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. Data Science

(MDT)

Curriculum & Syllabi

(2021–2022 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. Data Science

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be practitioners and leaders in their chosen field.

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

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

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

5. Graduates will pursue career paths in teaching or research.

M.Sc. Data Science

PROGRAMME OUTCOMES (POs)

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

PO_02: Having problem solving ability to address social issues.

PO_03: Having a clear understanding of professional and ethical responsibility.

PO_04: Having cross cultural competency exhibited by working in teams.

PO_05: Having a good working knowledge of communicating in English.

M.Sc. Data Science

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M.Sc. Data Science programme, graduates will be able to

PSO1: To become a skilled Data Scientist in industry, academia, or government

PSO2: To use specialist software tools for data storage, analysis and visualization

PSO3: Able to independently carry out research/investigation to solve practical problems

M.Sc. Data Science

CREDIT STRUCTURE

Category-wise Credit distribution

Category	Credits
University Core (UC)	29
University Elective (UE)	06
Programme Core (PC)	23
Programme Elective (PE)	22
Total Credits	**80**

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M.Sc. Data Science

DETAILED CURRICULUM

University Core (UC)							
S. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**J**	**C**
1	MAT5010	Foundations of Data Science	3	0	0	0	3
2	RES5001	Research Methodology	2	0	0	0	2
3	SET5001	Science, Engineering and Technology Project – I	0	0	0	0	2
4	SET5002	Science, Engineering and Technology Project – II	0	0	0	0	2
5	SET5003	Science, Engineering and Technology Project – III	0	0	0	0	2
6	MDT6099	Master's Thesis	0	0	0	0	14
7	ENG5003/ FRE5001/ GER5001	English for Science and Technology/ French/ German	0 2 2	0 0 0	4 0 0	0 0 0	2 2 2
8	STS4001	Essentials of Business Etiquettes-Soft Skills	3	0	0	0	1
9	STS4002	Preparing for Industry	3	0	0	0	1

M.Sc. Data Science

DETAILED CURRICULUM

Programme Core (PC)							
S. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**J**	**C**
1	MAT5011	Matrix Theory and Linear Algebra	3	0	0	0	3
2	MAT5012	Probability Theory and Distributions	3	0	2	0	4
3	MAT5013	Statistical Inference	3	0	2	0	4
4	MAT5016	Time series analysis and Forecasting	3	0	2	0	4
5	MAT5017	Multivariate Data Analysis	3	0	2	0	4
6	MAT6002	Regression Analysis and Predictive Models	3	0	2	0	4

M.Sc. Data Science

DETAILED CURRICULUM

Programme Elective (PE)							
S. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**J**	**C**
1	MAT6003	Programming for Data Science	0	0	4	0	2
2	MAT6004	Computational Statistics for Data Science	0	0	4	0	2
3	MAT6005	Machine learning for Data Science	3	0	2	0	4
4	MAT6007	Deep learning	2	0	2	0	3
5	MAT6008	Artificial intelligence for Data Science	2	0	2	0	3
6	MAT6009	Design and Analysis of Experiments	3	0	2	0	4
7	MAT6010	Optimization Techniques	3	2	0	0	4
8	MAT6011	Statistical Quality Control	3	0	2	0	4
9	MAT6012	Programming for Data Analysis	2	0	4	0	4
10	MATXