line
- Students are able to know the Fundamental theorems of Calculus
- Students are able to understand the concepts of Connectedness, Completeness and Compactness

Module:1	Sets and Functions	6 hours	

The Real Number System -Mathematical Induction -The Real Line-Sets and elements – Operations on sets – least upper bounds – Sequence of real numbers – Functions- Composition and inverses of functions-Relations-Equivalence Relations- Countable and uncountable sets

Module:2	Sequences	6 hours	

Definition of sequence and sub sequence – Limit of a sequence - Convergent sequence – Bounded sequence –Monotone sequence – Operations on convergent sequence.

Module:3	Series	6 hours	

Series of real numbers – Convergence and divergence – Series with non-negative terms – Alternating series – Conditional convergence and absolute convergence – Tests for absolute convergence

Module:4	Limits and Continuity	6 hours	

Limit of a Function – Algebra of Limits – Continuity of a function –Types of discontinuities – Elementary properties of continuous functions –Uniform continuity of a function-Applications.

Module:5	Derivatives	7 hours	

Functions continuous at a point on the real line – The Derivative – Rolle's theorem - Mean value theorem – Taylor's theorem – Maclaurin theorem – simple problems

Module:6	Integration	6 hours	

Riemann Integrability – Upper and Lower sums – Upper and Lower integral – The Riemann integral – Riemann criterion for integrability – Fundamental theorem of calculus –Improper integral – simple problems

Module:7	Functions of Several Variables	6 hours	

Limits and continuity Partial derivatives and Differentiability - Properties of differentiable functions Higher order derivatives and differentials - Maxima and Minima-Extrema under constraints

Module:8	Contemporary issues:	2 hours	

Lecture by Industry Experts

	Total Lecture hours:	45 hours	

Text Book(s)

- Goldberge, Richard R, Methods of Real Analysis, Oxford & IBHP Publishing Co., New Delhi, 1970
- M.K,Singhal & Asha Rani Singhal , A First Course in Real Analysis, R.Chand & Co., June 1997 Edition

Reference Books			
• Apostol T.M., Mathematical Analysis, 2nd Edition, Pearson, 1974. • Shanthi Narayan, A Course of Mathematical Analysis, S. Chand & Co., 1995 • Rudin W., Principles of Mathematical Analysis, 3rd Edition, McGraw Hill Education (India), 2013. • Robert G.Bartle and Donald R.Sherbert Introduction to Real Analysis, 4th Edition, Robert, Wiley-2014.			
Mode of evaluation: CAT / Digital Assignment / Quiz / FAT			
Recommended by Board of Studies	24-06-2020		
Approved by Academic Council	No. 59	Date	24-09-2020

Course Code	Fundamentals of Mathematics	L	T	P	J	C
MAT1001		3	2	0	0	4
Pre-requisite	None	Syllabus Version				
		1.0				

Course Objectives

The course is aimed at providing

- necessary and relevant background to understand the other important engineering mathematics courses
- basic knowledge for the non-mathematics students to learn further topics and apply it in solving real-world engineering problems

Course Outcomes

At the end of the course, the student should be able to

- Solve a system of linear equations by matrix method
- Apply the techniques of differentiation to find maxima and minima, and techniques of integration to evaluate areas and volumes of revolution
- Understand the concept of ordinary differential equations, and first and second-order linear differential equations
- Have a clear understanding of analytic geometry and vector algebra
- Apply concepts of mathematical logic and elementary probability to real-life problems

Module:1	Matrices	5 hours

Matrices - types of matrices - operations on matrices - determinants - adjoint matrix – Inverse of a matrix - solution of a system of linear equations by inversion method – elementary transformations – the rank of a matrix - consistency, and inconsistency of the system of equations

Module:2	Differential Calculus	6 hours

Differentiation of functions of a single variable – differentiation techniques physical interpretations - differentiation of implicit functions – higher-order derivatives – Taylor's, McClaurin's series - maxima and minima of functions of a single variable

Module:3	Integral Calculus	6 hours

Partial fractions - Integration- integration techniques- integration by parts- definite integrals – properties- evaluation of area and volume by integration

Module:4	Linear Ordinary Differential Equations	6 hours

Differential equations-definition and examples- formation of the differential equation- solving differential equations of the first order - solving second order homogenous differential equations with constant coefficients

Module:5	Analytic geometry	5 hours

Analytic geometry of three dimensions - direction cosines and direction ratios - plane, straight line and sphere, distance between points, distance to a plane

Module:6	Vector Algebra	7 hours

Vectors–operations on vectors-angle between two vectors-projection of one vector on another vector – equations of the plane, straight line, and sphere in vector forms-shortest distance between two skew lines - equation of a tangent plane to a sphere		
Module:7	**Logic and Probability**	**8 hours**
Mathematical logic – propositions – truth table – connectives– tautology – contradiction. Permutations and combinations – probability – classical approach – addition law - conditional probability - multiplicative law - Bayes' theorem and applications		
Module:8	**Contemporary Issues**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**45 hours**
Tutorial	• A minimum of 10 problems to be worked out by students in every Tutorial Class • Another 5 problems per Tutorial Class to be given as homework Mode: Individual Exercises, Team Exercises, Online Quizzes, Online Discussion Forums	**30 hours**

Text Book(s)

- Engineering Mathematics, K. A. Stroud, and Dexter J. Booth, 7th Edition, Palgrave Macmillan (2013).

Reference Books

- Elementary Engineering Mathematics, B. S. Grewal, 43rd edition, Khanna Publications, (2015).
- Discrete Mathematics, Seymour Lipschutz and Marc Lipson, 6th Edition, Tata McGraw -Hill (2017).
- Introduction to Probability and Statistics, Seymour Lipschutz and John Schiller, 3rd Indian Edition, Tata McGraw -Hill (2017).

Mode of Evaluation: Digital Assignments (Solutions by using a soft skill), Quiz, Continuous Assessments, Final Assessment Test

Recommended by Board of Studies	25-02-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

Course code	Lean Start up Management	L	T	P	J	C
MGT1022		1	0	0	4	2
Pre-requisite	None	Syllabus version				
		1.0				

Course Objectives: To develop the ability to

- Learn methods of company formation and management.
- Gain practical skills in and experience of stating business using a pre-set collection of business ideas.
- Learn the basics of entrepreneurial skills.

Expected Course Outcome: On the completion of this course, the student will be able to:

- Understand developing business models and growth drivers
- Use the business model canvas to map out key components of the enterprise
- Analyze market size, cost structure, revenue streams, and value chain
- Understand build-measure-learn principles Foreseeing and quantifying business and financial risks

Module:1		**2 Hours**
Creativity and Design Thinking (identify the vertical for business opportunity, understand your customers, accurately assess market opportunity)		
Module:2		**3 Hours**
Minimum Viable Product (Value Proposition, Customer Segments, Build- measure-learn process)		
Module:3		**3 Hours**
Business Model Development(Channels and Partners, Revenue Model and streams, Key Resources, Activities and Costs, Customer Relationships and Customer Development Processes, Business model canvas –the lean model- templates)		
Module:4		**3 Hours**
Business Plan and Access to Funding(visioning your venture, taking the product/ service to market, a Market plan including Digital & Viral Marketing, start-up finance - Costs/Profits & Losses/cash flow, Angel/VC,/Bank Loans and Key elements of raising money)		
Module:5		**3 Hours**
Legal, Regulatory, CSR, Standards, Taxes		
Module:6	**Contemporary Issues**	**2 Hours**
Lecture by Industry Experts		
	Total Lecture	**15 hours**

Text Book(s)

- The Startup Owner's Manual: The Step-By-Step Guide for Building a Great Company, Steve Blank, K & S Ranch; 1st edition (March 1, 2012)
- The Four Steps to the Epiphany, Steve Blank, K&S Ranch; 2nd edition (July 17, 2013)
- The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically

	Successful Businesses, Eric Ries, Crown Business; (13 September 2011)
Reference Books	
•	Holding a Cat by the Tail, Steve Blank, K&S Ranch Publishing LLC (August 14, 2014)
•	Product Design and Development, Karal T Ulrich, SD Eppinger, McGraw Hill
•	Zero to One: Notes on Startups, or How to Build the Future, Peter Thiel, Crown Business(2014)
•	Lean Analytics: Use Data to Build a Better Startup Faster (Lean Series), Alistair Croll & Benjamin Yoskovitz, O'Reilly Media; 1st Edition (March 21, 2013)
•	Inspired: How To Create Products Customers Love, Marty Cagan, SVPG Press; 1st edition (June 18, 2008)

Website References:

1. http://theleanstartup.com/
2. https://www.kickstarter.com/projects/881308232/only-on-kickstarter-the-leaders-guide-by-eric-ries
3. http://businessmodelgeneration.com/
4. https://www.leanstartupmachine.com/
5. https://www.youtube.com/watch?v=fEvKo90qBns
6. http://thenextweb.com/entrepreneur/2015/07/05/whats-wrong-with-the-lean-startup-methodology/#gref
7. http://www.businessinsider.in/Whats-Lean-about-Lean-Startup/articleshow/53615661.cms
8. https://steveblank.com/tools-and-blogs-for-entrepreneurs/
9. https://hbr.org/2013/05/why-the-lean-start-up-changes-everything
10. chventures.blogspot.in/ platformsandnetworks.blogspot.in/p/saas-model.html

Mode of Evaluation: Assignments; Field Trips, Case Studies; e-learning; Learning through research, TED Talks

Project		
1.	Project	**60 hours**
	Total Project	**60 hours**

Recommended by Board of Studies	08-06-2015		
Approved by Academic Council	No. 37	Date	16-06-2015

Course code	Physics	L	T	P	J	C
PHY1003		3	0	2	4	5

Pre-requisite	None	Syllabus version
		1.0

Course Objectives:

To enable the student to understand the basic principles of Physics behind (a) those latest areas of biotechnology such as nanobiotechnology and (b) medical applications involving lasers, ultrasound and fiber optics

Expected Course Outcome: Students will be able to

- Understand the concept of dual nature of the electromagnetic radiation and its verification
- Understand the quantum physics concept by studying the behavior of the particle in a box.
- Study the material properties as a function of particle size, especially at the nano level.
- Explore the properties and types of LASERs and its application.
- Understand the properties, production, and detection of Ultrasonic waves.
- Get insight into the communication system through fiber optics.
- Learn the applications of LASER, Ultrasonic and Fiber optics in the medical field and to appreciate the contemporary issues.
- Demonstrate the ideas of quantum nature and ultrasonic waves-LAB
- Carry out a mini project in the abovementioned topics-J COMPONENT

Module:1	Quantum Physics	7 hours

Dual nature of electromagnetic radiation, Compton effect (Qualitative), experimental verification-deBroglie waves- Davisson-Germer Experiment, Heisenberg uncertainty principle - Schrödinger equation.

Module:2	Applications of Quantum Physics	6 hours

Particle in a 1-D box (Eigen Value and Eigen Function), 3-D Analysis (Qualitative), Tunneling Effect (Qualitative), Scanning Tunneling Microscope, Atomic Force Microscope.

Module:3	Nanotechnology	6 hours

Introduction to Nano-materials, Properties of Nano-materials, Bionanomaterials, membranes, electrical properties of nano membranes, CNT, Applications of nanobiotechnology- longer-lasting medical implants, nanodrugs

Module:4	Lasers	6 hours

Laser characteristics, Einstein's theory of stimulated emission, pumping mechanisms-population inversion, three-level, four-level lasers, Nd-YAG, He-Ne-laser, CO2 laser.

Module:5	Ultrasonics	6 hours

Properties of ultrasonics, generation- Magnetostriction method, Piezoelectric method, detection of ultrasonics.

Module:6	Fiber Optics	6 hours

Light propagation through fiber, Acceptance angle, numerical aperture, types of fiber.

Module:7	Application of Lasers, Ultrasonics and Fiber Optics	6 hours

Laser in surgery, ophthalmology, dentistry, ultrasonogram, POT-sensors- fiber-optic- biosensors, keyhole surgery.

Module:8	Contemporary issues	2 hours

Lecture by Industry Experts

	Total Lecture hours:	**45 hours**

Text Book(s)

- Concepts of Modern Physics, Arthur Besier, Shobhit Mahajan, S. Rai Choudhury, 7th Edition, Tata - McGraw
- Laser Fundamentals, William Silfvast, 2nd edition, Cambridge University Press, Cambridge. 2008 [a Classic book on the subject of Laser]
- Fiber Optic Communication Technology, Djafar K. Mynbaev, and Lowell L. Scheiner, Addison Wesley Longman, Singapore, 2011
- Ultrasonics: Fundamentals, Technologies, and Application, Dale Ensminger, Leonard J. Bond, 3rd Edition, CRC Press, London, 2011

Reference Books

- Modern Physics, Raymond A. Serway, Clement J. Mosses, Curt A. Moyer, 3rd Edition, Cengage Learning, Boston, 2010
- Laser Systems and Applications, Nityanand Choudhary and Richa Verma, PHI Learning Private Ltd., New Delhi, 2011
- Lasers and Optical Instrumentation, S. Nagabhushana and B. Sathyanarayana, I.K. International Publishing House Pvt. Ltd., New Delhi, 2010
- Fundamentals and Applications of Ultrasonic Waves, J. David N. Cheeke, 2nd Edition, CRC Press, London, 2012

Mode of Evaluation: Quizzes, Digital Assignments, CAT-I and II and FAT			
Recommended by Board of Studies	13.05.2017		
Approved by Academic Council	No. 45	Date	15.06.2017

List of Challenging Experiments (Indicative)

1.	Calculation of interplanar spacing of polycrystalline graphite from electron diffraction pattern (Module 1)	2 hrs
2.	Fabry Perot Interferometer: Determination of wavelength of the laser beam and finding spacing of the etalon (Module 4)	2 hrs
3.	Determination of wavelength of the laser source (He-Ne laser and diode lasers of different wavelengths) using diffraction technique (Module 4)	2 hrs
4.	Integrated optics: Determination of refractive index of the prism (Module 6)	2 hrs
5.	Determination of refractive index of various liquids (Module 6)	2 hrs
6.	Optical Fiber Characterization: determination of numerical aperture of a given multimode optical fiber (Module 6)	2 hrs
7.	Determination of the size of the fine particle using laser diffraction (Module 4)	2 hrs
8.	Determination of the track width (periodicity) in a written CD (Module 4)	2 hrs
9.	Analysis of crystallite size and strain in a nano-crystalline film using a given X-ray diffraction pattern (Module 3)	2 hrs
10.	Ultrasonic interferometer: Determination of velocity of the ultrasonic wave in different liquids and its adiabatic compressibility (Module 5)	2 hrs
11.	Numerical solutions of Schrödinger equation (e.g., particle in a box problem) (can be given as an assignment) (Module 1)	2 hrs
12.	Exploring the link between quantum confinement and Heisenberg's uncertainty principle (can be given as assignment). (Module 1+3)	2 hrs
	Total Laboratory Hours	24 hrs

Recommended by Board of Studies	13.05.2017		
Approved by Academic Council	No. 45	Date	15.06.2017

Course code	ESPAÑOL FUNDAMENTAL	L	T	P	J	C
ESP1001		2	0	0	0	2
Pre-requisite	None	Syllabus version				
		1.1				

Course Objectives:

The course gives students the necessary background to:

- Demonstrate proficiency in reading, writing, and speaking in basic Spanish. Learning vocabulary related to profession, education centers, day-today activities, food, culture, sports and hobby, the family set up, workplace, market, and classroom activities is essential.
- Demonstrate the ability to describe things and will be able to translate into English and vice versa.
- Describe in simple terms (both in written and oral form) aspects of their background, immediate environment, and matters in areas of immediate need.

Expected Course Outcome:

The students will be able to

- Remember greetings, giving personal details and Identify genders by using correct articles
- Apply the correct use of SER, ESTAR and TENER verb for describing people, place, and things
- Create opinion about time and weather conditions by knowing months, days and seasons in Spanish
- Create opinion about people and places by using regular verbs
- Apply reflexive verbs for writing about the daily routine and create small paragraphs about hometown, best friend and family

Module:1	Abecedario, Saludos y Datos personales: Origen, Nacionalidad, Profesión	**3 hours**

Competencia Gramática: Vocales y Consonantes. Artículos definidos e indefinidos (Numero y Genero). Competencia Escrita: Saludos y Datos personales

Module:2	Edad y posesión. Números (1-20)	**3 hours**

Competencia Gramática: Pronombres personales. Adjetivos. Los verbos SER y TENER. Competencia Escrita: Escribe sobre mismo/a y los compañeros de la clase

Module:3	Vocabulario de Mi habitación. Colores. Descripción de lugares y cosas.	**5 hours**

Competencia Gramática: Adjetivos posesivos. El uso del verbo ESTAR. Diferencia entre SER y ESTAR.

Competencia Escrita: Mi habitación

Module:4	Mi familia. Números (21-100). Direcciones. Expresar la hora. Los meses del año.	**4 hours**

Competencia Gramática: Frases preposicionales. Uso del HAY. La diferencia entre MUY y MUCHO. Uso del verbo GUSTAR Competencia Escrita: Mi familia. Dar opiniones sobre tiempo

Module:5	Expresar fechas y el tiempo. Dar opiniones sobre personas y lugares.	**5 hours**

Competencia Gramática: Los verbos regulares (-AR, -ER, -IR) en el presente. Adjetivos demostrativos.

Competencia Escrita: Mi mejor amigo/a. Expresar fechas. Traducción ingles a español y Español a Ingles.

Module:6	Describir el diario. Las actividades cotidianas.	**3 hours**
Competencia Gramática: Los Verbos y pronombres reflexivos. Los verbos pronominales con e/ie, o/ue, e/i, u/ue. Competencia Escrita: El horario. Traducción ingles a español y Español a Ingles.		
Module:7	Dar opiniones sobre comidas y bebidas. Decir lo que está haciendo. Describir mi ciudad y Ubicar los sitios en la ciudad.	**5 hours**
Competencia Gramática: Los verbos irregulares. Estar + gerundio. Poder + Infinitivo. Competencia Escrita: Conversación en un restaurante. Traducción ingles a español y Español a Ingles. Mi ciudad natal. Mi Universidad. La clase. Mi fiesta favorita.		
Module:8	**Contemporary issues**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**30 hours**
Text Book(s)		
•	**Text Book**:**"Aula Internacional 1", Jaime Corpas, Eva Garcia, Agustin Garmendia, Carmen Soriano Goyal Publication ; reprinted Edition, (2010)**	
Reference Books		
•	"¡AcciónGramática!", Phil Turk and Mike Zollo, Hodder Murray, London 2006.	
•	"Practice makes perfect: Spanish Vocabulary," Dorothy Richmond, McGraw Hill Contemporary, USA,2012.	
•	"Practice makes perfect: Basic Spanish," Dorothy Richmond, McGraw Hill Contemporary, USA 2009.	
•	"Pasaporte A1 Foundation", Matilde Cerrolaza Aragón, Óscar Cerrolaza Gili, Begoña Llovet Barquero, Edelsa Grupo, España, 2010.	

Recommended by Board of Studies	22-02-2016		
Approved by Academic Council	No. 41	Date	17-06-2016

Course code	Français Progressif	L	T	P	J	C
FRE2001		2	0	1	0	3
Pre-requisite	Français quotidian	Syllabus version				

Course Objectives:

The course gives students the necessary background to:

- Understand isolated sentences and frequently used expressions in relation to immediate priority areas (personal or family information, shopping, close environment, work).
- Communicate in simple and routine tasks requiring only a simple and direct exchange of information on familiar and habitual topics.
- Enable students to describe with simply means his training, his immediate environment and evoke familiar and habitual subjects, evoke subjects that correspond to immediate needs.

Expected Course Outcome:

The students will be able to :

- Understand expressions in French.
- Create sentences by using frequent lexicon related to himself, his family, his close environment (family, shopping, work, school, etc).
- Understand simple, clear messages on the internet, authentic documents.
- Analyze predictable information in common documents, such as advertisements, flyers, menus, schedules, simple personal letters.
- Create simple and routine tasks.
- Create a simple and direct exchange of information on familiar activities and topics.

Module:1	Expressions simples	8 hours

La vie quotidiennes - Le verbe pronominal - Le passé composé avec l'auxiliaire - avoir et être- le passé récent : venir de + infinitif - Le comparatif - Le superlatif - Les mots interrogatifs (les trois formes)
Savoir-faire pour : Faire des achats, faire des commandes dans un restaurant, poser des questions.

Module:2	Les activitiés quotidiennes	6 hours

La vie privée et publique (Les achats, Les voyages, les transports-La nourriture, etc.) - Les lieux de la ville - Les mots du savoir-vivre - Les pronoms indéfinis - Les pronoms démonstratifs - Les pronoms compléments objets directs/ indirects - La formation du future simple et future proche
Savoir-faire pour : Réserver les billets pour le voyage, réserver les chambres dans un hôtel, S'informer sur les lieux de la ville, indiquer la direction à un étranger.

Module:3	Les activités de loisirs	7 hours

Les loisirs (sports/spectacles/activités) - Les moments de la journée, de l'année- La fête indienne et française – Les goûts - L'impératif - La négation de l'impératif-La place du pronom à l'impératif avec un verbe pronominal.
Savoir-faire pour : Parler de ses goûts, raconter les vacances, formuler des phrases plus compliquées, Raconter les souvenirs de l'enfance, parler sur la tradition de son pays natal.

Module:4	La Francophonie	7 hours

L'espace francophone - Première approche de la société française – La consommation alimentaire – caractériser un objet – décrire une tenue - Le pronom relatif (qui/que/dont/où)
Savoir-faire pour :
Articles de la presse-Portrait d'une personne-Cartes et messages d'invitation, d'acceptation ou de refus -Article de presse - rédaction d'un événement.

Module:5	**La culture française**	**5 hours**
Parler de ses activités quotidiennes - les fêtes en France – Parler de sa famille – réserver un billet à l'agence - la gastronomie française		
Module:6	**La description**	**5 hours**
Décrire physiquement une personne – les vacances – les achats – réserver une chambre dans un hôtel – les plus grands français - raconter des évènements passés		
Module:7	**S'exprimer**	**5 hours**
Parler du climat - parcours francophone – placer une commande au restaurant –- la mode - parler de son projet d'avenir.		
Module:8	**Contemporary issues**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**45 hours**

Text Book(s)	
•	Alter Ego 1, Méthode de français, Annie Berthet, Hachette, Paris 2010.
•	Alter Ego 1, Cahier d'exercices, Annie Berthet, Hachette, Paris 2010.
Reference Books	
•	CONNEXIONS 1, Méthode de français, Régine Mérieux, Yves Loiseau,Les Éditions Didier, 2010.
•	CONNEXIONS 1, Le cahier d'exercices, Régine Mérieux, Yves Loiseau, Les Éditions Didier, 2010
•	Fréquence jeunes-1, Méthode de français, G. Capelle et N.Gidon, Hachette, Paris, 2010.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	22-02-2016		
Approved by Academic Council	No.41	Date	17-06-2016

Course code	Grundstufe Deutsch	L	T	P	J	C
GER1001		2	0	0	0	2
Pre-requisite	None	Syllabus version				
		1				

Course Objectives:

The course gives students the necessary background to:

- Demonstrate proficiency in reading, writing, and speaking in basic German. Learning vocabulary related to profession, education centers, day-to-day activities, food, culture, sports and hobby, the family set up, workplace, market, and classroom activities are essential.
- Make the student's industry-oriented and make them adapt to the German culture.

Expected Course Outcome:

The students will be able to

- Remember greeting people, introducing oneself, and understanding basic expressions in German.
- Understand necessary grammar skills to use these in a meaning way.
- Remember beginner's level vocabulary
- Create sentences in German on a variety of topics with significant precision and detail.
- Apply good comprehension of written discourse in areas of special interests.

Module:1		3 hours

Begrüssung, Landeskunde, Alphabet, Personalpronomen, Verben- heissen, kommen, wohnen, lernen, Zahlen (1-100), W-Fragen, Aussagesätze, Nomen- Singular und Plural, der Artikel -Bestimmter- Unbestimmter Artikel)

Lernziel :

Sich vorstellen, Grundlegendes Verständnis von Deutsch, Deutschland in Europa

Module:2		3 hours

Konjugation der Verben (regelmässig /unregelmässig),das Jahr- Monate, Jahreszeiten und die Woche, Hobbys, Berufe, Artikel, Zahlen (Hundert bis eine Million), Ja-/Nein- Frage, Imperativ mit ,,Sie''

Lernziel:

Sätze schreiben, über Hobbys, Berufe erzählen, usw

Module:3		6 hours

Possessivpronomen, Negation, Kasus (Bestimmter- Unbestimmter Artikel) Trennbareverben, Modalverben, Uhrzeit, Präpositionen, Lebensmittel, Getränkeund Essen, Farben, Tiere

Lernziel :

Sätze mit Modalverben, Verwendung von Artikel, Adjektiv beim Verb

Module:4		4 hours

Übersetzung: (Deutsch – Englisch / Englisch – Deutsch)

Lernziel :

Die Übung von Grammatik und Wortschatz

Module:5		5 hours

Leserverständnis. Mindmap machen, Korrespondenz- Briefe und Email

Lernziel:

Übung der Sprache, Wortschatzbildung		
Module:6		**5 hours**
Aufsätze : Die Familie, Bundesländer in Deutschland, Ein Fest in Deutschland, **Lernziel :** Aktiver, selbständiger Gebrauch der Sprache		
Module:7		**4 hours**
Dialoge: a) Gespräche mit einem/einer Freund /Freundin. b) Gespräche beim Einkaufen ; in einem Supermarkt ; in einer Buchhandlung ; c) in einem Hotel - an der Rezeption ; ein Termin beim Arzt. d) Ein Telefongespräch ; Einladung–Abendessen		
Module:8	**Contemporary issues**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**30 hours**

Text Book(s)	
•	Netzwerk Deutsch als Fremdsprache A1, Stefanie Dengler, Paul Rusch, Helen Schmtiz, Tanja Sieber, Klett-Langenscheidt Verlag, München : 2013
Reference Books	
• .	Lagune, Hartmut Aufderstrasse, Jutta Müller, Thomas Storz, 2012.
•	Deutsche Sprachlehre für Ausländer, Heinz Griesbach, Dora Schulz, 2013
•	Studio d A1, Hermann Funk, Christina Kuhn, CorneslenVerlag, Berlin :2010
•	Tangram Aktuell-I, Maria-Rosa, SchoenherrTil, Max Hueber Verlag, Muenchen :2012
	www.goethe.de wirtschaftsdeutsch.de hueber.de klett-sprachen.de www.deutschtraning.org

Mode of Evaluation: CAT / Assignment / Quiz / FAT			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	No. 41	Date	17-06-2016

Course code	ESPAÑOL INTERMEDIO	L	T	P	J	C
ESP2001		2	0	2	0	3
Pre-requisite		Syllabus version				
		1.1				

Course Objectives:

The course gives students the necessary background to:

- Enable students to read, listen and communicate in Spanish in their day to day life.
- Enable students to describe situations by using present, past, and future tenses in Spanish.
- Enable to develop comprehension skill in Spanish language.

Expected Course Outcome:

The students will be able to

- Create sentences in near future and future tenses and correctly using the prepositions like POR and PARA
- Create sentences in preterito perfecto and correctly use the direct and indirect object pronouns
- Create sentences related to likes and dislikes and also give commands in a formal and informal way
- Create sentences in past tense by using imperfecto and idefinido forms and describe past events
- Create conversations in Spanish at places like restaurants, hotels, Shops and Railway stations
- Understand different Spanish speaking countries and its culture and traditions.

Module:1	Números (101 – 1 millón). Expresar los planes futuros. Los números ordinales.	7 hours

Competencia Gramática: Futuros cercanos (Ir+a+Infinitivo). Futuros (Verbos regulares e irregulares). Uso del POR y PARA.
Competencia Escrita: Traducción ingles a español y español a Ingles.
Comprensión - Los textos y Videos

Module:2	Las ropas, colores y tamaños. Costar, valer, descuentos y rebajas	8 hours

Competencia Gramática: Pronombres objetivos directos e indirectos. El verbo Gustar y Disgustar.
Competencia Escrita: Traducción ingles a español y español a Ingles. Comprensión - Los textos y Videos

Module:3	Escribir un Correo electrónico formal e informal.	7 hours

Competencia Gramática: Imperativos formales e informales. Pretérito perfecto.
Competencia Escrita: Traducción ingles a español y español a Ingles.
Comprensión - Los textos y Videos

Module:4	Currículo Vitae. Presentarse en una entrevista informal.	6 hours

Competencia Gramática: Pretérito imperfecto. Pretérito indefinido.
Competencia Escrita: Traducción ingles a español y español a Ingles.
Comprensión - Los textos y Videos

Module:5	Introducción personal, Expresar los planes futuros.	5 hours

Comprensión oral: Introducción personal, Expresar los planes futuros. ¿Qué vas a hacer en las próximas vacaciones?

Comprensión auditiva: Las preguntas sobre un cuento auditivo. Relacionar el audio con las imágenes. Las preguntas basadas en canciones. Medio de transporte: Comprar y Reservar billetes.		
Module:6	**Diálogos entre dos**	**5 hours**
Comprensión oral: Diálogos entre dos (cliente y tendero de ropas, pasajero y empleado, en un restaurante, Reservación de habitación en un hotel). Presentación en una entrevista. Comprensión auditiva: Las preguntas basadas en canciones. Las preguntas basadas en diálogos.		
Module:7	**Presentación de los países hispánicos.**	**5 hours**
Comprensión oral: Dialogo entre un médico y paciente. Presentación de los países hispánicos. Describir su infancia. Describir vacaciones últimas o las actividades de último fin de semana. Comprensión auditiva: Rellenar los blancos del cuento en pasado. Las preguntas basadas en el cuento. Las preguntas basadas en un anuncio		
Module:8	**Contemporary issues**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**45 hours**

Text Book(s)

•	"Aula Internacional 1", Jaime Corpas, Eva Garcia, Agustin Garmendia, Carmen Soriano Goyal Publication; reprinted Edition, Delhi (2010)

Reference Books

•	"¡AcciónGramática!", Phil Turk and Mike Zollo, Hodder Murray, London 2006.
•	"Practice makes perfect: Spanish Vocabulary", Dorothy Richmond, McGraw Hill Contemporary, USA,2012.
•	"Practice makes perfect: Basic Spanish", Dorothy Richmond, McGraw Hill Contemporary, USA 2009.
•	"Pasaporte A1 Foundation", Matilde Cerrolaza Aragón, Óscar Cerrolaza Gili, Begoña Llovet Barquero, Edelsa Grupo, España, 2010.
	Authors, book title, year of publication, edition number, press, place

Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	No. 41	Date	17-06-2016

Course code	Introduction to Soft skills	L	T	P	J	C
STS 1021		3	0	0	0	1
Pre-requisite	None			Syllabus version		

Course Objectives:

- To enhance critical thinking and innovative skills
- To have a working knowledge of communicating in English
- To have critical thinking and innovative skills

Expected Course Outcome:

- Students will be able to exhibit appropriate presentation skills
- Students will be able to exhibit appropriate analytical skills
- The students will be able to deliver impactful presentations

Module:1	Lessons on excellence	10 hours

Ethics and integrity

Importance of ethics in life, Intuitionism vs. Consequentialism, Non-consequentialism, Virtue ethics vs. situation ethics, Integrity - listen to conscience, Stand up for what is right

Change management

Who moved my cheese?, Tolerance of change and uncertainty, Joining the bandwagon, Adapting change for growth - overcoming inhibition

How to pick up skills faster?

Knowledge vs. skill, Skill introspection, Skill acquisition, "10,000 hours rule" and the converse

Habit formation

Know your habits? How habits work? - The scientific approach, How habits work? - The psychological approach, Habits and professional success, "The Habit Loop," Domino effect, Unlearning a bad habit

Analytic and research skills.

Focused and targeted information seeking, How to make Google work for you, Data assimilation

Module:2	Team skills	11 hours

Goal setting

SMART goals, Action plans, Obstacles -Failure management

Motivation

Rewards and other motivational factors, Maslow's hierarchy of needs, Internal and external motivation

Facilitation

Planning and sequencing, Challenge by choice, Full Value Contract (FVC), Experiential learning cycle, Facilitating the Debrief

Introspection

Identify your USP, Recognize your strengths and weakness, Nurture strengths, Fixing weakness, Overcoming your complex, Confidence building

Trust and collaboration

Virtual Team building, Flexibility, Delegating, Shouldering responsibilities

Module:3	Emotional Intelligence	12 hours

Transactional Analysis

Introduction**,** Contracting, Ego states**,** Life positions

Brain storming

Individual Brainstorming, Group Brainstorming, Stepladder Technique, Brain writing, Crawford's Slip

writing approach, Reverse brainstorming, Star bursting, Charlette procedure, Round robin brainstorming

Psychometric Analysis

Skill Test, Personality Test

Rebus Puzzles/Problem Solving

More than one answer, Unique ways

Module:4	**Adaptability**	**12 hours**

Theatrix

Motion Picture, Drama, Role Play, Different kinds of expressions

Creative expression

Writing, Graphic Arts, Music, Art and Dance

Flexibility of thought

The 5'P' framework (Profiling, prioritizing, problem analysis, problem-solving, planning)

Adapt to changes(tolerance of change and uncertainty)

Adaptability Curve, Survivor syndrome

	Total Lecture hours:	**45 hours**

Text Book(s)

- Chip Heath, How to Change Things When Change Is Hard (Hardcover**)**, 2010, First Edition, Crown Business.
- Karen Kindrachuk, Introspection**,** 2010, 1st Edition.
- Karen Hough, The Improvisation Edge: Secrets to Building Trust and Radical Collaboration at Work, 2011, Berrett-Koehler Publishers

Reference Books

- Gideon Mellenbergh, A Conceptual Introduction to Psychometrics: Development, Analysis, and Application of Psychological and Educational Tests, 2011, Boom Eleven International.
- Phil Lapworth, An Introduction to Transactional Analysis, 2011, Sage Publications (CA)

Mode of Evaluation: FAT, Assignments, Projects, Case studies, Roleplays,3 Assessments with Term End FAT (Computer Based Test)

Recommended by Board of Studies		09-06-2017	
Approved by Academic Council	No. 45	Date	15-06-2017

STS1022	Introduction to Personal Skills	L	T	P	J	C
		3	0	0	0	1
Pre-requisite		**Syllabus version**				
		2				

Course Objectives:

1. 1. To Identify and develop personal skills to become a more effective team member/leader.
2. To Examine, Clarify and apply positive values and ethical principles.
3. To Develop habits which promote good physical and mental health.

Expected Course Outcome:

- Enabling students to exhibit appropriate presentation and analytical skills

Module:1	**Presentation skills – Preparing presentation and Organizing materials and Maintaining and preparing visual aids and Dealing with questions**	**7 hours**

10 Tips to prepare PowerPoint presentation, Outlining the content, Passing the Elevator Test, Blue sky thinking, Introduction , body and conclusion, Use of Font, Use of Color, Strategic presentation, Importance and types of visual aids, Animation to captivate your audience, Design of posters, Setting out the ground rules, Dealing with interruptions, Staying in control of the questions, Handling difficult questions

Module:2	**Analytical Writing – Articulate and support complex ideas**	**6 hours**

30 minute - Analyse an Issue, 30 minute - Analyse an Argument, Construct and Evaluate arguments, Focused and Coherent discussion

Module:3	**Speed Reading and Things to avoid during speed reading**	**6 hours**

Skimming, Meta guiding, Auditory reading, Visual reading, Eye span expansion, Pareto principle, Applications of Pareto principle, Sub-vocalization, Regression, Pen Tracing

Module:4	**Debate**	**8 hours**

Idea generation, Research, Articulating, Style, Preparation of arguments –Rebuttal, Use of statistics, Practice rounds

Module:5	**PEST Analysis**	**7 hours**

SLEPT, STEEPLE, 360 Feedback

Module:6	**Lean Concepts**	**3 hours**

Product life cycle, Waste reduction, Technology change, Product support

Module:7	**Listening**	**8 hours**

Types of Listening, Hearing, Focus, Voice, Verbal and Non-verbal messages

	Total Lecture hours:	**45 hours**

Reference Books

1. Dale Carnegie,(1936) How to Win Friends and Influence People. New York City. Gallery Books
2. Joyce Aemstrong and Carroll(1992) Integrated Teaching of Reading, Writing, Listening, Speaking, Viewing and Thinking. Korea. Libraries Unlimited Inc.
3. Theo Theobald(2011) Develop your Presentation Skills. New Delhi. Kogan Page Limited.

Websites:			
www.chalkstreet.com www.skillsyouneed.com www.mindtools.com www.thebalance.com www.eguru.ooo			
Mode of Evaluation: FAT, Assignments, Projects, Case studies, Role plays, 3 Assessments with Term End FAT (Computer Based Test)			
Recommended by Board of Studies	09-06-2017		
Approved by Academic Council	No. 45	Date	15-06-2017

STS2021	Fundamentals of Aptitude	L	T	P	J	C
		3	0	0	0	1
Pre-requisite		Syllabus version				
		2.0				

Course Objectives:

1 To develop the students' vocabulary knowledge
2 To learn the strategies of solving quantitative ability problems
3 3 To enrich the verbal ability of the students
4 To enhance students communication skills

Expected Course Outcome:

- To open up the wide area of social interaction and improving business vocabulary.

Module:1	**Building personal lexicon**	**6 hours**
Benefits of becoming a logophile, Etymology – Root words, Prefix and suffix, Cue card technique, Mnemonic technique of learning words, word games		
Module:2	**Social interaction**	**4 hours**
Accountability, Commitment, Interdependency		
Module:3	**Audit**	**6 hours**
Questioning, IT auditing, System audit, Process audit, Audit cycle, Quality audit		
Module:4	**Thinking Skills and Introduction to problem solving process and Introduction to decision making and decision making process**	**6 hours**
Steps to solve the problem, Simplex process, Steps involved from identification to implementation, Decision making model		
Module:5	**Quantitative ability – Speed Maths**	**8 hours**
Multiplication Shortcuts, Cubes and squares, Cube root and square root, Vedic maths, Maths magic, puzzles, Brain teasers		
Module:6	**Logical ability – Logical Links**	**3 hours**
Logic based questions-based on numbers and alphabets		
Module:7	**Verbal ability – Strengthening Grammar Fundamentals**	**6 hours**
Parts of speech, Tenses, Verbs(Gerunds and infinitives)		
Module:8	**Communication and Attitude – Self managing:**	**6 hours**
Concepts of self management and self motivation, Greet and Know, Choice of words, Giving feedback, Taking criticism		
	Total Lecture hours:	**45 hours**

Reference Books

1. David Allen (2002) Getting Things done : The Art of Stress -Free productivity. New York City. Simon and Schuster.
2. M. Tyra (2013) Magical Book On Quicker Maths. New Delhi. BSC Publishing
3. FACE(2016) Aptipedia Aptitude Encyclopedia. Delhi. Wiley publications
4. ETHNUS(2013) Aptimithra. Bangalore. sMcGraw-Hill Education Pvt. Ltd.

Websites:			
1.	www.chalkstreet.com		
2.	www.skillsyouneed.com		
3.	www.mindtools.com		
4.	www.thebalance.com		
5.	www.eguru.ooo		
Mode of Evaluation: FAT, Assignments, Projects, Case studies, Role plays, 3 Assessments with Term End FAT (Computer Based Test)			
Recommended by Board of Studies	09-06-2017		
Approved by Academic Council	No. 45	Date	15-06-2017

STS2022	Introduction to Business Communication	L	T	P	J	C
		3	0	0	0	1
Pre-requisite	**None**	**Syllabus version**				
		2.0				

Course Objectives:

1 To develop the students' logical thinking skills
2 To learn the strategies of solving quantitative ability problems 3 To enrich the verbal ability of the students

Expected Course Outcome:

- Enabling students enhance knowledge of relevant topics and evaluate the information

Module:1	**Study skills**	**10 hours**

Memory techniques
Relation between memory and brain, Story line technique, Learning by mistake, Image-name association, Sharing knowledge, Visualization
Concept map
Mind Map, Algorithm Mapping, Top down and Bottom Up Approach
Time management skills
Prioritization - Time Busters, Procrastination, Scheduling, Multitasking, Monitoring
6. Working under pressure and adhering to deadlines

Module:2	**Emotional Intelligence (Self Esteem)**	**6 hours**

Empathy
Affective Empathy and Cognitive Empathy
Sympathy
Level of sympathy (Spatial proximity, Social Proximity, Compassion fatigue)

Module:3	**Business Etiquette**	**9 hours**

Social and Cultural Etiquette
Value, Manners, Customs, Language, Tradition
Writing Company Blogs
Building a blog, Developing brand message, FAQs', Assessing Competition
Internal Communications
Open and objective Communication, Two way dialogue, Understanding the audience
Planning
Identifying, Gathering Information, Analysis, Determining, Selecting plan, Progress check, Types of planning
Writing press release and meeting notes
Write a short, catchy headline, Get to the Point –summarize your subject in the first paragraph, Body – Make it relevant to your audience

Module:4	**Quantitative Ability**	**4 hours**

Numeracy concepts
Fractions, Decimals, Bodmas, Simplifications, HCF, LCM, Tests of divisibility

Beginning to Think without Ink Problems solving using techniques such as: Percentage, Proportionality, Support of answer choices, Substitution of convenient values, Bottom-up approach etc.			
Module:5	**Reasoning Ability**		**3 hours**
Interpreting Diagramming and sequencing information Picture analogy, Odd picture, Picture sequence, Picture formation, Mirror image and water image			
Module:6	**Verbal Ability**		**3 hours**
Reinforcements of Grammar concepts Subject Verb Agreement, Active and Passive Voice, Reported Speech			
Module:7	**Communication and Attitude**		**10 hours**
Writing Writing formal & informal letters, How to write a blog & knowing the format, Effective ways of writing a blog, How to write an articles & knowing the format, Effective ways of writing an articles, Designing a brochures Speaking skills How to present a JAM, Public speaking			
	Total Lecture hours:		**45 hours**

Text Book(s)	
1.	FACE, Aptipedia, Aptitude Encyclopedia, 2016, First Edition, Wiley Publications, Delhi.
2.	ETHNUS, Aptimithra, 2013, First Edition, McGraw-Hill Education Pvt. Ltd.
Reference Books	
1.	Alan Bond and Nancy Schuman, 300+ Successful Business Letters for All Occasions, 2010, Third Edition, Barron's Educational Series, New York.
2.	Josh Kaufman, The First 20 Hours: How to Learn Anything ... Fast , 2014, First Edition, Penguin Books, USA.

Mode of Evaluation: FAT, Assignments, Projects, Case studies, Role plays, 3 Assessments with Term End FAT (Computer Based Test)			
Recommended by Board of Studies	09-06-2017		
Approved by Academic Council	No. 45	Date	15-06-2017

STS3021	Reasoning Skill Enhancement	L	T	P	J	C
		3	0	0	0	1
Pre-requisite	**None**	**Syllabus version**				
		2.0				

Course Objectives:

1. To accomplish a very specific and measurable terms that supports social media and interaction.
2. To cultivate a positive outlook on responsibility, Delegation and Compliance.
3. To enhance their Quantitative, reasoning and Verbal ability.

Expected Course Outcome:

- Understanding the various strategies of conflict resolution among peers and supervisors and respond appropriately

Module:1	**Social Interaction and Social Media**	**6 hours**

Effective use of social media
Types of social media, Moderating personal information, Social media for job/profession, Communicating diplomatically
Networking on social media
Maximizing network with social media, How to advertise on social media
Event management
Event management methods, Effective techniques for better event management
Influencing
How to win friends and influence people, Building relationships, Persistence and resilience, Tools for talking when stakes are high
Conflict resolution
Definition and strategies , Styles of conflict resolution

Module:2	**Non Verbal Communication**	**6 hours**

Proximecs
Types of proximecs, Rapport building Reports and Data Transcoding Types of reports
Negotiation Skill
Effective negotiation strategies
Conflict Resolution
Types of conflicts

Module:3	**Interpersonal Skill**	**8 hours**

Social Interaction
Interpersonal Communication, Peer Communication, Bonding, Types of social interaction
Responsibility
Types of responsibilities, Moral and personal responsibilities
Networking
Competition, Collaboration, Content sharing
Personal Branding
Image Building, Grooming, Using social media for branding

Delegation and compliance Assignment and responsibility, Grant of authority, Creation of accountability		
Module:4	**Quantitative Ability**	**10 hours**
Number properties Number of factors, Factorials, Remainder Theorem, Unit digit position, Tens digit position Averages Averages, Weighted Average Progressions Arithmetic Progression, Geometric Progression, Harmonic Progression Percentages Increase & Decrease or successive increase Ratios Types of ratios and proportions		
Module:5	**Reasoning Ability**	**8 hours**
Analytical Reasoning Data Arrangement(Linear and circular & Cross Variable Relationship), Blood Relations, Ordering/ranking/grouping, Puzzle test, Selection Decision table		
Module:6	**Verbal Ability**	**7 hours**
Vocabulary Building Synonyms & Antonyms, One word substitutes, Word Pairs, Spellings, Idioms, Sentence completion, Analogies		
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	FACE, Aptipedia Aptitude Encyclopedia, 2016, First Edition, Wiley Publications, Delhi.
2.	ETHNUS, Aptimithra, 2013, First Edition, McGraw-Hill Education Pvt.Ltd.
3.	Mark G. Frank, David Matsumoto, Hyi Sung Hwang, Nonverbal Communication: Science and Applications, 2012, 1st Edition, Sage Publications, New York.

Reference Books

1.	Arun Sharma, Quantitative aptitude, 2016, 7th edition, Mcgraw Hill Education Pvt. Ltd.
2.	Kerry Patterson, Joseph Grenny, Ron McMillan, Al Switzler, Crucial Conversations: Tools for Talking When Stakes are High, 2001, 1st edition McGraw Hill Contemporary, Bangalore.
3.	Dale Carnegie, How to Win Friends and Influence People, Latest Edition, 2016. Gallery Books, New York.

Mode of evaluation: FAT, Assignments, Projects, Case studies, Role plays, 3 Assessments with Term End FAT (Computer Based Test)			
Recommended by Board of Studies	09-06-2017		
Approved by Academic Council	No. 45	Date	15-06-2017

STS3022	Introduction to Etiquette	L	T	P	J	C
		3	0	0	0	1

Pre-requisite	None	Syllabus version
		2.0

Course Objectives:

1. To learn how to analyze social psychological phenomena in terms of impression management.
2. To apply the skills of working collaboratively with others.
3. To strengthen quantitative, reasoning and verbal ability.

Expected Course Outcome:

Creating in the students an understanding of decision making models and generating alternatives using appropriate expressions.

Module:1	Impression Management	8 hours

Types and techniques
Importance of impression management,Types of impression management, Techniques and case studies,Making a good first impression in an interview (TEDOS technique) , How to recover from a bad impressions/experience,Making a good first impression online
Non-verbal communication and body language
Dressing, Appearance and Grooming,Facial expression and Gestures, Body language (Kinesics), Keywords to be used, Voice elements (tone, pitch and pace)

Module:2	Group Discussion	4 hours

1.Awareness 2.Information gathering 3.Intuition about speaker 4.Structuring thoughts 5.Articulation

Module:3	Beyond Structure	4 hours

Art of questioning
How to frame questions, Blooms questioning pyramid, Purpose of questions
Etiquette
Business, Telephone etiquette, Cafeteria etiquette, Elevator etiquette, Email etiquette, Social media etiquette

Module:4	Quantitative Ability	9 hours

Profit and Loss
Cost Price & Selling Price, Margins & Markup
Interest Calculations
Simple Interest, Compound Interest, Recurring
Mixtures and solutions
Ratio & Averages, Proportions

Time and Work Pipes & Cisterns, Man Day concept, Division Wages Time Speed and Distance Average speed, Relative speed, Boats and streams. Proportions & Variations		
Module:5	**Reasoning Ability**	**11 hours**
Logical Reasoning Sequence and series, Coding and decoding, Directions Visual Reasoning Abstract Reasoning, Input Type Diagrammatic Reasoning, Spatial reasoning, Cubes Data Analysis And Interpretation DI-Tables/Charts/Text		
Module:6	**Verbal Ability**	**9 hours**
Grammar Spot the Errors,Sentence Correction, Gap Filling Exercise, Sentence Improvisations, Misc. Grammar Exercise		
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Micheal Kallet,Think Smarter: Critical Thinking to Improve Problem-Solving and Decision-Making Skills, April 7, 2014, 1st Edition, Wiley, New Jersey.
2.	MK Sehgal, Business Communication, 2008, 1st Edition, Excel Books,India.
3.	FACE, Aptipedia Aptitude Encyclopedia, 2016, First Edition, Wiley Publications, Delhi.
4.	ETHNUS, Aptimithra, 2013, First edition, McGraw-Hill Education Pvt.Ltd, Banglore.

Reference Books

1.	Andrew J. DuBrin,Impression Management in the Workplace: Research, Theory and Practice, 2010, 1st edition, Routledge.
2.	Arun Sharma, Manorama Sharma, Quantitative aptitude, 2016, 7th edition, McGraw Hill Education Pvt. Ltd, Banglore.
3.	M. Neil Browne, Stuart M. Keeley, Asking the right questions, 2014, 11th Edition, Pearson, London.

Mode of Evaluation: FAT, Assignments, Projects, Case studies, Role plays, 3 Assessments with Term End FAT (Computer Based Test)

Recommended by Board of Studies	09-06-2017		
Approved by Academic Council	No. 45	Date	15-06-2017

STS4021	Preparedness for external opportunities	L	T	P	J	C
		3	0	0	0	1

Pre-requisite	None	Syllabus version
		2.0

Course Objectives:

1. To identify and improve the qualities of resume and interview skills.
2. To enhance the problem solving skills and basic mathematical skills.
3. To generate ideas from sources to develop content.

Expected Course Outcome:

- Enabling students acquire skills for preparing for interviews, presentations and higher education

Module:1	Interview Skills	3 hours

Types of interview
Structured and unstructured interview orientation, Closed questions and hypothetical questions, Interviewers' perspective, Questions to ask/not ask during an interview
Techniques to face remote interviews
Video interview, Recorded feedback , Phone interview preparation
Mock Interview
Tips to customize preparation for personal interview, Practice rounds

Module:2	Resume Skills	4 hours

Resume Template
Structure of a standard resume, Content, color, font
Use of power verbs
Introduction to Power verbs and Write up
Types of resume
Quiz on types of resume
Customizing resume
Frequent mistakes in customizing resume, Layout - Understanding different company's requirement, Digitizing career portfolio

Module:3	Organizational Culture	3 hours

Organizational Culture:
1.Understanding the hierarchy of an organization 2.Adapting to the culture of the work place
3.Meeting industry’s expectation
Company Videos Mock Tests

Module:4	Quantative Ability	14 hours

Permutation-Combinations
Counting, Grouping, Linear Arrangement, Circular Arrangements
Probability
Conditional Probability, Independent and Dependent Events
Geometry and Mensuration
Properties of Polygon, 2D & 3D Figures, Area & Volumes
Trigonometry
Heights and distances, Simple trigonometric functions

Logarithms Introduction, Basic rules Functions Introduction, Basic rules Quadratic Equations Understanding Quadratic Equations, Rules & probabilities of Quadratic Equations Set Theory Basic concepts of Venn Diagram		
Module:5	**Reasoning Ability**	**8 hours**
Logical reasoning Syllogisms, Binary logic, Sequential output tracing, Crypto arithmetic Data Analysis and Interpretation Data Sufficiency Data interpretation-Advanced Interpretation tables, pie charts & bar chats		
Module:6	**Verbal Ability**	**8 hours**
Comprehension and Logic Reading comprehension Para Jumbles Critical Reasoning : Premise and Conclusion, Assumption & Inference, Strengthening & Weakening an Argument		
Module:7	**Writing Skills**	**5 hours**
Note making What is note making, Different ways of note making Report writing What is report writing, How to write a report, Writing a report & work sheet Product description Designing a product, Understanding it's features, Writing a product description Research paper Research and its importance, Writing sample research paper		
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Michael Farra, Quick Resume & Cover letter Book, 2011, 1st Edition, JIST Editors, Saint Paul.
2.	Daniel Flage, An Introduction to Critical Thinking, 2002, 1st Edition, Pearson, London.
Reference Books	
1.	FACE, Aptipedia Aptitude Encyclopedia, 2016, 1st Edition, Wiley Publications, Delhi.
2.	ETHNUS, Aptimithra, 2013, 1st Edition, McGraw-Hill Education Pvt. Ltd.

Mode of Evaluation: FAT, Assignments, Projects, Case studies, Role plays, 3 Assessments with Term End FAT (Computer Based Test)

Recommended by Board of Studies	09-06-2017		
Approved by Academic Council	No. 45	Date	15-06-2017

Course Code	Comprehensive Examination	L	T	P	J	C
MIY4098		0	0	0	0	2
Pre requisite	None	Syllabus version				
		1.00				

Module 1:

Descriptive Statistics – Probability – Inferential Statistics – Linear Algebra – Structured Thinking

Module 2:

Tools (R/Python) - Exploration and Visualization (R/Python) – Feature Selection/ Engineering

Module 3:

Linear Regression-Logistic Regression-Decision Trees-KNN (K- Nearest Neighbours)-K-Means-Naïve Bayes-dimensionality Reduction

Module 4:

Random Forests-Dimensionality Reduction Techniques-Support Vector Machines-Gradient Boosting Machines-XGBOOST

Module 5:

Interactive Visualization -Creating Visualizations

Module 6:

Big Data: Using Smart Big Data, Analytics and Metrics to make better decisions and improve Performance

Module 7

Implement several feature learning/deep learning algorithms- Reinforcement Learning

Recommended by Board of Studies	11.03.2019	
Approved by Academic Council	55	13-06-2019

Course Code	Master's Thesis	L	T	P	J	C
MIY6099						
		0	0	0	0	14
Pre-requisite	As per the academic regulations	Syllabus version				
		1.0				

Course Objectives:

To provide sufficient hands-on learning experience related to the area of specialization with a focus on research orientation

Expected Course Outcome:

At the end of the course, the student will be able to

- Formulate specific problem statements for ill-defined real-life problems with reasonable assumptions and constraints.
- Perform a literature search and/or patent search in the area of interest.
- Design and Conduct experiments
- Perform error analysis /benchmarking/costing
- Synthesize the results and arrive at scientific conclusions
- Document the results in the form of technical report/presentation

Contents

1. It can be a theoretical analysis, modelling & simulation, experimentation & analysis, prototype design, correlation and analysis of data, software development, applied research, and any other related activities.
2. The project can be for one or two semesters based on the completion of the required number of credits as per the academic regulations.
3. It should be individual work.
4. Carried out inside or outside the university, in any relevant industry or research institution.
5. Publications in the peer-reviewed journals / International Conferences will be an added advantage

Mode of Evaluation: Periodic reviews, Presentation, Final oral viva, Poster submission

Recommended by Board of Studies	11.03.2019		
Approved by Academic Council	55	Date	13-06-2019

Programme Core

Course code	Fundamentals of Statistics	L	T	P	J	C
MAT1005		3	0	2	0	4
Pre-requisite	(10+2) level knowledge of Mathematics	Syllabus version				
		1.0				

Course Objectives:

- To acquaint the students with some basic concepts and knowledge of Statistics.
- To develop the foundations of some of the elementary statistical methods of analysis of data

Expected Course Outcomes:

- Students will be able to understand the data , data types, data scales and its measurement
- Students are able to acquire the fundamental knowledge of statistics in terms of definitions, theorems, results, numeric and graphical applications, solutions of basic problems and cases
- Students will be able to analyze: organize, tabulate, manipulate, and normalized the data and datasets.
- Students will be able to evaluate the properties and solutions of various statistical problems, methods, and meaningful applications.
- Students will be able to create, discuss, and share solutions of the problems. Students will be able to apply, the fundamental knowledge of statistics for further higher thinking and development of statistics

Module:1	Introduction to Statistical Data	4 hours	CO: 1

Statistical Methods: Definition and scope of Statistics, concepts of statistical population and sample Data: Quantitative and qualitative, attributes, variables, scales of measurements- nominal, ordinal, interval and ratio. Presentation of Data; Meaning and illustrations of Population and Samples. Finite & infinite population, homogenous population and heterogeneous population, concept of parameter and statistics, random and non - random sample.

Module:2	Table and graphical presentation of data	4 hours	CO: 1

Table presentation of data and different classification of tables Graphical Representation of data Bar-charts, Pie- diagrams- classification of data, frequency histograms, polygon, Ogives

Module:3	Measures of Central Tendency	8 hours	CO: 2

Mathematical Measures: Arithmetic Mean, Geometric Mean, Harmonic Mean, weighted Mean. Positional Measures: Median, Mode; Empirical relations between mean, median and mode; Partition Values: Quartiles, Deciles, Percentiles, IQR (Inter Quartile Range); Merits and demerits.
Illustrations and Numerical problems.

Module:4	Measures of Dispersion	8 hours	CO: 2

Absolute Measure of Dispersion: Range, Quartile deviation, Mean deviation: Mean Square deviation, Variance and standard deviation: Definition, concept, computations, and meanings. Merits and demerits, combined variance, combined standard deviation, generalizations, computations of numerical problems; Relative measures of dispersion: Coefficient of range, coefficient of quartile deviations, coefficient of mean deviation, coefficient of variation (C.V.). Uses, applications and numerical problems.

Module:5	Skewness and Kurtosis	6 hours	CO: 3

Skewness of frequency distribution, Types of Skewness, Measures of Skewness, Types of kurtosis, Measures of Kurtosis. Numerical problems.

Module:6	Moments	5 hours	CO: 4

Central Moments and raw moments for grouped and ungrouped data; Effects of change of origin and scale; Relationship between central and raw moments; Sheppard's correction for moments;

Module:7	Correlation analysis	8 hours	CO: 5

Definition, meaning and concept of correlation meanings and correlation-Scatter diagram and its uses for correlation analysis; Covariance between two variables: Definition, meaning, computations and effect of change of origin and scale; Karl Pearson's coefficient of Correlation (ρ or r): Computations for grouped and ungrouped data. Interpretation of results and Properties.

Module:8	**Contemporary issues:**	**02 hours**	**CO:5**
Lecture by Industry Experts			
	Total Lecture hours:	**45 hours**	

Text Book(s)

- Gupta.S.C. and Kapoor.V.K. (2014): Fundamentals of Mathematical Statistics ,Sultan Chand and sons.
- Agarwal.B.L (2007): Basic statistics , 3/e, New Age International (P) Ltd.
- Medhi.J. (1992): Statistical Methods an Introductory Text , Wiley Eastern Ltd.
- Douglas C. Montgomery, George C. Runger(2018),Applied Statistics and Probability for Engineers, Wiley

Reference Books

- Härdle, Wolfgang; Okhrin, Ostap; Okhrin, Yarema (2017),Basic Elements of computational Statistics, Springer
- Sheldon M.Ross (2006) : Introductory Statistics , 2/e, Elsevier Publications.
- Murray R. Spiegel and Larry J. Stephens (2005): Schaum's Outline of Theory and Problems of Statistics, 3/e, Tata Mc Graw Hill Publishing Company Ltd, New Delhi.

Mode of Evaluation: CAT / Assignment / Quiz / FAT

List of Experiments :

1	Use of random numbers to draw SRSWOR,SRSWR stratified, systematic sampling	5 hrs
2	Graphical and diagrammatic presentation of Statistical Problems	5 hrs
3	Pivot tables ,Tabulation, Parato Diagram	5 hrs
4	Computation of measures of central tendency (ungrouped and grouped data). Use of an appropriate measure and interpretation of results and computation of partition values.	5 hrs
5	Computation measures of dispersion (ungrouped and grouped data).	5 hrs
6	Scatter diagram, correlation coefficient (ungrouped data)	5 hrs
	Total Laboratory Hours	**30 hrs**

Recommended by Board of Studies	11.03.2019		
Approved by Academic Council	No.55	Date	13-06-2019

Course code	Probability and Random Variable	L	T	P	J	C
MAT1018		3	2	0	0	4
Pre-requisite	(10+2) level knowledge of Mathematics	Syllabus version				

Course Objectives:

- To acquaint the students with some basic concepts and knowledge of Statistical methods of computations and analysis of data.
- To develop the foundations of some of the elementary statistical methods of analysis of data

Expected Course Outcomes(CO's):

- Students are able to **acquire** the fundamental knowledge of Probability and random variables statistics in terms of definitions, theorems, results, numeric and graphical applications, solutions of basic problems and cases.
- Students will be able to **understand** the basic computations of probability of a random variable.
- Students will be able to **analyze** problems that could be solved using various computational methods based on random variable, functions of random variables and various probabilities laws , theorems and inequalities.
- Students will be able to **evaluate** the properties and solutions of various statistical problems, methods, and meaningful applications using knowledge of random variables and probabilities theories.
- Students will be able to **apply**, the fundamental results and knowledge of probability and random variables for further higher thinking and development of statistics.

Module:1	Probability: Sample space and events	6 hours	CO: 1

Definition, concepts and meanings of sample space, experiments, events, discrete sample space-finite and count ably infinite; Classical, axiomatic and empirical or limiting definition of probability. Some basic rules of probability. Addition and multiplication theorem of probability.

Compliments, Cases, examples, illustrations and Numerical problems.

Module:2	Conditional Probability	6 hours	CO: 1

Conditional probability and independence. Bayes's Theorem (with proof) and applications; Compliments, cases, examples, illustrations, discussions, and applications

Compliments, Cases, examples, illustrations and Numerical problems..

Module:3	Random Variable :One dimensional	7 hours	CO: 2

Random variable ,Discrete Random variable, Continuous random variables Probability mass function, Probability density function ;distribution functions and Cumulative distribution function

Compliments, Cases, examples, illustrations and Numerical problems.

Module:4	Random Variable :Two dimensional	7 hours	CO: 2

Concept of Joint Distribution, Joint Mass Function ;Bivariate distribution, Marginal and Conditional Distribution; Independence of Random Variables

Compliments, Cases, examples, illustrations and Numerical problems.

Module:5	Mathematical Expectation	6 hours	CO: 3

Introduction, concept, definition and meaning of expectation; The expected value of discrete and continuous random variables; Properties of mathematical expectation; Computations of conditional expectation; Computations of variance and covariance using simple and conditional expectations.

Compliments, Cases, examples, illustrations and Numerical problems.

Module:6	Generating Functions	6 hours	CO: 4

5.1 Introduction: Concepts, Definition and meaning; Moments Generating Function, characteristic function, Probability generating functions and cumulative Generating functions

Compliments, Cases, examples, illustrations and Numerical problems.

Module:7	Law of Large Numbers	5 hours	CO: 5

Introduction,Chebyshev's Inequality, Chebyshev's Theorem,LLN(Weak Law of Large Numbers)

Cauchy-Schwarz inequality, Markov's Inequality : proof and application,Compliments, Cases, examples, illustrations, discussion and Numerical applications			
Module:8	**Contemporary issues**	**02 hours**	
Lecture by Industry Experts			
	Total Lecture hours:	**45 hours**	
Tutorial	• A minimum of 5 problems to be worked out by students in every tutorial class • Another 5 problems per tutorial class to be given as a home work	**15 hours**	

Text Book(s)

- Bansilal, Sanjay Arora and Sudha Arora (2006): Introducing Probability and Statistics, 2/e, Satya Prakashan Publications, New Delhi
- Parzen E (1962):Modern Probability Theory and its applications, John Wiley and Sons
- Douglas C. Montgomery, George C. Runger(2018),Applied Statistics and Probability for Engineers, Wiley
- Gupta,S.C. and Kapoor, V.K. (2000): Fundamentals of Mathematical Statistics, 10/e, Sultan Chand and sons.

Reference Books

- Hogg, R.V. , Mc Kean J W and Craig, A.T.(2005): Introduction to Mathematical Statistics, 6/e Pearson Edition
- Bhat, B.R., Srivenkataramana, T and Rao Madhava, K.S. (1997): Statistics: A Beginner's Text, Vol. II New Age International (P) Ltd.
- Goon, A.M., Gupta, M.K. and Das Gupta,B. (2001): Fundamentals of Statistics, Vol. II, World Press, Calcutta.
- Mood, A.M., Graybill, F.A and Boes, D.C.(1974): Introduction to the Theory of Statistics, McGraw Hill
- Härdle, Wolfgang; Okhrin, Ostap; Okhrin, Yarema (2017),Basic Elements of computational Statistics, Springer

Mode of evaluation: CAT / Assignment / Quiz / FAT

Recommended by Board of Studies	11-03-2019		
Approved by Academic Council	No.55	Date	13-06-2019

Course code	Course Title	L	T	P	J	C
MAT1019	Statistical Methods for data analytics	3	2	0	0	4
Pre-requisite		Syllabus version				
		1.0				

Course Objectives:

- To acquaint the students with some basic concepts and knowledge of Statistical methods of computations and analysis of data.
- To develop the foundations of some of the important statistical methods of analysis of data

Expected Course Outcomes(CO's):

- Students are able to acquire the fundamental knowledge of Times Series in terms of definitions, theorems, results, numeric and graphical applications, solutions of basic problems and cases.
- Students will improve their Predictive Analytical knowledge.
- Understand the principles underlying sampling as a means of making inferences about a population
- Students are expected to understand preparation construction of life table.
- Students will be able to find out the association between the factors.
- Students will come to know about premium statistics institutes functioning in India.

Module:1	Basics in Times Series	6 hours

Concept of time series, components of a time series – Additive and Multiplicative models – Resolving the components of a time series – Evaluation of trend by least square method – Methods of moving averages.

Module:2	Measures in Times Series	6 hours

Seasonal indices – Simple average, Ratio to moving average – Ratio to trend – Concept of Cyclical fluctuations – Prediction in time series.

Module:3	Index numbers	7 hours

Definition and uses – Main steps in the construction of index numbers – Fixed and Chain base index numbers - Laspeyre's, Paasche's, Fisher's, Marshall – Edgeworth index numbers Construction and uses of cost of living and wholesale price index numbers

Module:4	Basic Sample theory	6 hours

Census and sample surveys – Advantages and disadvantages – principal steps in a sample survey – probability and non-probability sampling – sampling and non-sampling errors

Module:5	Vital and Population Statistics	6 hours

Introduction: Concept, definition and meaning of demography and vital statistics; Sources of demographic data; Computations of rate and ratios; Measurement of Fertility: CBR, GFR, ASFR, TFR etc; Measurement of Mortality: CDR, SDR etc; Measurement of Population Growth : Crude rate of natural growth, GRR and NRR

Module:6	Theory of Attributes and its measurement	6 hours

Attributes: Concept, definitions and meanings; Types of Attributes; Consistency of data. Concept of independence and association of two attributes. Yule's coefficient of association of two attributes. Computations of Yule's coefficients and interpretation.

Module:7	Official Statistics	6 hours

Present official statistical system in India – Methods of collection of official statistics – their reliability and limitations – Principal publications containing data on topics such as population, agriculture,

industry, trade, prices, labour and employment, transport and communications, banking and finance – Various official agencies responsible for data collection and their main functions		
Module:8	**Contemporary issues:**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**45 hours**
Tutorial	• A minimum of 5 problems to be worked out by students in every tutorial class • Another 5 problems per tutorial class to be given as a home work	**15 hours**

Text Book(s)

- Gupta.S.C. and Kapoor.V.K. (2014): Fundamentals of Applied Statistics , Sultan Chand and sons.
- Agarwal.B.L (2007): Basic statistics , 3/e, New Age International (P) Ltd.
- Medhi.J. (1992): Statistical Methods an Introductory Text , Wiley Eastern Ltd.
- Douglas C. Montgomery, George C. Runger(2018),Applied Statistics and Probability for Engineers, Wiley

Reference Books

- Härdle, Wolfgang; Okhrin, Ostap; Okhrin, Yarema (2017),Basic Elements of computational Statistics, Springer
- Sheldon M.Ross (2006) : Introductory Statistics , 2/e, Elsevier Publications.
- Murray R. Spiegel and Larry J. Stephens (2005): Schaum's Outline of Theory and Problems of Statistics, 3/e, Tata Mc Graw Hill Publishing Company Ltd, New Delhi.

Mode of evaluation: CAT / Digital Assignment / Quiz / FAT			
Recommended by Board of Studies	11-03-2019		
Approved by Academic Council	No. 55	Date	13-06-2019

Course code	Course Title	L	T	P	J	C
MAT1020	Sampling Techniques	3	0	0	0	3
Pre-requisite	None	Syllabus version				
		1.0				

Course Objectives:

- To amalgamate the intellectual facts of the sampling techniques to implement in projects and to motivate the students in carrying out the field projects in a scientific manner and statistical skills
- To convey some extended concepts in sampling to encourage the students in industrial and research aspects

Expected Course Outcome:

After completion of the course students will

- Accomplish research-oriented concepts in sampling
- use the sampling techniques in real time problems
- fetch the concepts of statistical quality control

Module:1	Sampling basics	4 hours

The concept of sampling - Need for sampling - population and sample - sampling unit and sample frame - Types of Population - Basic properties of the population - sample survey and census - Principal steps in a Sample survey - Notion of sampling error.

Module:2	Simple Random Sampling	4 hours

Simple Random Sampling with and without replacement - Estimation of Population mean and proportion and their variances- Determination of sample size

Module:3	Stratified sampling	4 hours

Stratified sampling - Principles of stratification - Estimation of population mean and its variance - Allocation techniques - Estimation of gain due to stratification

Module:4	Systematic sampling	4 hours

Systematic sampling - Estimation of population mean and its sampling variance - Circular systematic sampling - comparison of systematic, simple random and stratified random sampling - cluster sampling with equal sized clusters - estimation of population mean and variance.

Module:5	Unequal probability sampling	4 hours

PPSWR/WOR. Cumulative total and Lahiri's scheme; Methods and related estimators of finite population mean/total. Hurwitz – Thompson estimators – Des Raj ordered estimator and Murthy's unordered estimator.

Module:6	Cluster sampling	4 hours

Ratio and Regression methods of estimation- Two-stage sampling - Multi-stage sampling - Cluster sampling - Resampling methods and its applications.

Module:7	Two-stage sampling	4 hours

Double sampling for the difference ratio, regression and PPS estimators - Large scale sample surveys, Errors in surveys- A mathematical model for errors of measurement, Sampling and Nonsampling errors, Sources and types of non-sampling errors, Remedies for non-sampling errors.

Module:8	Contemporary issues	2 hours

Lecture by Industry Experts

	Total Lecture hours:	30 hours

Text Book(s)

- Sampath S, Sampling Theory and Methods, Narosa Publishing house, 2017.
- Parimal Mukhopadhyay, Theory of Sample Surveys, Prentice Hall of India, 2009.

Reference Books

- Raghunath Arnab, Survey Sampling theory and Applications, academic press, 2017.

<table>
<tr><td colspan="4">Cochran, W.G., Sampling Techniques, 3/e, Wiley, 2007.
Hanif M., Qaiser Shahbaz M. and Munir Ahmad, Sampling Techniques: Methods and Applications, Nova Science Publishers, 2018.
Sukhatme P.V., Sampling theory of surveys with applications, Iowa State University Press and IARS, 1984.
Singh D and Choudhary F.S., Theory and Analysis of Sample Survey and Designs, New Age International, 1986.</td></tr>
<tr><td colspan="4">Mode of Evaluation: CAT, Quiz, Digital Assignment and FAT.</td></tr>
<tr><td>Recommended by Board of Studies</td><td colspan="3">10-09-2019</td></tr>
<tr><td>Approved by Academic Council</td><td>No.56</td><td>Date</td><td>24-09-2019</td></tr>
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Course code	Course Title	L	T	P	J	C
MAT1025	DATABASE MANAGEMENT SYSTEM	3	0	2	0	4
Pre-requisite	None	Syllabus version				
		1.0				

Course Objectives:

1. To understand the concept of DBMS and ER Modeling.
2. To explain the normalization, Query optimization and relational algebra.
3. To apply the concurrency control, recovery, security and indexing for the real time data.

Expected Course Outcome:

1. Explain the basic concept and role of DBMS in an organization.
2. Illustrate the design principles for database design, ER model and normalization.
3. Demonstrate the basics of query evaluation and heuristic query optimization techniques.
4. Apply Concurrency control and recovery mechanisms for the desirable database problem.
5. Compare the basic database storage structure and access techniques including B Tree, B+Trees and hashing.
6. Design and implement the database system with the fundamental concepts of DBMS.

Module:1	DATABASE SYSTEMS CONCEPTS	5 hours

History and motivation for Database Systems , Classification of Database Systems, Data Abstraction, Data Independence, Data Definition, Data Manipulation Languages

Module:2	DATA MODELING	6 hours

Entity Relationship Model, Types of Attributes, Relationship, Structural Constraints, Relational Model, Relational model Constraints, Mapping ER model to a relational schema, Integrity constraints , Data manipulation operations

Module:3	RELATIONAL QUERY LANGUGAES	6 hours

Guidelines for Relational Schema , Relational Algebra, Tuple and domain relational calculus, SQL, QBE

Module:4	RELATIONAL DATABASE DESIGN	6 hours

Functional dependency, Armstrong axioms, Normalization, Boyce Codd Normal Form, Multi-valued dependency and Fourth Normal form, Join dependency and Fifth Normal form , Dependency preservation, Lossless design

Module:5	QUERY PROCESSING AND OPTIMIZATION	6 hours

Translating SQL Queries into Relational Algebra, Heuristic query optimization, Evaluation of relational algebra expressions, Query equivalence, Join strategies, Query optimization algorithms

Module:6	TRANSACTION PROCESSING	7 hours

Storage Strategies – Indices, B-trees, Hashing , Introduction to Transaction Processing, Transaction and System concepts, Desirable properties of Transactions , Characterizing schedules based on recoverability, Characterizing schedules based on serializability

Module:7	CONCURRENCY CONTROL AND RECOVERY TECHNIQUES	7 hours

Recovery and concurrency control, Two-Phase Locking Techniques for Concurrency Control, Concurrency Control based on timestamp, Recovery Concepts, Multiversion and Optimistic Concurrency Control Schemes, Recovery techniques based on deferred update, Recovery techniques based on immediate update, Shadow Paging.

Module:8	**CONTEMPORARY ISSUES**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Raghu Ramakrishnan, "Database Management Systems",Mcgraw-Hill, 4th edition, 2015.
2.	A. Silberschatz, H. F. Korth, S. Sudershan, "Database System Concepts", McGraw Hill, 6th Edition 2010.

Reference Books

1.	R. Elmasri S. B. Navathe, "Fundamentals of Database Systems", Addison Wesley, 7th Edition, 2015.
2.	Thomas Connolly, Carolyn Begg, "Database Systems: A Practical Approach to Design, Implementation and Management",6th Edition, 2012.
3.	Lipo Wang, Xiuju Fu, "Data Mining with Computational Intelligence", Springer, 2005
4.	Serge Abiteboul, Richard Humm and Victor Vianu, "Foundations of Databases", Addison Wesley, 1994

Mode of Evaluation: CAT / Assignment / Quiz / FAT

List of Challenging Experiments (Indicative)		
1.	Database Basics	3 hours
2.	Sorting Retrieved Data	3 hours
3.	Creating Calculated Fields , Aggregate Functions	3 hours
4.	Grouping and Filtering Data	3 hours
5.	Joins and Sub queries	3 hours
6.	Data Handling- Insertion, Updation	3 hours
7.	Iterations	3 hours
8.	Cursors	3 hours
9.	Functions and Procedures	3 hours
10.	Exception Handling and triggers	3 hours
Total Laboratory Hours		30 hours

Recommended by Board of Studies	24-06-2020		
Approved by Academic Council	No. 59	Date	24-09-2020

Course code	Discrete Mathematics	L	T	P	J	C
MAT1026		3	2	0	0	4
Pre-requisite	None	Syllabus version				
		1.0				

Course Objectives:

- The objective of the discrete mathematics is the study of mathematical structures that are fundamentally discrete rather than continuous.
- To make the students to understand the essential fundamental concepts in mathematics, which are very much applied to computer science and its applications

Expected Course Outcomes(CO's):

- To emphasize the concept of logic, Statement and Predicate calculus, Counting Techniques, Algebraic structures.
- To provide the comprehensive idea about Lattices, Boolean algebra, Graphs, Trees and its applications.
- Students are able to determine the Boolean algebra concepts
- Students are able to know the Fundamentals of graphs
- Students are able to understand the concepts of Trees.

Module:1	Logic and Statement Calculus	6 hours

Introduction -Statements and Notation - Connectives – Tautologies – Equivalence - Implications – Normal forms - Theory of Inference for the Statement Calculus.

Module:2	Predicate Calculus	4 hours

Predicate Calculus - Inference Theory of the Predicate Calculus

Module:3	Techniques of Counting	7 hours

Basics of counting - Pigeonhole principle –Permutations and combinations- Inclusion – exclusion principle-Recurrence relations- Solving recurrence relations- Generating functions- Solution to recurrence relations

Module:4	Algebraic Structures	7 hours

Semigroups and Monoids - Groups – Subgroups – Cosets – Normal subgroups- Lagranges Theorem- Homomorphism –Properties - Group Codes

Module:5	Lattices	5 hours

Posets - Partially Ordered Relations -Lattices as Posets – Hasse Digram – Properties of Lattices

Module:6	Boolean Algebra	5 hours

Boolean algebra - Boolean Functions - Representation and Minimization of Boolean Functions – Karnaugh map

Module:7	Fundamentals of Graphs	6 hours

Basic Concepts of Graph – Connected graphs-Isomorphic graphs- Planar and Complete regular graph - Matrix Representation of Graphs – Connectivity – Cut sets -Euler and Hamilton Paths – Shortest Path algorithms

Module:8	Trees	5 hours
Trees – properties of trees – distance and Centres in trees –Binary tree –Complete Binary tree- Spanning trees – Spanning tree algorithms		
	Total Lecture hours:	**45 hours**
Tutorial	• A minimum of 5 problems to be worked out by students in every tutorial class • Another 5 problems per tutorial class to be given as a home work	**15 hours**

Text Book(s)

- Discrete Mathematical Structures with Applications to Computer Science by J .P. Trembley and R. Manohar, Tata McGraw Hill – 35th reprint, 2008.
- Narasing Deo, Graph theory with application to Engineering and Computer Science, Prentice Hall India 2010.

Reference Books

- Discrete Mathematics and its applications by Kenneth H. Rosen, 7th Edition, Tata McGraw Hill, 2012.
- Discrete Mathematics by Richard Johnson baugh, 7th Edition, Prentice Hall, 2009.
- Discrete Mathematics by S. Lipschutz and M. Lipson, McGraw Hill Education (India) 2013.
- Elements of Discrete Mathematics – A Computer Oriented Approach by C.L, Liu, Tata McGraw Hill, Special Indian Edition, 2008.
- Introduction to Graph Theory by West. D.B, 3rd Edition, Prentice-Hall , Englewood Cliffs, NJ, 2007.

- Mode of evaluation: CAT / Digital Assignment / Quiz / FAT

Recommended by Board of Studies	24-06-2020		
Approved by Academic Council	No. 59	Date	24-09-2020

Course Code	Design And Analysis of Algorithms	L	T	P	J	C
MAT1027		3	0	2	0	4
Pre-requisite	None	Syllabus version				
		1.0				

Course Objectives:

- To understand the concepts of algorithms and their analysis in terms of space and time complexity.
- To enable the students for deciding appropriate data type and data structure for a given problem.
- To apply appropriate algorithms for a given problem by considering various characteristics of the given problem.

Expected Course Outcome:

- Explain the basic concepts and role of algorithms to solve problems.
- Appropriate analysis of algorithms in terms of space and time complexity.
- Develop proficiency in checking correctness of proofs.
- Demonstrate a familiarity with combinatorial optimization techniques.
- Learn various advanced algorithms and applications.
- Synthesize efficient algorithms in common engineering design situations

Module:1	Introduction Of Algorithms	3 hours

History and motivation for algorithms, Role of algorithms in computing, Analysis of Algorithms, Asymptotic notation, Loop Invariant, Euclid's Algorithm

Module:2	Principles Of Algorithm Design	5 hours

Basic Methods of algorithm design, Sorting Algorithms and their Complexity analysis, Divide and Conquer Technique, Solving recurrences – substitution, iteration, Recursion Tree, Changing variable and Master's method

Module:3	Combinatorial Optimization	5 hours

Introduction, Methods for optimization, Techniques of backtracking, Dynamic Programming – matrix chain multiplication, 0/1 Knapsack; Greedy algorithm – Coin change problem, activity selection; Method of branch and bound

Module:4	Graph Algorithms	7 hours

Introduction and concepts of graphs, Single source shortest Path algorithms – Dijkstra algorithm, Bellman Ford algorithm, Topological sorting , All pair shortest path algorithm – Floyd Warshall algorithm, Trees – Binary Tree, Binary Search Tree, Height Balanced Tree, Minimum Spanning Tree; Tree Traversals – BFS, DFS; Minimum Spanning Tree algorithms – Kruskal's algorithms, Prims algorithms; Network Flow problems

Module:5	Advanced Algorithmic Analysis	5 hours

Amortized analysis, Online and offline algorithms, Randomized algorithms, NP- completeness

Module:6	LP-Based ALGORITHMS	9 hours

Introduction to LP-Duality, Set cover via dual fitting, Rounding applied to set cover, Set-cover via the Primal-Dual Schema, Maximum Satisfiability – ¾ factor algorithm

Module:7	Parallel And Distributed Algorithms	9 hours

Parallel algorithms – Introduction, PRAM Model, Exclusive Vs. Concurrent Reads and Writes, Pointer Jumping, Brent's Theorem and Work efficiency, Distributed algorithms – Introduction, Consensus and election, Termination detection, Fault tolerance, Stabilization		
Module:8	**Contemporary Issues**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**45 hours**

Text Book(s)

- Cormen, Leiserson, Rivest and Stein, "Introduction to Algorithms", 3rd edition, McGraw Hill, 2009.
- Anany Levitin, "Introduction to the Design and Analysis of Algorithms". 3rd edition., Addison Wesley , 2011.

Reference Books

- Kurt Mehlorn, Peter Sanders, "Algorithms and Data Structures", Springer, 2008.
- Ellis Horowitz, "Fundamentals of Computer Algorithms", 2nd Edition, Universities Press, 2008
- Vijay V. Vajirani, "Approximation Algorithms", Springer, 2001
- Sukumar Ghosh, "Distributed Systems: An Algorithmic Approach" ,1st edition, Chapman & Hall/CRC Computer & Information Science Series, 2006

Mode of Evaluation: CAT / Assignment / Quiz / FAT

List of Challenging Experiments (Indicative)		
1.	Sorting Algorithms	3 hours
2.	Backtracking – Queen's problem and others	3 hours
3.	Dynamic Progamming – 0/1 Knapsack problem and others	3 hours
4.	Greedy Algorithm – Coin Change Problem and others	3 hours
5.	Shortest Path Algorithms	3 hours
6.	BFS, DFS	3 hours
7.	Tree Traversals	3 hours
8.	Subset Sum Problem	3 hours
9.	Traveling salesman problem	3 hours
10.	Satisfiability problems	3 hours
Total Laboratory Hours		**30 hours**

Recommended by Board of Studies	24-06-2020		
Approved by Academic Council	No. 59	Date	24-09-2020

MAT1028	Operations Research for Data Analysis	L	T	P	J	C
		3	2	0	0	4
Pre-requisite		**Syllabus version**				
		1.0				

Course Objectives:

- To familiarize the students with some basic concepts of optimization techniques and approaches.
- To formulate a real-world problem as a mathematical programming model.
- To develop the model formulation and applications are used in solving decision problems.
- To solve specialized linear programming problems like the transportation and assignment problems

Expected Course Outcomes(CO's):

1 Students will be able to apply operations research techniques like linear programming problem in industrial optimization problems.
2 Students are able to solve allocation problems using various OR methods.
3 Students will be able to understand the characteristics of different types of decision-making environment and the appropriate decision making approaches and tools to be used in each type.
4 Students are able to recognize competitive forces in the marketplace and develop appropriate reactions based on existing constraints and resources.

Module:1	Introduction to Operation Research	6 hours	

Introduction-Mathematical models of Operation Research-Scope and applications of Operation Research-Phases of Operation Research study-Characteristics of Operation Research-Limitations of Operation Research.

Module:2	Linear Programming	6 hours	

Introduction –Properties of Linear Programming-Basic assumptions-Mathematical formulation of Linear Programming-Limitations or constraints-Methods for the solution of LP Problem-Graphical analysis of LP-Graphical LP Maximization problem-Graphical LP Minimization problem.

Module:3	Linear Programming Models	7 hours	

Simplex Method-Basics of Simplex Method-Formulating the Simplex Method-Simplex Method with two variables-Simplex Method with more than two variables-Big M Method.

Module:4	Dual Linear Programming	6 hours	

Introduction- Primal and Dual problem -Dual problem properties-Solution techniques of Dual problem-Dual Simplex method-Relations between direct and dual problem-Economic interpretation of Duality.

Module:5	Transportation and Assignment Models	6 hours	

Introduction: Transportation problem-Balanced-Unbalanced-Methods of basic feasible solution-Optimal solution-MODI method. Assignment problem-Hungarian Method.

Module:6	Network Analysis	6 hours	

Basic concepts-Construction of Network-Rules and precautions-CPM and PERT Networks-Obtaining of critical path. Probability and cost consideration. Advantages of Network.

Module:7	**Theory of Games**	**6 hours**	
Introduction-Terminology-Two Person Zero-Sum game-Solution of games with saddle points and without saddle points-2X2 games-dominance principle – mX2 and 2Xn games-Graphical method.			
Module:8	**Contemporary issues:**	**2 hours**	
Lecture by Industry Experts			
	Total Lecture hours:	**45 hours**	
Tutorial	• A minimum of 5 problems to be worked out by students in every tutorial class • Another 5 problems per tutorial class to be given as a home work	**15 hours**	

Text Book(s)

1. Hamdy. A Taha (2019), Operations research, 10th edition, Prentice Hall of India Private Ltd.
2. P. K. Gupta and D. S. Hira, (2007), Operations Research, S. Chand & co.,

Reference Books

1. S.D. Sharma (2000), Operations Research, Nath & Co., Meerut.
2. Maurice Solient, Arthur Yaspen, Lawrence Fridman, (2003), OR methods and Problems, New Age International Edition.
3. J K Sharma (2007), Operations Research Theory & Applications, 3e, Macmillan India Ltd.
4. P. Sankara Iyer, (2008), Operations Research, Tata McGraw-Hill.

Mode of evaluation: CAT / Digital Assignment / Quiz / FAT

Recommended by Board of Studies	24-06-2020		
Approved by Academic Council	No. 61	Date	18-02-2021

MAT1029	Statistical Quality Control	L	T	P	J	C
		3	0	2	0	4
Pre-requisite		Syllabus version				
		v. xx.xx				

Course Objectives:

- **To enable students with necessary knowledge towards constructing models.**
- **To impart knowledge of distribution theory in real life situations.**

Expected Course Outcome:

- demonstrate deep knowledge about statistical methods for quality technology and management, and in a systematic way select methods to solve advanced quality related problems within industry and service production
- discuss the occurrence and consequences of variation in industrial processes and from a systems perspective identify situations where statistical methods can contribute to improvement of products and processes
- plan and conduct industrial improvement projects based on advanced statistical methods for quality improvement
- analyse and identify improvement needs for measurement systems in industrial organisations
- explain and discuss how procedures for statistical quality control can be implemented and contribute to development in industrial organisations

Module:1	Quality fundamentals	4 hours	

Introduction to SQC - The Meaning of Quality and Quality, Improvement; Brief History of Quality Methodology; Statistical Methods for Quality Control and Improvement; Quality costs and Quality loss.

Module:2	Process control and product control	6 hours	

Control limits, specification limits and Tolerance limits,3σ limits and Tools for SQC

Module:3	Control charts for variables	6 hours	

Control Charts for $\bar{X}$ and R (statistical basis, development and use, estimating process capability; interpretation, the effect of non- normality on the chart, the OC function, average run length); Control Charts for $\bar{X}$ and S; Control Chart for Individual Measurements; Applications of Variables Control Charts

Module:4	Control charts for attributes	9 hours	

P, np, C, control chart, Multi – variable chart, individual measurement charts – moving average and moving range charts, quality control in service sector

Module:5	Acceptance sampling inspection plans	6 hours	

Acceptable Quality level(AQL),Lot Tolerance Proportion or Percentage defective(LTPD),Process Average Fraction Defective, Consumer Risk, Producer Risk, Rectifying inspection plans, Average Out Quality Limit(AOQL),OC Curve

Module:6	Sampling inspection plans for attributes	6 hours	

Single sampling plan; Double sampling plan, single sampling vs double sampling plans, sequential sampling plan

Module:7	Six sigma	6 hours	

Concept of six sigma, methods of six sigma, DMAIC methodology, DFSS methodology, six sigma control chart, case studies.			
Module:8	**Contemporary issues**	**2 hours**	
Lecture by Industry Experts			
	Total Lecture hours:	**45 hours**	

Text Book(s)	
1.	Montgomery, D.C,Introduction to Statistical Quality Control, John Waley & Sons,2019
2.	Kapoor, V.K. and Gupta, S.P, Fundamentals of applied statistics, Sultan Chand & Sons,2017
Reference Books	
1.	Grant, E,L. and Laven Worth, R.S(2017): Statistical Quality Control, McGraw Hill
2.	Steven M. Zimmerman, Marjorie Icenogle(2000); Statistical Quality Control Using Excel, ASQ Quality Press

List of Challenging Experiments (Indicative)		
1.	Construction of Control charts for Mean and range	2
2.	Construction of control chart for standard deviation	1
3.	Construction of Control chart for Fraction defective	2
4.	Construction of Control chart for Number of defectives	2
5.	Construction of Control chart for number of defects per unit	2
6	Plot OC curve of Single Sapling plan	2
7	Plot OC curve of Double Sapling plan	2
8.	Plot AOQ curve and determine AOQL.	2
	Total Laboratory hours	15 hours

Mode of evaluation: CAT / Assignment / Quiz / FAT			
Recommended by Board of Studies	24-06-2020		
Approved by Academic Council	No. 61	Date	18-02-2021

Course code	Statistical computing for data analysis	L	T	P	J	C
MAT1030		0	0	4	0	2
Pre-requisite		Syllabus version				
		1.0				

Course Objectives:

1. Use of software packages for statistical theory towards computing environment.
2. To enhance the theoretical concepts and its application in the real time domain.

Expected Course Outcome:

Students will be able to

1. List motivation for learning a programming language
2. Access online resources for R and import new function packages into the R workspace
3. Import, review, manipulate and summarize data-sets in R
4. Explore data-sets to create testable hypotheses and identify appropriate statistical tests
5. Perform appropriate statistical tests using R Create and edit visualizations with

List of Challenging Experiments (Indicative)

1	Introduction, How to run R, R Sessions and Functions, Variables, Data Types, Vectors, Conclusion, Advanced Data Structures, Data Frames, Lists, Matrices, Arrays, Classes.	4 hours
2	Creating List, Common list operations ,Recursive list, Creating a Data Frame ,Common data frame operations	4 hours
3	R Programming Structures, Control Statements, Loops, - Looping Over Nonvector Sets,- If-Else, Arithmetic and Boolean Operators and values, Default Values for Argument, Return Values, Deciding Whether to explicitly call return- Returning Complex Objects, Functions are Objective, No Pointers in R.	2 hours
4	Graphics, Creating Graphs, The Workhorse of R Base Graphics, the plot() Function – Customizing Graphs, Saving Graphs to Files	4 hours
5	Maximum and Minimum, Frequency distribution ,Frequency distribution types, measure of central tendency and measure of dispersion, Correlation	4 hours
6	Probability Distributions, Normal Distribution- Binomial Distribution- Poisson Distributions Other Distribution	4 hours
7	Testing of the hypothesis (□, □, □ and □^{2}- tests)	4 hours
8	Linear Models, Simple Linear Regression, -Multiple Regression Generalized Linear Models, Logistic Regression, - Poisson Regression	4 hours
	Total Laboratory hours:	**30 hours**

Text Book(s)

1. Alain F. Zuur, Elena N. Ieno, Erik H.W.G. Meesters Beginner's Guide to R - Springer, 2009.
2. Allerhand M. Tiny Handbook of R - SpringerBriefs in Statistics, 2011

Reference Book(s)				
1.	Baayen R. Analyzing Linguistic Data - A Practical Introduction to Statistics using R , 2008.			
2.	Gardener M. Beginning R - The Statistical Programming Language , 2012.			
3.	Jim Albert, Maria Rizzo R by Example, 2012.			
4.	Matloff N. Art of R Programming - A Tour of Statistical Software Design , 2011.			
Mode of Evaluation: Continuous Assessment and FAT.				
Recommended by Board of Studies		24-06-2020		
Approved by Academic Council		No. 61	Date	18-02-2021

Course code	Distribution Theory for data analytics	L	T	P	J	C
MAT2006		3	0	2	0	4
Pre-requisite	Fundamentals of statistics	Syllabus version				
		1.0				

Course Objectives:

- To discuss the concepts of various functions of random variables and distribution functions for data analytics.
- To impart knowledge of distribution functions in real life situations.

Expected Course Outcome:

Students will be able to

- understand the basics of distribution theory.
- apply the discrete distributions to analyze the data.
- apply normal distributions for large samples
- apply the concepts of continuous distributions to analyze the data.
- analyse Pareto distribution
- analyse the data and interpret by sampling distributions.

Module:1	Functions of Random variables	7 hours

Basic concepts in distribution theory-functions of random variables and their distributions-Probability distribution functions-cumulative probability distribution function-Expected value and variance of a random variable.

Module:2	Standard Discrete Distributions	7 hours

Definition-properties and simple problems of Bernoulli-Binomial-Poisson distribution and its applications.

Module:3	Applications of Discrete Distributions	6 hours

Definition-properties and simple problems of Geometric-Negative Binomial- Hyper Geometric and its applications.

Module:4	Normal Distribution	6 hours

Definition-properties-mean and standard deviation-empirical rule-determining intervals-standard normal distribution-finding z scores from areas-calculating values, probabilities and percentiles

Module:5	Continuous Distributions	5 hours

Definition-properties and simple problems in Exponential-Gamma-Weibull and its applications

Module:6	Pareto Distributions	5 hours

Definition-properties and simple problems in Beta-Cauchy- Pareto and its applications

Module:7	Sampling Distributions	7 hours

Chi Square, Small samples, F, logistic distributions and their interrelations and characteristics – Applications in Tests of significance.

Module:8	Contemporary issues:	2 hours

Lecture by Industry Experts

	Total Lecture hours:	**45 hours**

Text Book(s)

- Probability and Mathematical Statistics by Prasanna Sahoo., 2015.
- Statistical Techniques in Business and Economics – Lind, Douglas., 2012

Reference Books

- Remadevi S, Bindu Krishnan, Probability Distribution, Random Processes and Numerical Methods, Wiley, 2016.
- **Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani.**
- An Introduction to Statistical Learning: With Applications in R (Springer Texts in Statistics) 1st ed. 2013, Corr. 5th printing 2015 Edition.

Mode of Evaluation: CAT, Quiz, Digital Assignment and FAT.

List of Challenging Experiments (Indicative)		
1	Introduction- Importing and Exporting data types	5 hours
2	Data Visualization/data cleansing	5 hours
3	Discrete Distributions	5 hours
4	Normal Distribution	5 hours
5	Continuous Distributions	5 hours
6	Sampling Distributions	5 hours
	Total Laboratory Hours	30 hours

Mode of evaluation: Continuous Assessment and FAT

Recommended by Board of Studies	10-09-2019		
Approved by Academic Council	No. 56	Date	24-09-2019

Course code	Linear Algebra and Numerical Methods	L	T	P	J	C
MAT2007		3	2	0	0	4
Pre-requisite	MAT1001-Fundamentals of Mathematics	Syllabus version				
		1.0				

Course Objectives:

The aim of this course is to

- understand basic concepts of linear algebra to illustrate its power and utility through applications to computer science and Engineering.
- apply the concepts of vector spaces, linear transformations, matrices in engineering.
- cover certain basic, important computer oriented numerical methods for analyzing problems that arise in engineering and physical sciences.

Expected Course Outcome:

At the end of the course the student should be able to

- Solve the system of linear equations using decomposition methods, the basic notion of vector spaces.
- Transform the vectors using linear transforms, which is the basic idea required in computer graphics.
- Observe the difference between exact solution and approximate solution.
- Use the numerical techniques (algorithms) to find the solution (approximate) of algebraic equations and system of equations.
- Fit the data using interpolation technique.

Module:1	System of Linear Equations	7 hours
Elementary row operations, echelon form of a matrix, row echelon form, reduced row echelon form, Gauss elimination, Gauss Jordan method.		
Module:2	**Vector Spaces**	**8 hours**
Vector space, subspace, sum of subspaces, linear combination, linear dependence and independence, basis and dimension, finite dimensional spaces, ordered bases, interpolation.		
Module:3	**Linear Transformations**	**7 hours**
Basic definitions, invertible linear transformations, rank-nullity theorem, matrix representation, algebra of linear transformations, change of basis		
Module:4	**Solution of System of Linear Equations**	**8 hours**
Direct methods: Gauss elimination method, LU-decomposition method. Iterative methods: Jacobi and Gauss-Seidel methods. Dominant and smallest eigen values of a matrix by power method.		
Module:5	**Interpolation**	**4 hours**
Finite difference operators, Newton's forward, Newton's backward, central differences, Bessel and Stirling's interpolation, Lagrange's interpolation.		
Module:6	**Numerical Differentiation**	**4 hours**
First and second order derivatives by various interpolation formulae, maxima and minima for tabulated values.		
Module:7	**Numerical Integration**	**5 hours**
Trapezoidal, Simpsons 1/3rd and 3/8th rules, Gauss Legendre 2-points and 3-points formulae		
Module:8	**Contemporary issues**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**45 hours**
Tutorial	• A minimum of 10 problems to be worked out by students in every Tutorial Class. • Another 5 problems per Tutorial Class to be given as home work.	**30 hours**

Text Book(s)

- Linear Algebra with Applications, Leon, S.J., 9th Edition, Pearson, 2014.
- Numerical Methods for Scientific and Engineering Computation, M. K. Jain, S. R. K. Iyengar and R. K. Jain, 6th Edition, New Age International Limited, 2012.

Reference Books

- Introduction to Linear Algebra, Gilbert Strang, 5th Edition, Wellesley-Cambridge Press, 2016.
- Linear Algebra, Hoffman, K. and Kunze, R., 2nd Edition, Prentice Hall India Learning Private Limited, 2015.
- Numerical Analysis: Mathematics of Scientific Computing, David Kincaid and Ward Cheney, 3rd Edition, American Mathematical Society, 2009.
- Applied Numerical Analysis, Gerald, C. F. and Wheatly, P. O., 7th Edition, Pearson Education India, 2007.

Mode of Evaluation: Digital Assignments, Continuous Assessment Tests, Quiz, Final Assessment Test

Recommended by Board of Studies	10-09-2019		
Approved by Academic Council	No. 56	Date	24-09-2019

Course code	Statistical Inference	L	T	P	J	C
MAT5013		3	0	2	0	4
Pre-requisite	None	Syllabus version				
		1.0				

Course Objectives:

- Understand the types of questions that the statistical method addresses for decision making.
- Apply statistical methods to hypotheses testing and inference problems.
- Interpret the results in a way that addresses the question of interest.
- Use data to make evidence-based decisions that are technically sound.
- Communicate the purposes of the analyses, the findings from the analysis, and the implications of those findings.

Expected Course Outcome:

At the end of the course students will be able to:

- Understand the notion of a parametric model and point estimation of the parameters of those models and properties of a good estimator.
- Learn the approaches to point estimation of parameters.
- Understand the concept of interval estimation and confidence intervals.
- Basic concepts in tests of hypotheses.
- Understand and apply large-sample tests.
- Use small-sample tests of hypotheses.
- Discuss nonparametric tests of hypotheses.
- Translate and correlate the statistical analysis into Statistical inference

Module:1	Introduction	9 hours

Population, sample, parameter and statistic; characteristics of a good estimator; Consistency – Invariance property of Consistent estimator, Sufficient condition for consistency; Unbiasedness; Sufficiency – Factorization Theorem – Minimal sufficiency; Efficiency – Most efficient estimator, likelihood equivalence, Uniformly minimum variance unbiased estimator, Rao - Blackwell Theorem and applications.

Module:2	Point Estimation	6 hours

Point Estimation- Estimator, Estimate, Methods of point estimation – Maximum likelihood method (the asymptotic properties of ML estimators are not included), method of moments, method of least square, method of minimum chi-square and modified minimum chi-square-Asymptotic Maximum Likelihood Estimation.

Module:3	Interval Estimation	4 hours

Confidence level and confidence coefficient; Duality between acceptance region of a test and a confidence interval; Construction of confidence intervals for population proportion (small and large samples) and between two population proportions(large samples); Confidence intervals for mean and variance of a normal population; Difference between the mean and ratio of two normal populations.

Module:4	Testing of hypotheses	6 hours

Types of errors, power of a test, most powerful tests; Neyman-Pearson Fundamental Lemma and its applications; Notion of Uniformly most powerful tests; Likelihood Ratio tests: Description and property of LR tests - Application to standard distributions.

Module:5	Large sample tests	4 hours

Large sample properties; Tests of significance (under normality assumption)- Test for a population mean, proportion; Test for equality of two means, proportions; Test for correlation, Test for Regression.

Module:6	Small sample tests	6 hours

Student's t-test, test for a population mean, equality of two population means, paired t-test, F-test for equality of two population variances; Chi-square test for goodness of fit and test for independence of attributes.		
Module:7	**Non-parametric tests**	**8 hours**
Sign test, Signed rank test, Median test, Mann-Whitney test, Run test and One sample Kolmogorov – Smirnov test (Description, properties and applications only).		
Module:8	**Contemporary issues**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**45 hours**

Text Book(s)

- Manoj Kumar Srivastava and Namita Srivastava, Statistical Inference – Testing of Hypotheses, Prentice Hall of India, 2014.
- Bansilal, Sanjay Arora and Sudha Arora, Introducing Probability and Statistics, 2/e, Satya Prakash Publications, 2006.

Reference Book(s)

- Marc S. Paolella, Fundamental statistical inference: A computational approach, Wiley, 2018.
- B. K. Kale and K. Muralidharan, Parametric Inference, Narosa Publishing House, 2016.
- Miller, I and Miller, M, John E. Freund's Mathematical statistics with Applications, Pearson Education, 2002.
- Rao, C.R., Linear Statistical Inference and its applications, 2nd Edition, Wiley Eastern, 1973.
- Gibbons, J.D., Non-Parametric Statistical Inference, 2/e,Marckel Decker, 1985.

Mode of Evaluation: CAT, Quiz, Assignment and FAT.

List of Experiments		
1.	Calculating Confidence intervals, *p*- value	3 hours
2.	Large Sample Tests- Test for Population mean	3 hours
3.	Large Sample Tests- Test for Population proportions	3 hours
4.	Small Sample Tests – t – test for population mean	3 hours
5.	Paired t – test	3 hours
6.	F- test for population variances	3 hours
7.	Chi-square test for goodness of fit	3 hours
8.	Chi-square test for independence of Attributes	3 hours
9.	Test for correlation coefficient	3 hours
10.	Non-parametric Tests	3 hours
	Total Laboratory hours	30 hours

Mode of evaluation: Digital Assignment, FAT.

Recommended by Board of Studies	11.03.2019		
Approved by Academic Council	No. 55	Date	13-06-2019

Course Code	Time Series Analysis and Forecasting	L	T	P	J	C
MAT5016		3	0	2	0	4
Pre-Requisite	NIL	Syllabus Version				
		1.0				

Course Objectives:

- To equip various forecasting techniques and familiarize on modern statistical methods for analyzing time-series data.
- To amalgamate the intellectual facts of the time series data to implement in the field projects scientifically.
- To link time-dependent analytical tools and building the models by extracting real-time data.

Expected Course Outcomes:

- On completion of the course, students will be able to
- understand the fundamental advantages and apply essential of forecasting techniques
- apply an appropriate forecasting method in any given situation.
- apply non-stationary methods in real-time problems.
- forecast with better statistical models based on statistical data analysis
- learn and apply variance transformation techniques
- understand the application of frequency-domain time series analysis.

Module:1	Exploratory analysis of Time Series	4 hours

Graphical display, classical decomposition model, Components and various decompositions of Time Series Models-Numerical description of Time Series: Stationarity, Autocovariance and Autocorrelation functions - Data transformations - Methods of estimation –Trend, Seasonal and exponential.

Module:2	Smoothing Techniques	6 hours

Moving Averages: Simple, centered, double and weighted moving averages; single and double exponential smoothing – Holt's and winter's methods - Exponential smoothing techniques for series with trend and seasonality-Basic evaluation of exponential smoothing.

Module:3	Stationary models	6 hours

Time series data, Trend, seasonality, cycles and residuals, Stationary, White noise processes, Autoregressive (AR), Moving Average (MA), Autoregressive and Moving Average (ARMA) and Autoregressive Integrated Moving Average (ARIMA) processes, Choice of AR and MA periods.

Module:4	Non-stationary time series models	9 hours

Tests for Nonstationarity: Random walk –random walk with drift –Trend stationary –General Unit Root Tests: Dickey Fuller Test, Augmented Dickey Fuller Test.

ARIMA Models: Basic formulation of the ARIMA Model and their statistical properties - Autocorrelation function (ACF), Partial autocorrelation function (PACF) and their standard errors.

Module:5	Forecasting	6 hours

Nature of Forecasting – Forecasting methods- qualitative and quantitative methods – Steps involved in stochastic model building – Forecasting model evaluation.

Model selection techniques: AIC, BIC and AICC – Forecasting model monitoring.

Module:6	Transfer function and Intervention analysis	6 hours

Transfer function models- Transfer function – noise models; Cross correlation function; Model specification; Forecasting with Transfer function – noise models; Intervention analysis.

Module:7	Spectral analysis	6 hours

Spectral density function (s. d. f.) and its properties, s. d. f. of AR, MA and ARMA processes, Fourier transformation and periodogram.

Module:8	Contemporary issues	2 hours

Lecture by Industry Experts

	Total Lecture hours:	**45 hours**

Text Book(s)

- Douglas C. Montgomery, Cheryl L. Jennings, Murat Kulahci, Introduction to Time Series Analysis and Forecasting, Second Ed., Wiley, 2016.
- George E. P. Box, Gwilym M. Jenkins, Gregory C. Reinsel, Greta M. Ljung, Time Series Analysis: Forecasting and Control, Fifth Ed., Wiley, 2016.

Reference Books

- Brockwell, P. J., & Davis, R. A., Introduction to time series and forecasting, Third Ed., Springer, 2016.
- Terence C. Mills, Applied Time Series Analysis: A Practical Guide to Modeling and Forecasting, Academic Press, 2019.

Mode of Evaluation: CAT, Quiz, Digital Assignment and FAT.

List of Challenging Experiments (Indicative)

1	Visualization of Stationary and Non-stationary time series	4 hours
2	Moving Average Time Series Model and Differencing	4 hours
3	Exponential smoothing technique (Single, double and triple)	4 hours
4	Auto-Regressive Model for Stationary Time Series	4 hours
5	Autoregressive Integrated Moving Average for Non- Stationary Time Series	4 hours
6	Forecasting With Univariate Models	4 hours
7	Transfer Functions and Autoregressive Distributed Lag Modeling	4 hours
8	Spectral density function	2 hours
	Total Laboratory hours	30 hours

Mode of Evaluation: Continuous assessment and FAT.

Recommended by Board of Studies	10.09.2019		
Approved by Academic Council	No. 56	Date	24-09-2019

Course Code	Multivariate Data Analysis	L	T	P	J	C
MAT5017		3	0	2	0	4
Pre-Requisite	Knowledge of Fundamental of Statistics, Matrices and Linear Algebra	Syllabus Version				
		1.0				

Course Objectives:

The objective of the course is to make the student:

- Understand the fundamental concepts of Multivariate Data Analysis / Multivariate Statistical Analysis.
- Conversant with various methods and techniques used in summarization and analysis of multivariate data.
- Prepare for investigation of multivariate data and examine the possible diagnostics in multivariate methods.
- Formulate real time problem in a form of multivariate model.
- Develop feasible solution of real-life problems, using multivariate methods and techniques.
- Conduct research using multivariate data analysis techniques.

Expected Course Outcome:

At the end of the course students will be able to:

- Learn to develop an in-depth understanding of the Multivariate models, methods and techniques.
- Demonstrate the knowledge and skill of multivariate normal distributions, related probability distributions and their applications.
- Examine the relationships between dependent and independent variables of multivariate models, estimate the parameters and fit a model.
- Perform, handle and manipulate the analysis of discriminant function and logistic regression.
- Apply the method and analysis of principal components, factor analysis and dimension reduction of sample data.
- Investigate the events of clustering and multidimensional scaling presence in sample data.
- Conduct the application of Structural Equation Modeling (SEM) to real-time observations.
- Research on real-time problems from various disciplines using multivariate data analysis.

Module:1	Introduction to Multivariate Data Analysis	5 hours

Multivariate data and their diagrammatic representation. Exploratory multivariate data analysis, sample mean vector, sample dispersion matrix, sample correlation matrix, graphical representation, means, variances, co-variances, correlations of linear transforms, six step approach to multivariate model building. Introduction to multivariate linear regression, logistic regression, principal component analysis, factor analysis, cluster analysis, canonical analysis and canonical variables, structured equation modeling (SEM).

Module:2	Multivariate Normal Distribution(MND)	8 hours

Introduction to multivariate normal distribution, probability density function and moment generating function of multivariate normal distribution, singular and nonsingular normal distributions, distribution of linear and quadratic form of normal variables, marginal and conditional distributions. Random sampling from multivariate normal distributions. Goodness of fit of multivariate normal distribution. Wishart matrix-its distribution and properties.

Module:3	Multivariate Linear Model and Analysis of Variance and Covariance	8 hours

Maximum likelihood estimation of parameters, tests of linear hypothesis, distribution of partial and multiple correlation coefficients and regression coefficients. Multivariate linear regression,

multivariate analysis of variance of one and two way classification data (only LR test). Multivariate analysis of covariance. Hoteling $\square^2$ and Mahalanobis $\square^2$ applications in testing and confidence set construction.

Module:4	**Multiple Discriminant Analysis and Logistic Regression**	**7 hours**

Discriminant model and analysis: a two group discriminant analysis, a three group discriminant analysis, the decision process of discriminant analysis(objective, research design, assumptions, estimation of the model, assessing overall fit of a model, interpretation of the results, validation of the results). **Logistic Regression model** and analysis: regression with a binary dependent variable, representation of the binary dependent variable, estimating the logistic regression model, assessing the goodness of fit of the estimation model, testing for significance of the coefficients, interpreting the coefficients.

Module:5	**Principal Components and common Factor Analysis**	**5 hours**

Population and sample principal components, their uses and applications, large sample inferences, graphical representation of principal components, Biplots, the orthogonal factor model, dimension reduction, estimation of factor loading and factor scores, interpretation of factor analysis.

Module:6	**Cluster Analysis and Multidimensional Scaling**	**5 hours**

Concepts of cluster analysis and multidimensional scaling, similarity measures, hierarchical clustering methods, Ward's hierarchical clustering method's, nonhierarchical clustering methods, K-means methods. Clustering based on statistical models, multidimensional scaling and correspondence analysis, perceptual mapping.

Module:7	**Structural Equation Modelling (SEM)**	**5 hours**

Concept of structural equation modeling, Confirmatory factor analysis, canonical correlation analysis, conjoint analysis.

Module:8	**Contemporary issues**	**2 hours**

Lecture by Industry Experts

	Total Lecture Hours:	**45 hours**

Text Book(s)

- Hardly W.K. and Simor L., Applied Multivariate Statistical Analysis, 4th Edition, Springer- Verlag, **2015.**
- Richard A. Johnson and Dean W. Wichern, Applied Multivariate Statistical Analysis, Prentice hall India, 7th Edition, **2019.**

Reference Books

- Joseph F. Hair, Jr., William C. Black, Barry J. Babin, Rolph E. Anderson and Ronald L. Tatham, Multivariate Data Analysis, 7th Edition, Pearson Education India, **2014.**
- Rao, C. R. and Rao, M. M., Multivariate Statistics and Probability, Elsevier & Academic Press, **2014.**
- Kshirsagar, A. M., Multivariate Analysis, Marcel Dekkar, 2006.
- Anderson T.W., An Introduction to Multivariate Statistical Analysis, John Wiley & sons, 3rd Edition, **2009.**
- Bhuyan, K. C., Multivariate Analysis and its Applications, New Central book Agency Pvt. Ltd., **2005.**

•	Weisberg S., Applied Linear Regression, 4th Edition, Wiley, 2013. Kollo T., and Rosen D. Von, Advanced Multivariate Statistical Analysis with Matrices, Springer, New York, **2005.**

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar.		
List of Challenging Experiments (Indicative) using packages, software's and other scientific devices		
1.	MLE of mean vector and variance-covariance matrix from the normal population. Generating random numbers from a multivariate normal distribution.	4 hours
2.	Hoteling $\square^2$ and Mahalanobis $\square^2$	4 hours
3.	Computation of principal components and conducting factor analysis	4 hours
4.	Fitting a multivariate linear regression model and its interpretation.	4 hours
5.	Error analysis, outliers detection and related tests	2 hours
6.	Estimation, fitting and validating a logistic regression model.	4 hours
7.	Classification between two normal populations using discriminant analysis.	2 hours
8.	Cluster analysis	2 hours
9.	Computation of canonical variables and correlation	2 hours
10	Structural Equation Modeling and related computations	2 hours
Total Laboratory Hours		**30 hours**
Mode of assessment: Continuous Assessment and FAT.		

Recommended by Board of Studies	24-06-2020		
Approved by Academic Council	No. 59	Date	24-09-2020

Course Code	Regression Analysis and Predictive Modelling	L	T	P	J	C
MAT6002		3	0	2	0	4
Pre-Requisite	MAT5012 - Probability Theory and Distributions	Syllabus Version				
		1.0				

Course Objectives:

- Develop an understanding of regression analysis and model building.
- Provide the ability to develop relationship between variables
- Investigate possible diagnostics in regression techniques
- Formulate feasible solution using regression model for real-life problems.

Expected Course Outcome:

At the end of the course students will be able to:

- develop in-depth understanding of the linear and nonlinear regression model.
- demonstrate the knowledge of regression modeling and model selection techniques.
- examine the relationships between dependent and independent variables.
- estimate the parameters and fit a model.
- investigate possible diagnostics in regression modeling and analysis.
- validate the model using hypothesis testing and confidence interval approach.
- understand the generalizations of the linear model to binary and count data.

Module:1	Simple Regression Analysis	6 hours

Introduction to a linear and nonlinear model. Ordinary Least Square methods. Simple linear regression model, using simple regression to describe a linear relationship. Fitting a linear trend to time series data, Validating simple regression model using t, F and p test. Developing confidence interval. Precautions in interpreting regression results.

Module:2	Multiple Regression Analysis	6 hours

Concept of Multiple regression model to describe a linear relationship, Assessing the fit of the regression line, inferences from multiple regression analysis, problem of overfitting of a model, comparing two regression model, prediction with multiple regression equation.

Module:3	Fitting Curves and Model Adequacy Checking	6 hours

Introduction, fitting curvilinear relationship, residual analysis, PRESS statistics, detection and treatment of outliers, lack of fit of the regression model, test of lack of fit, Problem of autocorrelation and heteroscedasticity. Estimation of pure errors from near neighbors.

Module:4	Transformation techniques	5 hours

Introduction, variance stabilizing transformations, transformations to linearize the model, Box-Cox methods, transformations on the repressors variables, Generalized and weighted least squares, Some practical applications.

Module:5	Multicollinearity	7 hours

Introduction, sources of multicollinearity, effects of multicollinearity. Multicollinearity diagnostics: examination of correlation matrix, variance Inflation factors (VIF), Eigen system analysis of X^1X. Methods of dealing with Multicollinearity: collecting additional data, model re-specification, and ridge regression.

Module:6	Generalized Linear Models	7 hours

Generalized linear model: link functions and linear predictors, parameter estimation and inference in the GLM, prediction and estimation with the GLM, Residual Analysis, and concept of over dispersion.

Module:7	Model building and Nonlinear Regression	6 hours

Variable selection, model building, model misspecification. Model validation techniques: Analysis of model coefficients, and predicted values, data splitting method. Nonlinear regression model, nonlinear least squares, transformation to linear model, parameter estimation in nonlinear system, statistical inference in nonlinear regression.

Module:8	Contemporary issues:	2 hours

Lecture by Industry Experts

	Total Lecture hours:	**45 hours**

Text Book(s)

- Douglas C. Montgomery, Elizabeth A. Peck, G. Geoffrey Vining, Introduction to Linear Regression Analysis, Third Ed., Wiley India Pvt. Ltd., 2016.
- Norman R. Draper, Harry Smith; Applied Regression Analysis, WILEY India Pvt. Ltd. New Delhi; Third Edition, 2015.

Reference Books

- . Johnson, R A., Wichern, D. W., Applied Multivariate Statistical Analysis, Sixth Ed., PHI learning Pvt., Ltd., 2013.
- . Iain Pardoe, Applied Regression Modeling, John Wiley and Sons, Inc, 2012.

Mode of Evaluation: CAT / Digital Assignment / Quiz / FAT

List of Challenging Experiments

1.	Correlation Analysis using- scatter diagram, Karl Pearson's correlation coefficient and drawing inferences.	2 hours
2.	Simple linear regression: model fitting, estimation of parameters, computing R^2 and adjusted R^2 and model interpretation.	4 hours
3.	Residual analysis and forecast accuracy for a given data set.	2 hours
4.	Validating Simple linear regression using t, F and p- test.	4 hours
5.	Developing confidence interval and testing the model simple and multiple regression.	4 hours
6.	Multiple regression: estimation of parameters, fitting of the model, error analysis, model validation, variable selection and testing.	4 hours
7.	Problem of multicollinearity and, determination of VIF.	2 hours
8.	Diagnostic measures and outliers detection, Durbin Watson test, variable selection and model building	4 hours
9.	Autocorrelation, auto regressive model.	2 hours
10.	Fitting of nonlinear regression model.	2 hours
Total Laboratory Hours:		**30 hours**

Mode of assessment: Continuous Assessment and FAT

Recommended by Board of Studies	10-09-2019		
Approved by Academic Council	No. 56	Date	24-09-2019

Course Code	Computational Statistics for Data Science	L	T	P	J	C
MAT6004		0	0	4	0	2
Pre-Requisite	MAT5013 - Statistical Inference	Syllabus Version				
		1.0				

Course Objectives:

- Use of software packages for statistical theory towards computing environment.
- To enhance the theoretical concepts and its application in the real-time domain.

Expected Course Outcomes:

Students will be able to

- use software tools for projects in data management.
- apply technical skills in the statistical data analysis to transform a simple to multiple variables.
- understand the statistical decision-making theory and interpretation.
- analyze and solve real-time problems

List of Challenging Experiments (Indicative)

1	Data Management – Handling Big data sets and variable selection	6 hours
2	Descriptive statistics and their interpretation	8 hours
3	Tabulation of Data and Cross Tabulation	6 hours
4	Correlation analysis	8 hours
5	Regression analysis	8 hours
6	Testing of the hypothesis (□, □, □ and □^{2}- tests)	8 hours
7	Non-parametric tests	8 hours
8	Design and analysis of experiments	8 hours
	Total Laboratory hours:	**60 hours**

Text Book(s)

- McCormick, Keith; Salcedo, Jesus, SPSS statistics for data analysis and visualization, Wiley, 2017.
- K. V. S. Sarma, Statistics Made Simple Do It Yourself, 2nd Ed, Prentice-Hall, 2010.

Reference Book(s)

- Murtaza Haider, Getting Started with Data Science: Making Sense of Data with Analytics, IBM Press, 2015.
- J.P. Verma, Data Analysis in Management with SPSS Software, Springer, 2013.

Mode of Evaluation: Continuous Assessment and FAT.

Recommended by Board of Studies	10.09.2019		
Approved by Academic Council	No. 56	Date	24-09-2019

Course Code	Design and Analysis of Experiments	L	T	P	J	C
MAT6009		3	0	2	0	4
Pre-Requisite	MAT5013 – Statistical Inference	Syllabus Version				
		1.0				

Course Objectives

- Describe how to design experiments, carry them out, and analyze the data they yield.
- Construct appropriate experimental designs for given problems: sample size determination, choice of levels of variables, designs with restrictions on randomization, utility functions for measuring design objectives, use of simulation to characterize properties of designs.

Expected Course Outcome

- Describe the purpose of robust construction and how it is applied in experimental design
- To formulate and validate the experimental designs in agricultural, medical, biomedical projects
- Avails them to fetch the background concepts of Model formulation and validation
- To accomplish research-oriented concepts given for statistical techniques required for experimental designs

Module:1	Basic Principles of Experimental design	2 hours

Strategy of Experimentation - Applications of Experimental Design – Basic Principles – Guidelines for designing experiments.

Module:2	Simple Comparative Experiments	8 hours

Principles of scientific experimentation – Basic Designs: Completely Randomized Design (CRD), Randomized Block Design (RBD) and Latin Square Design (LSD) – Analysis of RBD (with one observation per cell, more than one but equal number of observations per cell).

Module:3	Analysis of Co-variance	6 hours

Multiple Comparisons – Multiple Range Tests - Analysis of Covariance – Construction of Orthogonal Latin Square – Analysis of Graeco Latin Squares.

Module:4	Factorial experiments	8 hours

Factorial experiments - 2^2, 2^3 and 3^2, 3^3 experiments and their analysis - Fractional replication in Factorial Experiments.

Module:5	Confounding	6 hours

Necessity of confounding, Types of confounding, complete and partial confounding in 2^n, 3^2 and 3^3- factorial designs, Analysis of confounded factorial designs; Fractional Replication.

Module:6	Balanced Incomplete Block design	6 hours

Balanced Incomplete Block Design (BIBD)– Types of BIBD – Simple construction methods – Concept of connectedness and balancing – Intra Block analysis of BIBD.

Module:7	Partially Balanced Incomplete Block design	6 hours

Partially Balanced Incomplete Block Design with two associate classes – intra block analysis - Split plot and strip plot design and their analysis.

Module:8	Contemporary issues	2 hours

Lecture by Industry Experts

	Total Lecture hours	45 hours

Text Book(s)

- Douglas C. Montgomery, Design and Analysis of Experiments, 9h Edition, John Whiley and Sons, 2017.

	Angela Dean and Daniel Voss Danel Draguljić, Design and Analysis of Experiments, 2nd Edition, Springer International Publishing AG, 2017.			
Reference Books				
•	Das M.N. and Giri N.C., Design and Analysis of Experiments, 3rd Edition, New Age International (P) Ltd 2017			
•	John Lawson, Design and Analysis of Experiments with R, 1st Edition, CRC Press, 2015.			
Mode of Evaluation: CAT, Quiz, Digital Assignment and FAT				
List of Challenging Experiments (Indicative)				
1	One-way analysis of variance - CRD			2 hours
2	RBD & LSD analysis of one and two observations			4 hours
3	Analysis of Co-variance CRD & RBD			4 hours
4	Analysis of Graeco Latin Squares			4 hours
5	Factorial experiments			4 hours
6	Confounding			4 hours
7	BIBD and PBIBD			4 hours
8	Split plot design			4 hours
	Total Laboratory hours			**30 hours**
Mode of Evaluation: Continuous assessment and FAT				
Recommended by Board of Studies	24.06.2020			
Approved by Academic Council	No. 59	Date	24-09-2020	

Course Code	Programming for Data Analysis	L	T	P	J	C
MAT6012		2	0	4	0	4
Pre-Requisite	None	Syllabus Version				
		1.0				

Course Objectives:

- To introduce core programming basics required for data science using Python language
- To read and write simple Python programs
- To develop Python programs with conditionals and loops
- To use Python data structures – lists, tuples, dictionaries
- To introduce the important data science modules NumPy, SciPy and Matplotlib
- To introduce the input/output with files in Python and statistical processing of a data using Pandas

Expected Course Outcome:

At the end of the course students will be able to:

- Read, write, execute simple Python programs
- Decompose a Python program into functions
- Manipulate with 1-d,2-d and multidimensional data using Python
- Read and write data from/to files in Python programs
- Develop algorithmic solutions to data science related problems

Module:1	Algorithmic Problem Solving	3 hours

Algorithms, building blocks of algorithms (statements, state, control flow, functions); algorithmic problem solving; iteration, recursion. Illustrative problems: finding minimum in a list, guess an integer number in a range, factorial of a number

Module:2	Data, Expressions, Statements in Python	4 hours

Python Strengths and Weakness; Installing Python; IDLE - Spyder – Jupyter; Mutable and Immutable Data Types, Naming Conventions; String Values; String Operations; String Slices; String Operators; String functions – split, join, chr, ord; Numeric Data Types; Arithmetic Operators and Expressions; Comments in the Program; Understanding Error Messages

Module:3	Data Collection and Language Component of Python	4 hours

List; Tuples; Sets; Dictionaries; Sorting Dictionaries; Control Flow and Syntax; Indenting; The if statement; Relational Operators; Logical Operators; Bit-wise Operators; The while Loop – break and continue statements; The for Loop; List Comprehension

Module:4	Functions and Modules in Python	4 hours

Functions - Introduction; Defining your own functions; parameters; local and global scope; passing collections to a function; variable number of arguments; passing functions to a function; Lambda function; map; filter; Modules: Introduction; Standard Modules – sys, math, time

Module:5	Python Modules for Data Science – I	5 hours

NumPy arrays – 1-d, multidimensional arrays and matrices; Mathematical operations with arrays; Slicing and addressing arrays; Boolean masks; Difference between lists and arrays

SciPy – Scientific Computing library of Python – Introduction, Basic functions, Special functions, scipy.integrate, scipy.optimize, scipy.interpolate

Module:6	**Python Modules for Data Science – II**	**5 hours**
Python Plotting: PyPlot – Basic Plotting; Logarithmic Plots; Plots with multiple axes; Matplotlib – interactive functions 3d plotting; Pandas – Introduction, DataFrame, Reading and writing CSV, XLS files, Working with missing data, categorical data, data visualization with pandas		
Module:7	**Error Handling in Python**	**3 hours**
Handling IO Exceptions, Metadata, Errors, Runtime Errors, Exception Model		
Module:8	**Contemporary issues**	**2 hours**
Lecture by Industry Experts		
Total Lecture Hours		**30 hours**
Mode of Evaluation: CAT, Quiz, Digital Assignment and FAT. List of Challenging Experiments (Indicative)		
1. Python Program Environment, IDLE, Jupyter, Spyder environments First Basic Experiment(s): (i) "Hello World!" Program in IDLE, Jupyter, Spyder Environments. (ii) Program(s) to demonstrate the Python data types		**4 hours**
2. Python Operators, Expressions and Flow Controls Simple Experiment(s): (i) Program to demonstrate the Python operators and their order of preference. (ii) Program to add/multiply/divide two numbers (iii) Program to verify whether a given number is even or odd Perfection: Program to verify whether a given number is Armstrong number or not. A number is said to Armstrong number if sum of the cubes of individual digits of that number is equal to the number itself. Viz., 153 = 1^3 + 5^3 + 3^3		**4 hours**
3. Python Lists, Tuples, Dictionaries & Sets Simple Experiment: Write a Python program which demonstrate the use of Lists, Tuples Dictionaries and Sets. This program should accepts the elements into various types and perform the other operations such as append, copy, extend, pop, remove operations.		**6 hours**
4. Python Functions, Modules and Packages Simple Experiment(s): Write a function file which accepts a set of numbers and displays the largest among them Perfection: Write a function which accepts a number 'n' and list the first 'n' Fibonacci numbers Challenging: Create a own module in Python which includes functions such as greeting() which greets a welcome message to user. This module should also contain some variables and functions which finds the maximum among the two given numbers.		**4 hours**
5. Array and Matrix Manipulation in Python Simple Experiment: Write a Python program demonstrating the NumPy matrix operations such as accepting two matrices finding the dimension, adding the two matrices Perfection: Write a Python program which accepts a matrix A of order m x p another matrix B of order p x n and checks whether the matrix multiplication is possible or not. If possible then finds matrix multiplication and displays it to user.		**4 hours**

6. Data Manipulation – SciPy Module Simple Experiment: Write a Python program to find the det, inv, eigenvalues and eigenvectors of a matrix using corresponding SciPy module functions Challenging: Create a data set consisting of time series observations of an experiment. Using the interpolation techniques of SciPy module form an interpolating polynomial and use it to estimate the experimental values for intermediate values.	**6 hours**
7. Data Visualization in Python – PyPlot Module *Compare:* Given the examination scores of students of three different classes for the same subject taught by different professors, display them visually to aid comparison of pass percentage, A grades etc.	**6 hours**
8. Data Manipulation using Pandas – Exploring a Dataset and Analysing a Dataset *Simple Experiments:* Create a data frame consists of five countries, their capitals, area of the country, population. The program should also print the description of the data frame and finally save this data frame to a csv file. *Challenging:* Write a Python program demonstrating the Pandas indexing capabilities, identifying the null values in the dataset and filling them with or dropping them from the dataset. Also demonstrate the merging, joining and concatenating data frames using Pandas.	**6 hours**
9. Descriptive Statistical Analysis – Evaluation, Plotting and Interpretation *Linear Regression:* Read a data frame in csv/xls format containing the weather data such as pressure, min temp, max temp, humidity, rainfall. Using the Pandas, MatPlotlib and SciPy plot the scatter plots and develop a linear interpolation between rainfall with all other parameters and evaluate the statistical significance of the model.	**6 hours**
10. Evaluation of Probability using various Distributions Functions *Simple Experiments:* Write Python programs to generate a normal distribution, binomial distribution and Poisson distribution using Python and visualize them. *Challenging:* Write Python program to check the normality of a dataset, which a foremost important test, required to determine whether to apply parametric tests or nonparametric tests on the given test. These tests include Histogram, Quantile-quantile plot, Shapiro-Wilk test, D'Agotino's K-squared test, Anderson-Darling test	**6 hours**
11. Linear and Nonlinear Regression in Python *Simple Linear Regression:* Write a Python program to implement the Simple Linear Regression model to predict the wine quality using the physicochemical and sensory variables by using Scikit-Learn module and estimate the statistical significance of the model. *Nonlinear Linear Regression:* Write a Python program to predict the price of oil (OIL) from indicators such as the West Texas Intermediate (WTI) price, Henry Hub gas price (HH), and the Mont Belvieu (MB) propane spot price. Data is available for OIL, WTI, HH, and MB from the years 2000 to 2016 at the link https://apmonitor.com/me575/uploads/Main/oil_data.txt. The OIL is related with WTI, HH and MB nonlinearly as follows: $OIL = A\ (WTI^B)\ (HH^C)\ (MB^D)$	**4 hours**
12. Decision Trees and Time Series Analysis in Python Programs to illustrate the use of decision trees in machine learning to develop the decisions and their possible consequences. In this experiment we will use the dataset related breast cancer to predict the breast cancer spread using decision trees.	**4 hours**

Total Laboratory Hours	**60 hours**
Mode of Evaluation: CAT and FAT	

Text Book(s)

- David J. Pine, Introduction to Python for Science and Engineering, CRC Press, 2019.
  Jake vander Plas, Python Data Science Handbook – Essential Tools for Working with Data, O'Really Media, 2017

Reference Book(s)

- Robert Johansson, Numerical Python – Scientific Computing and Data Science Applications with NumPy, SciPy and Matplotlib, Apress, 2019
- Robert Sedgewick, Kevin Wayne, Robert Dondero, Introduction to Programming in Python: An Inter-disciplinary Approach, Pearson India Education Services Pvt. Ltd., 2016
- Nelli, F., Python Data Analytics: with Pandas, NumPy and Matplotlib, Apress, 2018.

Mode of Evaluation: CAT, Quiz, Digital Assignment and FAT.

Recommended by Board of Studies	24-06-2020		
Approved by Academic Council	No. 59	Date	24-09-2020

Programme Elective

Course Code	Total Quality Management	L	T	P	J	C
MAT3010		3	0	0	4	4
Pre-Requisite	Nil	Syllabus Version				
		1.0				

Course Objective:

The objective of the course is to make the student:

- To understand the basic concepts, contribution of gurus, barriers and benefits of TQM.
- To understand the basic principles of TQM.
- To understand the analysis and applications of tools and techniques in TQM.
- To understand the various concepts of TQM, quality concepts related to manufacturing and service processes.
- To understand the quality standards and systems in TQM.

Course Outcome:

At the end of the course, the students will be able to:

- Gain basic knowledge in total quality management relevant to both manufacturing and service industry including IT sector.
- Implement the basic principles of TQM in manufacturing and service based organization.
- Apply the tools and techniques-I of quality management to Manufacturing and services processes.
- Explore industrial applications of Quality function deployment, Taguchi quality concepts and TP and apply the tools and techniques-II of quality management to manufacturing and services processes.
- Gain the knowledge on various ISO standards and quality systems.

Module: 1	Introduction TQM	6 Hours

Introduction - Need for quality - Evolution of quality - Definition of quality - Dimensions of Product and Service Quality –Definition of TQM - Basic Concepts of TQM –- Gurus of TQM (Brief introduction) - TQM Framework- Barriers to TQM –Benefits of TQM.

Module: 2	TQM Principles	7 Hours

Leadership -The Deming Philosophy, Quality council, Quality statements and Strategic planning- - Customer Satisfaction – Customer Perception of Quality, Feedback, Customer complaints, Service Quality, Kano Model and Customer Retention – Employee involvement – Motivation, Empowerment, Team and Teamwork, Recognition & Reward and Performance Appraisal - Continuous process improvement – Juran Trilogy, PDSA cycle, 5s and Kaizen - Supplier Partnership – Partnering, Supplier Selection, Supplier Rating and Relationship Development.

Module: 3	TQM Tools and Techniques I	6 Hours

The seven traditional tools of quality – New management tools – Six-sigma Process Capability– Bench marking – Reasons to bench mark, Bench marking process, What to Bench Mark, Understanding Current Performance, Planning, Studying Others, Learning from the data, Using the findings, Pitfalls and Criticisms of Bench Marking .

Module: 4	TQM Tools and Techniques II	6 Hours

FMEA – Intent of FMEA, FMEA Documentation, Stages, Design FMEA and Process FMEA.

Module: 5	TQM Tools and Techniques III	6 Hours

Quality Circles – Quality Function Deployment (QFD) – Taguchi Quality Loss Function – TPM – Concepts, Improvement Needs – Performance Measures-- Cost of Quality - BPR.

Module: 6	**Quality Management System**	**6 Hours**
Introduction — Benefits of ISO Registration — ISO 9000 Series of Standards — Sector-Specific Standards — AS 9100, TS16949 and TL 9000 -- ISO 9001 Requirements — Implementation — Documentation — Internal Audits — Registration.		
Module: 7	**Environmental Management System**	**6 Hours**
Introduction - ISO 14000 Series Standards — Concepts of ISO 14001 — Requirements of ISO 14001 — Benefits of EMS.		
Module: 8	**Contemporary Issues**	**2 Hours**
Lecture by Industry Experts.		
	Total Lecture Hours:	**45 Hours**

Text Book(s)

- Dale H. Besterfiled, Carol B. Michna, Glen H. Besterfield, Mary B.Sacre, Hemant Urdhwareshe and Rashmi Urdhwareshe, "Total Quality Management", Pearson Education, Revised Third Edition, Indian Reprint, Sixth Impression,2013.

Reference Book(s)

- James R. Evans and William M. Lindsay, "The Management and Control of Quality", Sixth Edition, South-Western (Thomson Learning),2005.
- Oakland,J.S."TQM–Text with Cases", Butterworth–Heinemann Ltd., Oxford, Third Edition, 2003.
- Suganthi,L and Anand Samuel, "Total Quality Management", Prentice Hall of India, 2006.
- Janakiraman,B and Gopal,R.K, "Total Quality Management–Text and Cases", Prentice Hall of India,2006.

Mode of Evaluation: Assignments, Quizzes, CATs and FAT.

Recommended by Board of Studies	30-06-2021		
Approved by Academic Council	No.:	Date:	

Course Code	Biostatistics	L	T	P	J	C
MAT1031		3	0	2	0	4
Pre-Requisite	None	Syllabus Version				
						1.0

Course Objectives:

The objective of the course is to make the student:

- To understand the role of biostatistics in medical studies, biology and others.
- To provide a foundation on statistical methods.
- To use appropriate statistical techniques to analyze real-world problems arising in medical science, public health and others.
- To interpret the statistical results accurately and effectively.

Course Outcomes:

At the end of the course, the students will be able to:

- Apply basic statistical concepts commonly used in Health and Medical Sciences.
- Calculate and interpret confidence intervals, p-value in hypothesis testing.
- Acquire knowledge in epidemiological study designs.
- Analyze categorical data and diagnostic tests.
- Familiar with the appropriate use of Non-parametric tests.
- Impart skills in measuring demographic and vital statistics.
- Understand survival analysis and construction of life table.

Module: 1	Introduction to Clinical Trials	8 Hours

Statistical Methods in Clinical Trials: Introduction to clinical trial and it's phases I, II, III and IV, statistical designs-fixed sample trials: simple randomized design, stratified randomized crossover design.

Module: 2	Randomization and Sequential Designs	6 Hours

Sequential design - open and close sequential design. Randomization-Dynamic randomization, Permuted block randomization; Blinding-Single, double and triple.

Module: 3	Bioassays	6 Hours

Biological Assays: Introduction, parallel-line assay, slope- ratio assays and quantile- response assay, Feller's theorem. Dose-response relationships-qualitative and quantitative response, dose response relation- estimation of median effective dose.

Module: 4	Epidemiology Study Designs and Measures	5 Hours

Measures of disease frequency – incidence – prevalence – relative risk – Epidemiological study designs – Cohort study design and its analysis – Case control study design and its analysis – concept of bias – information bias and selection bias.

Module: 5	ROC Curve Analysis	6 Hours

ROC Curve analysis - Estimation of Binomial Model and the Area under the Curve, its applications – Properties of ROC curve - Kullback –Leibler Divergence (KLD)– definition – functional relationship between Kullback – Leibler Divergence and the slope of the ROC curve – derivations of KLD expressions for Bi-normal ROC model.

Module: 6	Repeated Measures Data	6 Hours

Repeated Measures ANOVA – One Way and Two Classified Data and its analysis and interpretation – Profile Analysis.

Module: 7	Survival Analysis and Life Tables	6 Hours

Describe survival data - compare survival of several groups - survival and hazard functions- Log-rank test - Cox regression - Exponential survival curves - Construction of a life table- Modified life table - Kaplan-Meier's Method - Censoring and different types of censoring.		
Module: 8	**Contemporary Issues**	**2 Hours**
Lecture by Industry Experts		
Total Lecture Hours:		**45 Hours**
Text Book(s)		
• Elisa T.Lee & John Wenyu Wang (2003): Statistical methods for Survival Data analysis, 3rd Edition, John Wiley. • Krzanowski, W and Hand, D.J.(2009): ROC Curves for Continuous Data, Chapman and Hall.		
Reference Book(s)		
• Jerrold H. Zar (2014): Bio-statistical Analysis, 5th edition, Pearson. • Daniel, W. W. and Chad L. Cross (2018). Bio-Statistics: A Foundation for Analysis in the Health Sciences, John Wiley & Sons, 11th Edition. • Klein J. P. and Moeschberger, M.L. (2013), Survival Analysis – Techniques for Censored and Truncated Data, Springer Inc, 2nd Edition. • Rastogi, V.B. (2006): Fundamentals of Biostatistics, ANE Books, India. • Gordis L; Epidemiology; 4th Edition, Philadelphia, 2014.		
Mode of Evaluation: Assignments, Quizzes, CATs and FAT.		
List of Challenging Experiments (Indicative)		
1.	Preparation of simple Randomization, Permuted Block Randomization	3 Hours
2.	Fitting Slope-Ratio Assay and its analysis cum interpretation	3 Hours
3.	Fitting Parallel Line assay and its analysis cum interpretation	3 Hours
4	Construction of Bi-Normal ROC Curve and its measures	3 Hours
5	Computation of Incidence, prevalence, risk ratio and odds ratio	3 Hours
6.	One Way Repeated Measures ANOVA	3 Hours
7.	Two Way Repeated Measures ANOVA	3 Hours
8.	Computation of Life tables	3 Hours
9.	Kaplan-Meier Analysis with log rank, breslow tests	3 Hours
10.	Cox Regression Analysis	3 Hours
Total Laboratory Hours:		**30 Hours**
Mode of Evaluation: Continuous Assessments, Oral Examination and FAT.		
Recommended by Board of Studies	30-06-2021	
Approved by Academic Council	No.	Date

Course Code	Decision Modelling Techniques	L	T	P	J	C
MAT1032		2	0	2	0	3
Pre-Requisite	Probability and Statistics	Syllabus Version				
		1.0				

Course Objectives:

The objective of the course is to make the student:

- To understand the fundamental concepts of data analysis, data description, decision making, simulation, random number generation, regression modeling, decision modeling, and simulation modeling.
- To conversant with various methods and techniques used in summarization and analysis of data.
- To prepare for investigation of data and examine the possible diagnostics of regression model.
- To formulate real time problem in a form of model.
- To develop feasible solution of real-life problems, using spreadsheet, decision, simulation modeling techniques.
- To conduct research using data analysis and decision models.

Course Outcomes:

At the end of the course, the students will be able to:

- Learn to develop in-depth understanding of the data analysis and decision modeling.
- Demonstrate the knowledge and skill of data scaling, acquisition, handling, and manipulation.
- Examine the relationships between dependent and independent variables of simple and multiple regression models estimate the parameters and fit a model.
- Perform, handle and manipulate the analysis of various types of data and develop an appropriate decision model.
- Apply the methods of random number generators and use it to solve real life problems.

Module: 1	Introduction to Data Analysis and Visualization	4 Hours

Data and measurement, absolute and relative measures of data, data scale (nominal, ordinal, interval, and ratio), data types, methods of data acquisition, normalization of data, data transformation, concept of Z-score, Data visualization, Boxplot, stem-and-leaf plots, radar charts, Pie chart, stacked bar-charts, histograms, Time-series plots, concept of outliers, identification of outliers analytically (using Z-score) and graphically (using Boxplot).

Module: 2	Data Processing and Manipulation	4 Hours

Processing of data, methods of getting right data, sources of data, data sources on the Web, official statistics, data handling using Excel auto-filter, complex queries with advanced filter, importing external data from Access, creating pivot table from external data, exploring data with pivot table, data cleansing, handling the missing data, data manipulation, summary statistics and process of decision making.

Module: 3	Decision Making under Uncertainty	4 Hours

Introduction to elements of decision making, the precision tree, decision problems: single and multistage, Bayes rule, numerical problems and cases, and applications based on binomial, Poisson, normal and exponential distributions.

Module: 4	Random Number Generation	4 Hours

Concept and meaning of random number and its relevance, methods of random number generation, Generating Discrete Random Variates, Techniques for Generating Continuous Random Variates.

Module: 5	Modeling through Regression	6 Hours

Concept and definition of a model, steps of modeling, covariance and correlation, simple and multiple regression model, estimation of coefficients, fitting of a model, drawing inferences for regression coefficients, concept of $\square^2$ and adjusted $\square^2$, Problem of overfitting of regression model, model validation, construction of confidence intervals for regression coefficients, developing prediction intervals.

Module: 6	**Modelling in Excel**	**3 Hours**
Introduction to Excel built-in (Analysis ToolPak, Solver Add-in) and external add-in modules, Add-in for multiple regression and correlation, partial least squares introduction to Excel macros.		
Module: 7	**Simulation Modelling**	**3 Hours**
Introduction - Simulation modeling, Discrete Simulation model, Continuous Simulation model - Monte-Carlo simulation. Spreadsheet simulation modelling - selecting probability distributions for specific simulation, simulating correlated values.		
Module: 8	**Contemporary Issues**	**2 Hours**
Lecture by Industry Experts		
Total Lecture Hours:		**30 Hours**

Text Book(s)

- Albright, S. C., Winston, W. L. and Zappe, C. Data Analysis and Decision Making, 7th Edition, Cengage Learning Pvt. Ltd. 2020.

Reference Book(s)

- A.M. Law and W.D. Kelton. Simulation Modeling and Analysis, T.M.H. Edition (2016).
- S.M. Ross. Simulation, India Elsevier Publication (2016).
- Wendy L. Martinez, Angel R. Martinez., Computational Statistics handbook with MATLAB, Chapman & Hall / CRC (2002).

Mode of Evaluation: Assignments, Quizzes, CATs and FAT.

List of Challenging Experiments (Indicative)

1.	Introduction to Data Analysis	3 Hours
2.	Data analysis using statistics, missing value estimation, data transformations	3 Hours
3.	Graphical visualization techniques	3 Hours
4.	Generating continuous random variables	3 Hours
5.	Generating Discrete random variables	3 Hours
6.	Pivot Tables and Conditional Formatting	3 Hours
7.	Data Processing and Manipulation	4 Hours
8.	Decision Making under Uncertainties	3 Hours
9.	Modelling using clustering (k-means)	2 Hours
10.	Modelling Through Regression	3 Hours
Total Laboratory Hours:		**30 Hours**

Mode of Evaluation: Continuous Assessments, Oral Examination and FAT.

Recommended by Board of Studies	30-06-2021		
Approved by Academic Council	No.:	Date:	

Course code	Programming in C	L	T	P	J	C
CSE1008		3	0	2	0	4
Pre-requisite	None	Syllabus version				
		1.0				

Course Objectives

a. To impart essential problem solving skills through general problem solving concepts.
b. To provide basic knowledge on programming essentials using C as implementation tool.
c. To introduce the Unix file system interface and introduce various programming methods using C.

Course Outcomes

After completion of this course, students will be able to:

1. Propose solutions for a given problem using algorithm and flowchart designs.
2. Infer the fundamental programming elements in C language and learn to apply basic control structures in C.
3. Visualize the capabilities of modular programming approach in C and demonstrate the same in the real world scenario.
4. Understand the basic principles of pointers and their association with various data structures during implementations.
5. Demonstrate the applications of structures and unions.
6. Apply various input, output and error handling functions in C while solving the given problem through unix system interface.
7. Showcase the attained knowledge by applying them to solve various real world problems.

Module: 1	Introduction to C-Programming	3 hours

How to solve basic problems using C-programming, Decisions and Loops, Introduction to imperative language, Syntax and constructs

Module:2	C-operators and expressions	4 hours

Types of variables, Data Type and Sizes, Identifiers and Keywords, Various operators – Arithmetic operators, Relational operators, Logical operators, Increment Decrement Operators, Bitwise Operators, Assignment Operators and Expressions, Type Conversion, Precedence and
Order of Evaluation, Hungarian Notation

Module:3	Structured and Unstructured programming	7 hours

Statements and Blocks, Introduction to If-Else-If, Switch, and Loops - while, do, for, break and continue, Goto Labels, Introduction to structured and un- structured programming

Module:4	Functions and Program Structure with Standard Library Functions	6 hours

Functions, recursion, macros, parameter passing and references, Scope Rules, Block structure, Initialization, Introduction to preprocessor, Standard Library Functions and return types

Module:5	Pointers and Arrays	8 hours

Introduction to Pointers, Types of pointers and arrays, Pointers and Strings, Arrays of Strings, Multi-dimensional arrays, Pointers to Arrays, Pointers and Dynamic allocation of memory, Pointers to Functions, Evaluation of complicated declarations.

Module:6	Structures	9 hours

Introduction to Structures, Pointers and Structures, Structures and Functions, Array of structures, Self-referral Structures, Table look up**,** Input and Output methods, Variable length argument list, File access including FILE structure, Error Handling, Line I/O, miscellaneous functions		
Module:7	**Files and Directories**	**6 hours**
File Descriptor, Low level I/O, Random access, Introduction to Directories, Storage allocator, Different programming method, Debugging, User Defined Header, User Defined Library Function		
Module:8	**ntemporary issues**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**45 hours**
Text Book(s)		
1.	B. W. Kernighan and D. M. Ritchi, "The C Programming Language", Second Edition, Pearson, June 2015.	
2.	Gary J Bronson, "ANSI C Programming", Fourth Edition, Cengage Learning India Private Limited; Fourth edition, 2016.	
3.	B. Gottfried, "Programming in C", Second Edition, Schaum Outline Series, Tata Mc-Graw Hill Publishers, 1996.	
Reference Books		
1.	Herbert Schildt, "C: The Complete Reference", Fourth Edition, McGraw Hill, 2000.	
2.	Yashavant Kanetkar, "Let Us C", BPB Publications, 2017.	
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar		
List of Challenging Experiments (Indicative)		
1.	Algorithm and flowcharts of small problems like GCD	2 hours
2.	Small but tricky codes (use of operators and expressions)	3 hours
3.	Solving sequences (applications of control structures)	4 hours
4.	Proper parameter passing (User defined functions)	3 hours
5.	Command line Arguments (Understanding main( ))	2 hours
6.	Variable parameter (Pointers and Arrays)	3 hours
7.	Pointer to functions (Pointer and functions)	3 hours
8.	User defined header (Creation of headers)	3 hours
9.	Make file utility (unix make file)	2 hours
10.	Multi file program and user defined libraries (Use of pre-processor directives)	3 hours
11.	Interesting substring matching / searching programs (String matching and searching)	2 hours
	Total Laboratory Hours	**30 hours**

Mode of assessment:			
Recommended by Board of Studies	03-06-2019		
Approved by Academic Council	No. 55	Date	13.06.2019

Course Code	Modelling and Simulation	L	T	P	J	C
MAT5022		2	0	2	0	3
Pre-Requisite	Calculus and Basic Probability and Statistic Concepts	Syllabus Version				
		1.0				

Course Objectives:

- To understand the functioning of industries and business strategies.
- To provide students hands-on experience in using industry-standard simulation modelling software in order to structure and solve complex and large-scale managerial decision problems.

Expected Course Outcome:

- Have a comprehensive understanding of the theoretical foundations of stochastic simulation, including
- Random number generation, sampling from discrete and continuous distributions, and statistical analysis of transient/steady-state outputs.
- Build realistic discrete-event simulation models using industry-standard software.
- Apply simulation model building and analysis skills to systematically frame and solve complex business planning problems.
- Explain Verification and Validation of simulation model.
- Interpret the model and apply the results to resolve critical issues in a real world environment.
- Demonstrate various statistical software for simulation technique.

Module:1	Introduction to Modelling and Simulation	4 hours

Introduction to Simulation modeling, Advantages, Disadvantages, Areas of application, System environment, components of a system, Model of a system, types of models, steps in a simulation study. Simulation Examples: Simulation of Queuing systems, Simulation of Inventory System, Other simulation examples.

Module:2	General Principles	2 hours

Concepts in discrete - event simulation, event scheduling/ Time advance algorithm, simulation using event scheduling.

Module:3	Random Number and Random Variate Generation	6 hours

Random Numbers: Properties, Generations methods, Tests for Random number- Frequency test, Runs test, Autocorrelation test. Random Variate Generation: Inverse Transform Technique- Exponential, Uniform, Weibull, Triangular distributions, Direct transformation for Normal and log normal Distributions, convolution methods- Erlang distribution, Acceptance Rejection Technique

Module:4	Optimization via Simulation	3 hours

Meaning, difficulty, Robust Heuristics, Random Search.

Module:5	Analysis of Simulation Data	4 hours

Input Modelling: Data collection, Identification and distribution with data, parameter estimation, Goodness of fit tests, Selection of input models without data, Multivariate and time series analysis. Verification and Validation of Model – Model Building, Verification, Calibration and Validation of Models.

Module:6	Output Analysis	5 hours	

Types of Simulations with Respect to Output Analysis, Stochastic Nature of output data, Measures of Performance and their estimation, Output analysis of terminating simulation, Output analysis of steady

state simulations.			
Module:7	**Simulation Software**	**4 hours**	
Selection of Simulation Software, Simulation packages, Trend in Simulation Software.			
Module:8	**Contemporary issues:**	**2 hours**	
Lecture by Industry Experts			
	Total Lecture hours:	**30 hours**	

Text Book(s)	
•	Robinson, S. (2014) Simulation: The Practice of Model Development and Use (2nd Edition). Palgrave Macmillan.
•	Averill M Law, W David Kelton, Simulation Modelling & Analysis, McGraw Hill International Editions – Industrial Engineering series, 4th Edition, ISBN: 0-07-100803-9.
Reference Books	
•	Geoffrey Gordon, (1978) System Simulation, Prentice Hall publication, 2nd Edition, ISBN: 81-203-0140-4.
•	Pidd, M., (2004) Computer Simulation in Management Science. John Wiley & Sons.
•	Narsingh Deo (2004), Systems Simulation with Digital Computer, PHI Publication (EEE), 3rd Edition, ISBN : 0-87692-028-8.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar		
List of Challenging Experiments (Indicative)		
1.	Features of Pro model Package and Input Modelling	6 hours
2.	Simulation of Manufacturing System	6 hours
3.	Simulation of Service Operations	6 hours
4.	Modelling a Live Problem	6 hours
5.	Modelling and simulation problems	6 hours
Total Laboratory Hours		30 hours
Mode of assessment: Weekly Assessment / FAT		

Recommended by Board of Studies	24-06-2020		
Approved by Academic Council	No. 59	Date	24-09-2020

Course Code	Decision Support Systems	L	T	P	J	C
MAT5024		2	0	0	4	3
Pre-Requisite	None	Syllabus Version				
		1.0				

Course Objectives:

- To review and clarify the fundamental terms, concepts and theories associated with Decision Support Systems, computerized decision aids, expert systems, group support systems and executive information systems.
- To discuss and develop skills in the analysis, design and implementation of computerized Decision Support Systems.
- To discuss organizational and social implications of Decision Support Systems.

Expected Course Outcomes:

- Explain the nature of modelling and how real-world systems may be represented in mathematical form and realised on a computer.
- Determine when a realistic problem is in non-standard form and represent it quantitatively using a computer.
- To examine examples and case studies documenting computer support for organizational decision making, and various planning, analysis and control tasks.
- Distinguish among data processing systems, management information systems, and decision support/expert systems.
- Analyze how information is used to solve problems.

Module:1	Introduction to Systems Principles	4 hours

The Characteristics and elements of systems, General systems model, Explore communication systems, Differentiate between data processing systems, management information systems, and decision support systems.

Module:2	Methods of Decision Making and Problem Solving	2 hours

Elements of problem solving process - Problems versus systems - Structured, unstructured, and semi-structured problems - The systems approach and its relationship to the scientific approach.

Module:3	Decision Support Systems (DSS)	5 hours

Development of DSS - Relationship to data processing and database systems - DSS development and implementation - DSS features and capabilities - DSS in the information center.

Module:4	Expert Systems Overview	5 hours

Expert behaviour in decision-making situations - Knowledge capture - Expert systems development process - Build a minimal expert system - Apply and modify the system - Multiple levels of knowledge representation - Multiple levels of control and search procedures.

Module:5	Spreadsheet Facilities	4 hours

Modelling with a spread sheet - Hands-on use of a spreadsheet for business decision-making - Spreadsheet in the information center.

Module:6	Manipulation of Models as a decision making procedure	5 hours

Effects of data manipulation to support decisions in pricing, production, cash flow, and new product

evaluation models - Proficiency in utilizing expert system, spreadsheet, database, graphic and statistical software for "what if" analyses.		
Module:7	**Building Management Models**	**3 hours**
Picking a model type - Validation of models - Management models and expert systems in the information center.		
Module:8	**Contemporary issue**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**30 hours**

Text Book(s)

- Bennett, John L. Building Decision Support Systems. Reading, MA: Addison Wesley, 1983.
- S. Christian Albright. VBA for Modelers: Developing Decision Support Systems with Microsoft Office Excel (5th Edition) Cengage Learning. 2016.

Reference Books

- Leigh, William E. & Michael E. Doherty. Decision Support and Expert Systems. Cincinnati: South Western Publishing, 1986.
- Sprague, Ralph H., Jr., & Hugh J. Watson, eds. Decision Support Systems. Englewood Cliffs, NJ: Prentice-Hall, 1986.
- Turban, Efraim. Decision Support and Expert System: Managerial Perspectives. New York: Macmillan, 1988.
- Young, Lawrence F. Decision Support and Idea Processing Systems, Dubuque, IA: Wm. C. Brown Publishers, 1989.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	24-06-2020		
Approved by Academic Council	No. 59	Date	24-09-2020

Course code	Machine Learning for Data Science	L	T	P	J	C
MAT6005		3	0	2	0	4
Pre-requisite	MAT 5010- Foundations of Data Science	Syllabus version				
		1.0				

Course Objectives:

- Lay the foundation of machine learning and its practical applications and prepare students for real-time problem-solving in data science.
- Develop self-learning algorithms using training data to classify or predict the outcome of future datasets.
- Distinguish overtraining and techniques to avoid it such as cross-validation.

Expected Course Outcome:

At the end of the course students will be able to:

- understand the most popular machine learning algorithms
- analyze and perform an evaluation of learning algorithms and model selection.
- compare the strengths and weaknesses of many popular machine learning approaches
- appreciate the underlying mathematical relationships within and across machine learning algorithms and the paradigms of supervised and unsupervised learning.
- design and implement various machine learning algorithms in a range of real-world applications.

Module:1	Introduction to Machine Learning	2 hours

The origins of machine learning-How machines learn - Machine learning in practice- Exploring and understanding state-of-the-art methods.

Module:2	Classification	6 hours

Learning Associations-Classification-Regression- Decision Trees - Reinforcement Learning- Probably Approximately Correct Learning (PAC)- Noise-Learning -Multiple classes-Model Selection and Generalization- Support Vector Machines.

Module:2	Parametric Methods	5 hours

Introduction to Parametric methods-Maximum Likelihood Estimation: Bernoulli, binomial, Poisson distributions - Gaussian Density. Evaluating an Estimator: Bias and Variance-The Bayes Estimator-Parametric Classification.

Module:3	Nonparametric Methods	8 hours

Introduction-Nonparametric Density Estimation: Histogram Estimator-Kernel Estimator-K-Nearest Neighbour Estimator-Generalization to Multivariate Data-Nonparametric classification-Distance Based Classification-Outlier Detection.

Module:4	Multivariate Methods	8 hours

Multivariate Data-Parameter Estimation-Estimation of Missing Values- Expectation-Maximization algorithm -Multivariate Normal Distribution- Multivariate Classification-Tuning Complexity-Discrete Features.

Module:5	Dimensionality Reduction	8 hours

Introduction- Subset Selection-Principal Component Analysis, Feature Embedding-Factor Analysis-Singular Value Decomposition-Multidimensional Scaling- Canonical Correlation Analysis.

Module:7	Supervised Learning and Unsupervised Learning	6 hours

Linear Discrimination: Introduction- Generalizing the Linear Model-Geometry of the Linear Discriminant - Linear Discriminant Analysis- Pairwise Separation-Gradient Descent-Logistic Discrimination. Clustering: Introduction, K-Means Clustering- Mixtures of Latent Variable Models-Spectral Clustering-Hierarchical Clustering-Clustering, Choosing the number of Clusters.

Module:8	Contemporary issues	2 hours

Lecture by Industry Experts

	Total Lecture hours:	45 hours

Text Book(s)			
• E. Alpaydin, Introduction to Machine Learning, 3rd Edition, MIT Press, 2015. • Pratap Dangeti, Statistics for Machine Learning, Packt Publishing, 2017.			
Reference Book(s)			
• C.M. Bishop, Pattern Recognition and Machine Learning, Springer, 2016 • K. P. Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012			
Mode of Evaluation: CAT, Quiz, Digital Assignment and FAT			
List of Challenging Experiments (Indicative)			
1	Exploring and Understanding data and formats		5 hours
2	Classification techniques using Decision Trees		5 hours
3	Support Vector Machines and Clustering Algorithms		5 hours
4	Computation of missing values and multivariate classification		5 hours
5	Dimensionality reduction: A factor analysis.		5 hours
6	Discriminant analysis and Canonical Correlation analysis		5 hours
	Total Laboratory hours:		**30 hours**
Mode of evaluation: Continuous Assessment and FAT.			
Recommended by Board of Studies	10.09.2019		
Approved by Academic Council	No. 56	Date	24-09-2019

Course Code	Computational Statistics for Data Science	L	T	P	J	C
MAT6004		0	0	4	0	2
Pre-Requisite	MAT5013 - Statistical Inference	Syllabus Version				
		1.0				

Course Objectives:

- Use of software packages for statistical theory towards computing environment.
- To enhance the theoretical concepts and its application in the real-time domain.

Expected Course Outcomes:

Students will be able to

- use software tools for projects in data management.
- apply technical skills in the statistical data analysis to transform a simple to multiple variables.
- understand the statistical decision-making theory and interpretation.
- analyze and solve real-time problems

List of Challenging Experiments (Indicative)

1	Data Management – Handling Big data sets and variable selection	6 hours
2	Descriptive statistics and their interpretation	8 hours
3	Tabulation of Data and Cross Tabulation	6 hours
4	Correlation analysis	8 hours
5	Regression analysis	8 hours
6	Testing of the hypothesis (□, □, □ and $□^2$- tests)	8 hours
7	Non-parametric tests	8 hours
8	Design and analysis of experiments	8 hours
	Total Laboratory hours:	**60 hours**

Text Book(s)

- McCormick, Keith; Salcedo, Jesus, SPSS statistics for data analysis and visualization, Wiley, 2017.
- K. V. S. Sarma, Statistics Made Simple Do It Yourself, 2nd Ed, Prentice-Hall, 2010.

Reference Book(s)

- Murtaza Haider, Getting Started with Data Science: Making Sense of Data with Analytics, IBM Press, 2015.
- J.P. Verma, Data Analysis in Management with SPSS Software, Springer, 2013.

Mode of Evaluation: Continuous Assessment and FAT.

Recommended by Board of Studies	10.09.2019		
Approved by Academic Council	No. 56	Date	24-09-2019

Course Code	Machine Learning for Data Science	L	T	P	J	C
MAT6005		3	0	2	0	4
Pre-Requisite	MAT5010 – Foundations of Data Science	Syllabus Version				
		1.0				

Course Objectives:

- Lay the foundation of machine learning and its practical applications and prepare students for real-time problem-solving in data science.
- Develop self-learning algorithms using training data to classify or predict the outcome of future datasets.
- Distinguish overtraining and techniques to avoid it such as cross-validation.

Expected Course Outcome:

At the end of the course students will be able to:

- understand the most popular machine learning algorithms
- analyze and perform an evaluation of learning algorithms and model selection.
- compare the strengths and weaknesses of many popular machine learning approaches
- appreciate the underlying mathematical relationships within and across machine learning algorithms and the paradigms of supervised and unsupervised learning.
- design and implement various machine learning algorithms in a range of real-world applications.

Module:1	Introduction to Machine Learning	2 hours

The origins of machine learning-How machines learn - Machine learning in practice- Exploring and understanding state-of-the-art methods.

Module:2	Classification	6 hours

Learning Associations-Classification-Regression- Decision Trees - Reinforcement Learning-Probably Approximately Correct Learning (PAC)- Noise-Learning -Multiple classes-Model Selection and Generalization- Support Vector Machines.

Module:3	Parametric Methods	5 hours

Introduction to Parametric methods-Maximum Likelihood Estimation: Bernoulli, binomial, Poisson distributions - Gaussian Density. Evaluating an Estimator: Bias and Variance-The Bayes Estimator-Parametric Classification.

Module:4	Nonparametric Methods	8 hours

Introduction-Nonparametric Density Estimation: Histogram Estimator-Kernel Estimator-K-Nearest Neighbour Estimator-Generalization to Multivariate Data-Nonparametric classification-Distance Based Classification-Outlier Detection.

Module:5	Multivariate Methods	8 hours

Multivariate Data-Parameter Estimation-Estimation of Missing Values- Expectation-Maximization algorithm -Multivariate Normal Distribution- Multivariate Classification-Tuning Complexity-Discrete Features.

Module:6	Dimensionality Reduction	8 hours

Introduction- Subset Selection-Principal Component Analysis, Feature Embedding-Factor Analysis-Singular Value Decomposition-Multidimensional Scaling- Canonical Correlation Analysis.

Module:7	Supervised Learning and Unsupervised Learning	6 hours

Linear Discrimination: Introduction- Generalizing the Linear Model-Geometry of the Linear Discriminant- Linear Discriminant Analysis- Pairwise Separation-Gradient Descent-Logistic Discrimination. Clustering: Introduction, K-Means Clustering- Mixtures of Latent Variable Models-Spectral Clustering-Hierarchical Clustering-Clustering, Choosing the number of Clusters.

Module:8	Contemporary issues	2 hours

Lecture by Industry Experts

	Total Lecture hours:	**45 hours**

Text Book(s)

- E. Alpaydin, Introduction to Machine Learning, 3rd Edition, MIT Press, 2015.
- Pratap Dangeti, Statistics for Machine Learning, Packt Publishing, 2017.

Reference Book(s)

- C.M. Bishop, Pattern Recognition and Machine Learning, Springer, 2016
- K. P. Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012

Mode of Evaluation: CAT, Quiz, Digital Assignment and FAT

List of Challenging Experiments (Indicative)

1	Exploring and Understanding data and formats	2 hours
2	Classification techniques using Decision Trees	4 hours
3	Support Vector Machines	4 hours
4	Clustering Algorithms	4 hours
5	Computation of missing values and multivariate classification	4 hours
6	Dimensionality reduction: A factor analysis.	4 hours
7	Discriminant analysis	4 hours
8	Canonical Correlation analysis	4 hours
	Total Laboratory hours:	**30 hours**

Mode of evaluation: Continuous Assessment and FAT.

Recommended by Board of Studies	10.09.2019		
Approved by Academic Council	No. 56	Date	24-09-2019

Course Code	Deep Learning	L	T	P	J	C
MAT6007		2	0	2	0	3
Pre-Requisite	None	Syllabus Version				
		1.0				

Course Objectives:

- To introduce the fundamentals of neural networks as well as some advanced topics such as recurrent neural networks, long/short term memory cells and convolutional neural networks.
- To introduce complex learning models and deep learning models
- To explore various learning models using different software packages

Expected Course Outcome:

On completion of the course, students will be able to

- understand the fundamentals of deep learning and build deep learning models
- Apply the most appropriate deep learning method in any given situation.
- Develop neural network models in data-intensive real-time problems.
- Develop efficient generative models
- Learn and apply convolutional and recurrent neural network techniques.

Module:1	Introduction	4 hours

What is neural network, Biological Neuron, Idea of computational units, McCulloch–Pitts unit and Thresholding logic, Linear Perceptron, Perceptron Learning Algorithm, Convergence theorem for Perceptron Learning Algorithm, Linear separability, feed-forward networks, input, hidden and output layers, organization and architecture of neural networks, linear and nonlinear networks

Module:2	Training algorithms for Feedforward networks	5 hours

Learning the weights, Cost functions, Back-propagation algorithms, gradient descent algorithm, unit saturation, heuristics to avoid local optima, accelerated algorithms, Multilayer Perceptron, Empirical Risk Minimization, regularization, autoencoders

Module:3	Deep Neural Networks	4 hours

Architectures, Properties of CNN representations: invertibility, stability, invariance, convolution, pooling of layers, CNN and Tensorflow, Difficulty of training deep neural networks, Greedy layer-wise training.

Module:4	Better Training of Neural Networks	4 hours

Newer optimization methods for neural networks (Adagrad, adadelta, rmsprop, adam, NAG), second order methods for training, Saddle point problem in neural networks, Regularization methods (dropout, drop connect, batch normalization).

Module:5	Recurrent neural networks	4 hours

LSTM, GRU, Encoder-decoder architectures, Auto-encoders (standard, de-noising, contractive, etc), Variational Autoencoders, kohonen SOM, **:** Back propagation through time, Long Short Term Memory, Gated Recurrent Units, Bidirectional LSTMs, Bidirectional RNNs.

Module:6	Deep Generative learning	4 hours

Dynamic memory models. Reinforcement learning, Restrictive Boltzmann Machines (RBMs), Introduction to MCMC and Gibbs Sampling, gradient computations in RBMs, Deep Boltzmann Machine., deep belief networks, convolutional networks, LeNet, AlexNet

Module:7	Recent trends	3 hours

Variational Auto-encoders, Generative Adversarial Networks, Multi-task Deep Learning, Multi-view Deep Learning

Module:8	Contemporary issues	2 hours

Lecture by Industry Experts

	Total Lecture hours:	30 hours

Text Book(s)				
•	Bengio, Yoshua, Ian Goodfellow, Aaron Courville, Deep learning, MIT press, 2016.			
Reference Book(s)				
•	Raúl Rojas, Neural Networks: A Systematic Introduction, 1996, 2nd edition Bishop C., neural networks for pattern recognition, 2015, Oxford university press			
Mode of Evaluation: CAT / Digital Assignment / Quiz / FAT				
List of Challenging Experiments (Indicative)				
1.	Setting up a neural network in memory			6 hours
2.	Backpropagation training experiment			6 hours
3.	Recurrent NN			6 hours
4.	Experiment: Object recognition			6 hours
5.	Experiment: Highway sign recognition			6 hours
Total Laboratory Hours				**30 hours**
Mode of assessment: Continuous assessment and FAT				
Recommended by Board of Studies	24.06.2020			
Approved by Academic Council	No. 59	Date	24-09-2020	

Course Code	Big Data Analytics and Visualization	L	T	P	J	C
MAT6015		2	0	2	0	3
Pre-Requisite	None	Syllabus Version				
		1.0				

Course Objectives:

- To understand the functioning of industries and business strategies.
- To introduce the power of big data analytics and data visualisation techniques in contributing to business value creation.
- To solve a variety of complex data centred business problems using computer software tools.

Expected Course Outcome:

- Display conceptual understanding of big data analytics and visualization techniques.
- Demonstrate a systematic understanding of database management concepts and their connections with big data analytics.
- Develop a systematic understanding in order to build and apply skills in big data network analytics, text mining, and social media data mining.
- Demonstrate critical awareness of how managers and executives utilise big data analytics for business value creation by improving their operational, social, and financial performance and create opportunities for new business development.
- Critically evaluate and apply big data techniques using statistical software.

Module:1	Introduction to Big Data Analytics	3 hours

Big Data Overview - State of the Practice in Analytics - The Data Scientist - Big Data Analytics in Industry Verticals - Data Analytics Lifecycle.

Module:2	Advanced Analytics	4 hours

K-means clustering - Association rules- Linear Regression- Logistic Regression- Naïve Bayes Decision Trees- Time Series Analysis- Text Analysis.

Module:3	Big Data Analysis Models and Algorithms	5 hours

Analytics for Unstructured Data (Map Reduce and Hadoop)- The Hadoop Ecosystem- In-database Analytics – SQL Essentials- Advanced SQL and MADlib for in-database Analytics.

Module:4	Research Trends and Applications	2 hours

Operationalizing an Analytics Project -Creating the Final Deliverables- Data Visualization Techniques- Final Lab: Application of Data Analytics Lifecycle to a Big Data Analytics Challenge.

Module:5	Data Analytics Methods Using Statistical Packages	4 hours

Analyzing and Exploring the Data - Importing and Exporting of files – Recoding and Computing new variables – Visual Binning – Selection of cases – splitting and merging of files – multiple responses – Graphical plots : Box Plot, Scatter plot, Histogram, Bar and Pie charts - Fitting of Curves: Parabola, cubic and exponential – correlation and regression: simple, multiple – Rank correlation – Variable Selection in Multiple Regression - Residual Analysis: model adequacy, detection of outliers and influence observations.

Module:6		6 hours	

Testing of Hypotheses – two sample and paired samples t – test; F-test for two sample variances; Chi-square test for independence of attributes – One way and Two Way Analysis of Variance – Multiple Comparison tests : Tukey's test, Duncan's Multiple range test and Dunnett's test. Non-Parametric

tests: One sample and Two sample Kolmogorov – Smirnov test, Kruskal – Wallis test, Friedman test, Median Test – One Way MANOVA – Hotelling's T^2 two sample test – Test for two Covariance matrices – One way Repeated Measures ANOVA.

Module:7	**Factor Analysis**	**4 hours**	

Identification of Principle Component, Varimax rotation – Discriminant Analysis – Enter and Stepwise procedures, discriminant scores – Logistic regression – variable selection procedures (Backward and Forward with conditional and wald methods), Odds ratio, Classification matrix – 2^2 , 2^3 , 3^2 and 3^3 factorial designs – Split Plot designs.

Module:8	**Contemporary issues**	**2 hours**	

Lecture by Industry Experts

	Total Lecture hours:	**30 hours**

Text Book(s)

- Lemahieu, W., vanden Broucke, S., Baesens, B. (2018). Principles of Database Management: The Practical Guide to Storing, Managing and Analyzing Big and Small Data. Cambridge University Press.
- Sanders, R.N. (2014). Big Data Driven Supply Chain Management: A Framework for Implementing Analytics and Turning Information into Intelligence. Pearson FT Press.

Reference Books

- Luke, D.A. (2015). A User's Guide to Network Analysis in R. Springer.
- Kolaczyk, E.D., Csardi, G. (2014) Statistical Analysis of Network Data with R. Springer.
- Frank J. Ohlhorst (2013): Big data Analytics, Turning Big data into big money, John Wiley and Sons.
- Michael Minelli, Michele Chambers, Ambiga Dhiraj (2013): Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends . John Wiley and Sons.
- Arvind Sathi (2012): Big Data Analytics: Disruptive Technologies for Changing the Game., MC PressLLC.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)

1.	Import and Export of data files, Recoding into different variables, visual binning. Summary statistics using Descriptive option and Means option.	2 hours
2.	Fitting of curves and Simple Correlation	3 hours
3.	Multiple regression with variable selection	3 hours
4.	Parametric and Non-parametric Tests	3 hours
5.	One Way ANOVA, Two Way ANOVA, One way MANOVA post hoc tests – Tukey, Bonferonni	4 hours
6.	Pictorial Representations of Multivariate data: 2D-bar, pie, histogram; 3D-pie, bar, histogram and bivariate Box plot, scatter matrix plot.	3 hours
7.	Logistic regression – odds ratio, Wald's statistic – Variable Selection	3 hours
8.	Discriminant Analysis – Stepwise Method – classification matrix and cross validation	3 hours
9.	Principal Component Analysis – Scree plot – eigen values – Interpretation and its uses – Factor analysis – Initial extraction of factors through Principal Components – varimax rotation - Assigning factor scores and its Applications	3 hours

10.	Concept of Change point analysis – ecp package for detecting single and multiple change points in univariate and multivariate data structures.			3 hours
Total Laboratory Hours				**30 hours**
Mode of assessment: Weekly Assessment / FAT				
Recommended by Board of Studies	24-06-2020			
Approved by Academic Council	No. 59	Date	24-09-2020	

Course Code	Course Title	L	T	P	J	C
MAT6017	Actuarial Statistics	3	0	0	0	3
Pre-Requisite	NIL	Syllabus Version			1.0	

Course Objectives:

The objective of the course is to make the student:

- To understand different introductory concepts in Actuarial science.
- To help the students for taking decision for life policies.
- To link and analyse the various stochastic models for Actuarial statistical applications.

Course Outcomes:

At the end of the course, the students will be able to:

- Understand the fundamental advantages and apply essential of life policies.
- Apply appropriate models for construction of life tables.
- Apply some standard distributions for construction of sampling plans.
- Able to construct the life tables of the policy holders.
- Learn and apply variance transformation techniques.

Module: 1	Basic Deterministic Model	4 Hours

Cash flows, discount function, interest and discount rates, balances and reserves, internal rate of return, The life table: Basic definitions, probabilities, construction of life tables, life expectancy.

Module: 2	Life Annuities	6 Hours

Introduction, calculating annuity premium, interest and survivorship discount function, guaranteed payments, deferred annuities.

Module: 3	Fractional Durations	6 Hours

Life annuities paid monthly, immediate annuities, fractional period premium and reserves, reserves at fractional durations, Continuous payments: Continuous annuities, force of discount, force of mortality, Insurance payable at the moment of death, premiums and reserves.

Module: 4	The General Insurance	9 Hours

Annuity identity, Select morality: Select an ultimate tables, Changed in formulas.

Module: 5	Multiple Life Contracts	6 Hours

Joint life status, joint annuities and insurances, last survivor annuities and insurances, moment of death insurances. The general two life annuity and insurance contracts, contingent insurances.

Module: 6	Multiple Decrement Theory	6 Hours

Basic model, insurances, Determination of the models from the forces of decrement. Stochastic approach to insurance and annuities; Stochastic approach to insurance and annuity benefits, deferred contracts, Stochastic approach to reserves and premiums, variance formula.

Module: 7	Stochastic Approach to Life Policies	6 Hours

Stochastic approach to insurance and annuity benefits, deferred contracts, Stochastic approach to reserves and premiums, variance formula.

Module: 8	**Contemporary Issues**	**2 Hours**
Guest Lecture from Industry and R&D Organizations.		
Total Lecture Hours:		**45 Hours**

Text Book(s)

- Promislow, S.D (2006): Fundamentals of Actuarial Mathematics, John Willey.
- Neill, A. (1977): Life contingencies, Heinemann, London.

Reference Book(s)

- Donald D.W.A. (1970): Compound Interest and Annuities, Heinemann, London.
- Hooker, P.F. and Longley Cook, L.W. (1953): Life and other Contingencies, Volume I and Volume II (1957) Cambridge University Press.

Mode of Evaluation: Assignments, Quizzes, CATs and FAT.

Recommended by Board of Studies	30-06-2021		
Approved by Academic Council	No.:	Date:	

Course Code	Course Title	L	T	P	J	C
MAT3011	Non-Parametric Tests	3	0	2	0	4
Pre-Requisite	Nil	Syllabus Version			1.0	

Course Objectives:

The objective of the course is to make the student:

- To discover the unknown underlying distribution of the observed data, as well as to make a statistical inference in the absence of the underlying distribution.
- To permeate the ideas of advanced statistical test and applications in data science including the real problems.

Course Outcomes:

At the end of the course, the students will be able to:

- Compare and contrast parametric and nonparametric tests.
- Identify the appropriate nonparametric hypothesis testing procedure based on type of outcome variable and number of samples.
- Discover the unknown underlying distribution of the observed data make a statistical inference in disregard of the underlying distribution.
- Understand that the Non parametric tests can analyze ordinal data, ranked data, and outliers.
- Identify multiple applications where nonparametric approaches are appropriate.

Module: 1	Non-Parametric Methods	4 Hours

Introudction to non-parametric methods. Test for Randomness. Test for Goodness of fit - Chi-Square Goodness-of fit Test.

Module: 2	One-Sample and Paired-Sample Procedures	6 Hours

Sign Test and Confidence Interval for the Median. Kolmogorov-Smirnov One-Sample Statistic. Wilcoxon Signed-Rank Test and Confidence Interval.

Module: 3	The General Two-Sample Problem	6 Hours

Wald-Wolfowitz Runs Test. Kolmogorov-Smirnov Two-Sample Test. Median Test. Control Median Test. Mann-Whitney U Test.

Module: 4	Multiple Sample Tests	9 Hours

Median Test. Kruskal-Wallis One-Way ANOVA Test and Multiple Comparisons. Chi-Square Test for k-Proportions. Friedman's test for multiple tretment of a series of objects.

Module: 5	Measures of Association	6 Hours

Test for Bivariate samples- Kendall’s Tau Coefficient, Spearman’s Coefficient of Rank Correlation. Multiple Classifications tests.

Module: 6	Likelihood Ratio (LR) Tests	6 Hours

Asymptotic distribution of LR test statistic – Consistency of LR test – Construction of LR tests for standard statistical distributions. Monotone likelihood ratio property – Uniformly most powerful tests. Applications to standard statistical distributions.

Module: 7	Sequential Tests	6 Hours

Basic Structure of Sequential tests – Sequential Probability Ratio Test (SPRT) and its applications –

Determination of the boundary constants – Operating Characteristic(OC) and expected sample size of SPRT – Optimum properties of SPRT. OC and ASN functions and their plotting.		
Module: 8	**Contemporary Issues**	**2 Hours**
Guest Lecture from Industry and R&D Organizations.		
Total Lecture Hours:		**45 Hours**

Text Book(s)

- Jean Dickinson Gibbons, Subhabrata Chakraborti, Nonparametric Statistical Inference, 4th Edition, Taylor & Francis, 2014.
- Vilijandas Bagdonavicius, Julius Kruopis, Mikhail S. Nikulin, Nonparametric Tests for Complete Data, Wiley, 2013.

Reference Book(s)

- Myles Hollander, Douglas A. Wolfe, Eric Chicken, Nonparametric Statistical Methods, Wiley, 2013.
- John Kloke, Joseph W. McKean , Nonparametric Statistical Methods Using R, CRC Press, 2014.
- V. Rajagopalan, Statistical Inference, New Age International Publishers, 2006.

Mode of Evaluation: Assignments, Quizzes, CATs and FAT.

List of Challenging Experiments (Indicative)

1.	Test for Randomness, Chi-Square Goodness-of fit Test	2 Hours
2.	Sign Test and Confidence Interval for the Median	4 Hours
3.	Kolmogorov-Smirnov test. Wilcoxon Signed-Rank Test	4 Hours
4.	Wald-Wolfowitz Runs Test and Kolmogorov-Smirnov Two-Sample Tests	4 Hours
5.	Median Test and Mann-Whitney U two sample tests	4 Hours
6.	Median Test. Kruskal-Wallis One-Way ANOVA Test	4 Hours
7.	Testsfor Association	4 Hours
8.	Sequential Tests	4 Hours
Total Laboratory Hours:		**30 Hours**

Mode of Evaluation: Continuous Assessments, Oral Examination and FAT.

Recommended by Board of Studies	30-06-2021		
Approved by Academic Council	No.:	Date:	

Course Code	Course Title	L	T	P	J	C
MAT3012	Data Warehousing and Data Mining	3	0	0	0	3
Pre-Requisite	Nil	Syllabus Version			1.0	

Course Objectives:

The objective of the course is to make the student:

- To understand the fundamental processes, concepts and techniques of data mining and develop an appreciation for the inherent complexity of the data mining task.
- Advance relevant programming skills and advance research skills through the investigation of data mining literature.

Course Outcomes:

At the end of the course, the students will be able to:

- Define knowledge discovery and data mining.
- Recognize the key areas and issues in data mining.
- Apply the techniques of clustering, classification, association finding, feature selection and visualization to real life data.
- Determine whether a real world problem has a data mining solution.
- Apply evaluation metrics to select data mining techniques.

Module: 1	Fundamentals of Data Mining	4 Hours

Introduction to data mining – data types – Measures of similarity and dissimilarity – Data mining tools – supervised and unsupervised learning - Classification of Data Ming Systems ,Data Mining Task Primitives, Major issues in Data mining.

Module: 2	Cluster Analysis	6 Hours

Introduction to Cluster Analysis – Types of clustering – Agglomerative Hierarchical clustering algorithm – Issues – strength and weaknesses - Basic k-means algorithm – Issues.

Module: 3	Fuzzy Clustering and Decision Trees	6 Hours

fuzzy clustering – fuzzy c means algorithm - cluster evaluation – unsupervised and supervised measures - Introduction to classification – Decision Trees – Building a decision tree – Tree induction algorithm – model over fitting – Evaluating the performance of a classifier.

Module: 4	Supervised Learning Methods	9 Hours

Nearest Neighbor classifiers – kNN algorithm – Naïve Bayesian classifier – Binary logistic regression – odds ratio – Interpreting logistic regression coefficients – Multiple logistic regression.

Module: 5	Association Rules	6 Hours

Association rules mining – Basics – Apriori algorithm – Pruning and candidate generation – Rule mining – Market Basket Analysis.

Module: 6	Data Warehousing	6 Hours

Data Warehousing Components - Multi Dimensional Data Model - Data Warehouse Architecture - Data Warehouse Implementation - Mapping the Data Warehouse to Multiprocessor Architecture - OLAP - Need - Categorization of OLAP Tools. Uses of data warehouse.

Module: 7	**Applications of Data Mining**	**6 Hours**
Applications of Data Mining - Social Impacts of Data Mining - Tools - An Introduction to DB Miner - Case studies - Mining WWW - Mining Text Databases - Mining Spatial Databases – Market Basket Analysis.		
Module: 8	**Contemporary Issues**	**2 Hours**
Guest Lecture from Industry and R&D Organizations.		
Total Lecture Hours:		**45 Hours**

Text Book(s)

- Tan, T., Steinbach, M. and Kumar, V. (2006): Introduction to Data Mining, Pearson Education.
- Gupta, G.K. (2008): Introduction to Data Mining with case studies, Prentice – Hall of India Pvt. Ltd.

Reference Book(s)

- M. Kantardzic, Data Mining: Concepts, Models, Methods, and Algorithms, 2nd edition, Wiley-IEEE Press, 2011.
- Mehmed Kantardzic, Datamining Concepts, Models, Methods, and Algorithms", Wiley Interscience, 2003.
- Jiawei Han and Micheline Kambers, Data Mining - Concepts and Techniques, 3rd Edition, Morgan Kaufman Publications, 2012.
- David Hand, Heikki Mannila and Prdhraic Smyth, Principles of Data Mining, 3rd Edition, Morgan Kaufman Publications, 2009.

Mode of Evaluation: Assignments, Quizzes, CATs and FAT.

Recommended by Board of Studies	30-06-2021		
Approved by Academic Council	No.:	Date:	

Course Code	Course Title	L	T	P	J	C
MAT3013	Data Engineering for Analytics	2	0	2	4	4
Pre-Requisite	Nil	Syllabus Version			1.0	

Course Objectives:

The objective of the course is to make the student:

- To understand bi-directional data transfer between Hadoop and external database.
- To learn import and export data techniques in Hadoop and external database.

Course Outcomes:

At the end of the course, the students will be able to:

- Students are able understand the different databases and import and export techniques for high end applications for data analytics.
- Students having the identification ideology for hive modules and its applications.
- Students having an ability to create, show and drop Hive QL indexes.
- Students are having identifying skills purpose and evolution of data lakes.
- Students are able to understand the concept of Kafka Streams.

Module: 1	Importing and Handling Relational Data in Hadoop Using Sqoop	3 Hours

Relational database management in Hadoop: Bi directional data transfer between Hadoop and external database. Import data- Transfer an entire table, import subset data, use different file format. Incremental import – import new data, incrementally import data, preserving the value.

Module: 2	Exporting and Handling Relational Data in Hadoop Using Sqoop	4 Hours

Export – Transfer data from Hadoop, update the data, update at the same time, export subset of columns. Hadoop ecosystem integration import data to hive, using partitioned hive tables, replace special delimiters.

Module: 3	Apache Hive Fundamentals	4 Hours

Introduction-Hive modules, Data types and file formats, Hive QL-Data Definition and Data Manipulation.

Module: 4	Apache Hive Advanced Concepts	4 Hours

Hive QL queries, Hive QL views- reduce query complexity. Hive scripts. Hive QL Indexes- create, show, drop. Aggregate functions. Bucketing vs Partitioning, Joins.

Module: 5	**Flume**	**5 Hours**
Architecture, Data flow, Fetching Data using Flume.		
Module: 6	**Data Lakes with Spark**	**3 Hours**
Purpose and evolution of data lakes. Use Spark to run ELT processes and analytics on data of diverse sources, structures and vintages. Components and issues of data lakes.		
Module: 7	**Kafka**	**5 Hours**
Fundamentals, Stream processing, Kafka streams, Integration with spark.		
Module: 8	**Contemporary Issues**	**2 Hours**
Guest Lecture from Industry and R&D Organizations.		
Total Lecture Hours:		**30 Hours**

Text Book(s)

- Jason Rutherglen, Dean Wampler and Edward Caprialo, "Programming Hive", O'Reilly Media Inc, 2012.
- Kathleen Ting and Jarek Jarcec Cecho, "Apache Sqoop Cookbook", O'Reilly Media Inc, 2013.
- Neha Narkhede, Gwen Shapira and Todd Palino, "Kafka- The definitive guide", O'Reilly Media Inc. 2017.

Reference Book(s)

- Tom White, Hadoop: The Definitive Guide, 4th Edition, 2015.

Mode of Evaluation: Assignments, Quizzes, CATs and FAT.

List of Challenging Experiments (Indicative)

1.	Using different file format techniques to transfer tables and import subset data	**4 Hours**
2.	Transfer data from Hadoop, update the data and export techniques	**4 Hours**
3.	Developing a map reducing applications	**4 Hours**
4.	Explore on Big Data applications Using Pig and Hive	**4 Hours**
5.	Streaming external data, Capture events in Flume and store them in Hadoop	**3 Hours**

Course code	Course Title	L	T	P	J	C
CSE1030	Introduction to IoT	3	0	2	0	4
Pre-requisite	Nil	Syllabus Version				

	Distributed File System for analysis	
6.	Performing data loading and cleaning using Spark	**3 Hours**
7.	Importing/ exporting data as Streams of event with Kafka	**4 Hours**
8.	Build a complete business data analytics solution	**4 Hours**
Total Lab Hours:		**30 Hours**

Mode of Evaluation: Continuous Assessments, Oral Examination and FAT.

Recommended by Board of Studies	30-06-2021		
Approved by Academic Council	No.:	Date:	

Course Objectives		
• To study the hardware design of IoT objects • To understand the software development framework for Internet of things. • To learn the cross platform enabling technologies in IoT		
Course Outcomess		
• To develop prototypes for domain specific Internet of Things. • To implement IoT applications for various domains. • To customize real time data for IoT applications. • To design functional model specification for Internet of Things based on domain specification. • To develop an Internet of Things application based on real time applications.		
Module:1	**Building IoT**	**6 hours**
Characterization of IoT - Physical design Things in IoT- IoT protocols- Logical Design. Enabling Technologies		
Module:2	**IoT Systems**	**5 hours**
IoT levels and deployment templates -six levels		
Module:3	**Domain Specific IoTs**	**5 hours**
Smart home- smart city Environment- Energy-Retail- Logistics- Industry Agriculture- Health and Lifestyle		
Module:4	**IoT platforms design methodology**:	**6 hours**
Process Specification- Domain model specification- Information model specification- Service specification- IoT level specification- Functional view specification- Operational view specification- Device and component integration Application development - Case Studies		
Module:5	**Physical Devices and End points**	**6 hours**
Basic building blocks of IoT device - Examples – Raspberry PI interfaces – Arduino interfaces – programming Raspberry Pi with Python –Other IoT devices		
Module:6	**IoT physical servers and cloud offerings**	**7 hours**
Introduction to cloud storage models and communication APIs- Xively cloud for IoT – Python web application framework – Django- Designing RESTful web API- Amazon web services for IoT		

Module:7	**IoT Analytics**	**7 hours**
Batch Data Analysis-Real-time Data Analysis-Case Studies: Object Tracking , Electric Vehicle Management, Anomaly Detection, Mobility Pattern Analytics, Crowd Analytics, Behavior Learning and Prediction		
Module:8	**Expert Talk on Current Industry Trends in Data Analytics**	**3 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

- Arshdeep Bahga, Vijay Madisetti "Internet of Things - A Hands-on Approach", Universities Press, First Edition, 2015.

Reference Book(s)

- Dieter Uckelmann, Mark Harrison Florian, Michahelles "Architecting the Internet of things", Springer-Verlag Berlin Heidelberg, First Edition, 2011.

Mode of Evaluation: CAT, Quiz, Assignment and FAT.

List of Experiments:

Experiment 1	Architecture of IOT Tool Kit and familiarization with working principle of Arduino/Raspberry Pi	**3 hours**
Experiment 2	To interface Bluetooth with Arduino/Raspberry Pi and write a program to send sensor data to smartphone using Bluetooth	**3 hours**
Experiment 3	To interface Push button/Digital sensor (IR/LDR) with Arduino/Raspberry Pi and write a program to turn ON LED when push button is pressed or at sensor detection	**3 hours**
Experiment 4	Programming experiment on Arduino/Raspberry Pi to upload temperature and humidity data to thingspeak cloud	**3 hours**
Experiment 5	Programming experiment on Arduino/Raspberry Pi to retrieve temperature and humidity data from thingspeak cloud.	**3 hours**
Experiment 6	Programming experiment on Arduino/Raspberry Pi to publish temperature data to MQTT broker.	**3 hours**
Experiment 7	Programming experiment on Arduino/Raspberry Pi to subscribe to MQTT broker for temperature data and print it.	**3 hours**

Course code	Course Title	L	T	P	J	C
CSE1031	Web Technologies	2	0	2	0	3

Pre-requisite		Syllabus Version

Experiment 8	To install MySQL database on Raspberry Pi and perform basic SQL queries	**3 hours**
Experiment 9	Programming experiment to create TCP server on Arduino/Raspberry Pi and respond with humidity data to TCP client when requested.	**3 hours**
Experiment 10	Programming experiment to create UDP server on Arduino/Raspberry Pi and respond with humidity data to UDP client when requested.	**3 hours**
	Total	**30 hours**

Course Objectives

- To understand the web architecture and web languages.
- To program for web client and web server objects.
- To understand web development environment and methodology

Recommended by Board of Studies			
	No.	**Date**	

Course Outcomes

- Implement interactive and responsive web pages using HTML and CSS.
- Use Java script language to transfer data and add interactive components to web pages.
- Develop a sophisticated web application that appropriately employs the MVC architecture.
- Demonstrate a client server application using HTTP protocol and access web services for dynamic content using AJAX. Exhibit the working of server-side scripts.
- Understand the fundamental working of data using open source databases.
- Develop advanced web frameworks by combining multiple web technologies.
- Implement Client side and Server side programming.

Module:1	**Fundamentals of Web Technologies**	**4 hours**
Introduction to Web Applications, Web Architecture, Evolution of Web, Basics of Web programming		
Module:2	**Client-Side Scripting**	**5 hours**
Fundamentals of Javascript, Javascript language- declaration of variables, Arrays, Functions, Javascript objects, event handlers, Document object model, Form validations		
Module:3	**Applications**	**5 hours**
History and Motivation of Web applications, Application Frameworks, Responsive Web Design		
Module:4	**Fundamentals of Servlets**	**4 hours**
Common Gateway Interface (CGI), Lifecycle of a Servlets, Implementation of Servlets, Reading Servlets parameters, Reading initialization parameters, Handling HTTP Request/Response Model-, HTTP Methods, Using cookies and sessions		
Module:5	**Web Services**	**5 hours**
Concepts of JAX-RPC, Description of Web services, Writing a Java Web Service, Representing Data types, Node.js, NPM, Express framework, Scaling, XML Schema – Communicating Object Data		
Module:6	**Web Storage**	**3 hours**
Introduction to MongoDB, Schema Design and Data Modelling, Manipulating and Accessing MongoDB Documents from Node.js, Indexing and Aggregation Framework, Scalability and Availability, MongoDB tools		
Module:7	**Reactive frameworks**	**2 hours**

JS framework, JS Templates, Events Handling, Sessions, Publish & Subscribe, Accounts		
Module:8	**Case studies with contemporary issues**	**2 hours**
Expert talk on Web Technology applications.		
	Total Lecture hours:	**30 hours**

Text Book(s)

- Brad Dayley, Node.js, MongoDB, and AngularJS Web Development, Addison Wesley, 2014
- Morris Mano, Digital logic and Computer design, 4th Edition, Pearson, 2008.

Reference Book(s)

- Jon Duckett,HTML&CSSDesign and Build Websites,Wiley, 2011
- Jon Duckett,JavaScript and JQuery: Interactive Front-End Web Development,Wiley,2014
- Holdener, Ajax: The Definitive Guide,Oreilly,2010

List of Challenging Experiments (Indicative)

1	Applications of DHTML	**2 hours**
2	Implementing Javascript and DOM	**2 hours**
3	Applications of Jquery and JSON	**4 hours**
4	Implementation of Angular JS	**4 hours**
5	Basics of MongoDB	**2 hours**
6	Applications of MongoDB	**2 hours**
7	Understanding node.js	**2 hours**
8	Implementation of node.js	**4 hours**
9	Jquery	**4 hours**
10	Express JS	**4 hours**
	Total laboratory Hours	**30 hours**

Mode of Evaluation: CAT, Quiz, Assignment and FAT.

List of Experiment

Recommended by Board of Studies			
	No.	**Date**	

Course code	Course Title	L	T	P	J	C
CSE1032	Cloud Computing Techniques	3	2	0	0	4
Pre-requisite	Nil	Syllabus Version				

Course Objectives

- To understand the concept of cloud and utility computing.
- To understand the various issues in cloud computing.
- To familiarize themselves with the lead players in cloud.
- To appreciate the emergence of cloud as the next generation computing paradigm.
- To be able to set up a private cloud

Course Outcomes

The students will be able to:

- Articulate the main concepts, key technologies, strengths and limitations of cloud computing.
- Identify the architecture, infrastructure and delivery models of cloud computing.
- Explain the core issues of cloud computing such as security, privacy and interoperability
- Choose the appropriate technologies, algorithms and approaches for the related issues.
- Understanding the concepts of Big data tool and its analysis techniques

Module:1	**INTRODUCTION**	**6 hours**

Introduction - Historical Development - Cloud Computing Architecture – The Cloud Reference Model – Cloud Characteristics – Cloud Deployment Models: Public, Private, Community, Hybrid Clouds - Cloud Delivery Models: IaaS, PaaS, SaaS – Open Source Private Cloud Software: Eucalyptus, Open Nebula, Open Stack.

Module:2	**FUNDAMENTALS OF VIRTUALIZATION**	**6 hours**

Data Center Technology - Virtualization – Need of Virtualization - Pros and Cons of Virtualization- Characteristics of Virtualized Environments – Hardware Virtualization – Software Virtualization

Module:3	**VIRTUALIZATION TECHNIQUES**	**6 hours**

Taxonomy of Virtualization Techniques -Virtualization and Cloud Computing - Implementation Levels of Virtualization – Virtualization and Infrastructure Optimization Model - Tools and Mechanisms: Xen, VMWare, Microsoft Hyper-V

Module:4	**CLOUD COMPUTING MECHANISM I**	**9 hours**

Cloud Infrastructure Mechanism: Cloud Storage, Cloud Usage Monitor, Resource Replication – Specialized Cloud Mechanism: Load Balancer, SLA Monitor, Pay-per-use Monitor, Audit Monitor, Failover System, Hypervisor, Resource Cluster.

Module:5	**CLOUD COMPUTING MECHANISM II**	**6 hours**

Multi Device Broker, State Management Database – Cloud Management Mechanism: Remote Administration System, Resource Management System, SLA Management System, Billing Management

System.		
Module:6	**HADOOP AND MAP REDUCE**	**6 hours**
Apache Hadoop – Hadoop Map Reduce – Hadoop Distributed File System- Hadoop I/O- Developing a Map Reduce Application - Map Reduce Types and Formats - Map Reduce Features– Hadoop Cluster Setup – Administering Hadoop.		
Module:7	**SECURITY IN THE CLOUD**	**4 hours**
Basic Terms and Concepts – Threat Agents – Cloud Security Threats – Cloud Security Mechanism: Encryption, Hashing, Digital Signature, Public Key Infrastructure, Identity and Access Management, Single Sign-on, Cloud Based Security Groups, Hardened Virtual Server Images		
Module 8	**Contemporary Issues**	**2 hours**

	Total Lecture hours:	**45 hours**
Tutorial		**15 hours**

Text Book(s)

- Thomas Erl,Zaigham Mahood, Ricardo Puttini, "Cloud Computing, Concept, Technology and Architecture", Prentice Hall, 2013.

Reference Book(s)

- .Toby Velte, Anthony Velte, Robert C. Elsen peter, "Cloud Computing, A Practical Approach", Tata McGraw-Hill Edition, 2010.
- Rajkumar Buyya, Christian Vecchiola, S. Thamarai Selvi, "Mastering Cloud Computing", Tata McGraw-Hill, 2013.
- Arshdeep Bahga, Vijay Madisetti, "Cloud Computing: A Hands-On Approach", Universities Press, 2014.
- Tom White, "Hadoop:The Definitive Guide", O'Reilly Media,4thEdition, 2015.
- James E Smith and Ravi Nair, "Virtual Machines", Elsevier, 2005.
- John Ritting house and James Ransome, "Cloud Computing, Implementation, Management and Strategy", CRC Press, 2010

Mode of Evaluation: CAT, Quiz, Assignment and FAT.

List of Experiment

Recommended by Board of Studies			
	No.	**Date**	

Course Code	Object Oriented Programming	L	T	P	J	C
CSE2037		3	0	2	0	4
Pre-requisite		Syllabus Version				
		1.0				

Course Objectives:

- To provide basic characteristics of OOP through Python
- To impart skills on various kinds of overloading and inheritance
- To introduce design patterns in Python together with file handling

Expected Course Outcome:

At the end of this course the students are expected to

- Realize the need and features of OOP and understanding object-orientedness of Python.
- Infer knowledge on various types of overloading.
- Choose suitable inheritance while proposing solution for the given problem.
- Illustrate application of design patterns in Python.
- Demonstrate file handling in Python.
- Showcase the attained knowledge by applying the learned techniques to solve various real world problems.

Module:1	Object-oriented Design	6 hours

Objects and classes - Specifying attributes and behaviors - Hiding details and creating the public interface - Composition and inheritance

Module:2	Objects in Python	8 hours

Creating Python classes - Modules and packages - Basic inheritance - Multiple inheritance – Polymorphism - Treat objects as objects - Managing objects

Module:3	Python Data Structures	6 hours

Empty objects - Tuples and named tuples - Dictionaries - Lists - Sets - Extending built-ins

Module:4	Python Object-oriented Shortcuts	6 hours

Python built-in functions - Comprehensions - Generators - An alternative to method overloading - Functions are objects

Module:5	Python Design Patterns I	6 hours

Design patterns - Decorator pattern - Observer pattern - Strategy pattern - State pattern - Singleton pattern - Template pattern

Module:6	Python Design Patterns II	6 hours

Adapter pattern - Flyweight pattern - Command pattern - Abstract factory pattern - Composite pattern

Module:7	Files and Strings	5 hours

Strings - File IO - Storing objects

Module:8	**Contemporary Issues**		**2 hours**
Industry Expert Lecture on Common Python 3 Libraries			
	Total Lecture hours:	45 hours	

Text Book(s)	
1.	Dusty Phillips, "Python 3 Object-Oriented Programming" Third Edition, Packt Publishing, 2010.
2.	Steven F. Lott, "Mastering Object Oriented Python", Second Edition, Packt Publishing, 2019.
Reference Books	
1.	Jeeva Jose, P. Sojan Lal, "Introduction to computing and problem solving with Python", First Edition, Khanna Publishing, 2016.
2	Eric Freeman, Elisabeth Robson, "Head First Design Patterns", Second Edition, O' Reilly Media, 2020.

Mode of Evaluation		
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar		
List of Challenging Experiments (Indicative)		
1.	Fundamental constructs in Python including Classes and Objects	3 hours
2.	Constructors and Destructors	3 hours
3.	Types of Overloading	4 hours
4.	Types of inheritance	4 hours
5.	Decorator Pattern, Strategy Pattern, State Pattern and others	5 hours
6.	Adaptor Pattern, Flyweight Pattern, Command Pattern and others	5 hours
7.	File Handling	3 hours
8.	Strings	3 hours
	Total Laboratory Hours	30 hours
Mode of Evaluation:		
Weekly Assessment, Final Assessment Test		

Recommended by Board of Studies			
Approved by Academic Council		Date	

Course Code	Course Title	L	T	P	J	C
CSE3100	Java Programming	3	0	2	0	4

Pre-requisite	Nil	Syllabus version

Course Objectives

- To apply the core Java fundamentals to learn the advanced concepts in J2SE
- To design and develop web application development and database connectivity using Servlets, JSP and JDBC
- To apply the advanced Java frameworks for the problems in Data Science

Course Outcomes

1) Provide a basic understanding of core Java concepts.
2) Comprehend Java's support in parallel programming, GUI creation and network programming.
3) Design and develop server side programming using Servlets.
4) Understand and implement Data visualization using Java.
5) Learn Java tools for data processing.
6) Implement the concepts of data mining using Java.

Module:1	Introduction to Java Programming:	6 hours

Features of Java, Data Types, Variables, Operators, Arrays, Control Statements. Introducing
Classes and Objects, Methods, Inheritance, Packages and Interfaces, Exception Handling, Inner classes, String Handling

Module:2	Exploring Core Java	6 hours

Multithreaded Programming, Files and IO Streams, Object Serialization ,Applets , Java GUI Programming and Event Handling, Java Networking, RMI, Reflection, Collections, Generics,

Java Autoboxing and Annotations

Module:3	Introducing JavaEE	6 hours

Enterprise Java, Basic Application Structure, Using Web Containers, Creating Servlets, Configuring Servlets, Understanding HTTP methods, Using Parameters and Accepting Form

Submissions, Using Init parameters, File Uploading, JDBC

Module:4	**Java Server Pages**	**6 hours**
Creating JSPs, Using Java within JSP, Combining Servlets and JSPs, Maintaining State using Sessions, JSP 2.0 EL, Using Java beans components in JSP Documents, JSP Custom Tag Library, Integrating Servlets and JSP: Model View Controller Architecture		
Module:5	**Data Visualization using Java**	**6 hours**
Data Visualization using Java – Charts, Time Series Charts, Histograms, Plots – Line, Box, Advanced Visualization Techniques – IVTK Graph Toolkit		
Module:6	**Data Processing Toolbox in Java**	**6 hours**
Basic concepts of machine learning; Data science libraries; Data processing tool box : Standard Java Library, Extensions to the standard Java library; Data acquisition; Exploratory Data Analysis		
Module:7	**Data Mining in Java**	**7 hours**
Introduction to data mining, Object modeling for data mining concepts, Modular packages, object factories, executing mining operations, exploring mining capabilities, object list methods, Model and data load methods		
Module:8	**Contemporary issues:**	**2 hours**
Expert talk on Java programming applications		
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Herbert Schildt, The Complete Reference-Java, Tata Mcgraw-Hill Edition, Eighth Edition, 2014.
2.	Richard M. Reese, Jennifer L. Reese, Alexey Grigorev, Java: Data Science Made Easy, Pocket Publishing, 2017.
Reference Books	
1.	Nicholas S. Williams, Professional Java for Web Applications, Wrox Press, 2014.
2.	Ed Burns, Chris Schalk, Java Server Faces 2.0, The Complete Reference, McGraw-Hill Publishers, 2010.
3.	Christian Bauer, Gavin King, Gary Gregory, Java Persistence with Hibernate, 2015.
4.	Rajat Mehta, Big Data Analytics with Java, Pocket Publishing, 2017.
List of Experiments (Indicative)	

1	Basic Java Programs	2 hours
2	Classes and Objects, Inheritance	3 hours
3	Exception handling, File handling, String handling	4 hours
4	Multithreaded Programming	2 hours
5	Creating and configuring servlets, HTTP methods	4 hours
6	Problems on Application development	3 hours
7	JSP, Servlets and JSP	3 hours
8	Data Visualization	2 hours
9	Data Processing	3 hours
10	Data Mining	4 hours
	Total Laboratory Hours	30 hours

Recommended by Board of Studies			
Approved by Academic Council		Date	

Course code	SOFTWARE QUALITY AND TESTING	L	T	P	J	C
MAT3014		2	0	0	4	3
Pre-requisite		Syllabus version				
		v. xx.xx				

Course Objectives:

- To understand the basics of software quality
- To learn and apply the metrics related to software quality
- To emphasize the importance of testing in SDLC
- To differentiate the test case view for functional and structural testing
- To gain insight into automation

Expected Course Outcome:

- Assess Quality standards of various software using Software Quality Metrics
- Judge the use of infrastructure components and use configuration items for Quality control.
- Differentiate between Functional and Structural Testing practices
- Test a given application using various testing methods.
- Develop test cases to remove bugs

Student Learning Outcomes (SLO):	2,7,9,18

[2] Having a clear understanding of the subject related concepts and contemporary issues
[7] Having computational thinking (Ability to translate vast data into abstract concepts and to understand database reasoning)
[9] Having problem-solving ability- solving social issues and engineering problems.
[18]Having critical thinking and innovative skills.

Module:1	INTRODUCTION TO SOFTWARE QUALITY	4 hours	

Ethical Basis for Software Quality ,Total Quality Management Principles ,Software Processes and Methodologies, Quality Standards, Practices & Conventions, Improving Quality with Methodologies ,Structured/Information Engineering , Measuring Customer Satisfaction

Module:2	SOFTWARE QUALITY ENGINEERING	4 hours	

Defining Quality Requirements , Management Issues for Software Quality ,Data Quality Control – Benchmarking and Certification.

Module:3	SOFTWARE QUALITY METRICS	4 hours	

Writing Software Requirements and Design Specifications , Analyzing Software Documents using Inspections and Walkthroughs , Software Metrics , Lines of Code, Cyclomatic Complexity, Function Points, Feature Points , Software Cost Estimation

Module:4	RELIABILITY	4 hours	

Reliability Models , Reliability Growth Models ,OO Metrics.

Module:5	TEST CASEDESIGN	4 hours	

Testing as an Engineering Activity , Testing Fundamentals , Defects ,Strategies and Methods for Black Box Test Case Design , Strategies and Methods for White, Box Test Case Design ,Test Adequacy Criteria , Evaluating Test Adequacy Criteria , Levels of Testing and different Types of

Testing ,OO Testing.			
Module:6	**TESTMANAGEMENT**	**4 hours**	
Testing and Debugging Goals and Policies ,Test Planning ,Test Plan Components ,Test Plan Attachments , Locating Test Items , Reporting Test Results ,The Role of Three Groups in Test Planning and Policy Development , Process and the Engineering Disciplines ,Introducing the test specialist ,Skills needed by a test specialist – Building a Testing Group.			
Module:7	**CONTROLLING ANDMONITORING**	**4 hours**	
Measurement and Milestones for Controlling and Monitoring , Status Meetings ,Reports and Control Issues , Criteria for Test Completion , SCM ,Types of Reviews ,Developing a Review Program , Components of Review Plans , Reporting Review Results.			
Module:8	**Contemporary issues:**	**2 hours**	
	Total Lecture hours:	**30 hours**	

Text Book(s)	
1.	Ilene Burnstein, "Practical Software Testing", Springer International Edition,2003.
2.	Stephen Kan, "Metrics and Models in Software Quality", Addison-Wesley, Second Edition, 2004
Reference Books	
1.	Milind Limaye, "SoftwareQualityAssurance ,McGrawHill,2011.
2	MGLimaye, "Software Testing– Principles, Techniques and Tools", McGraw Hill, 2011.
3	Edward Kit, "Software Testing in the Real World – Improving the Process", Pearson Education, 1995.
4	Elfriede Dustin, "Effective Software Testing", Pearson Education, 2003.
5	Renu Rajani and Pradeep Oak, "Software Testing – Effective Methods, Tools and Techniques", Tata McGraw Hill, 2003

Mode of evaluation: CAT / Assignment / Quiz / FAT			
Recommended by Board of Studies	30.06.2021		
Approved by Academic Council	No.	Date	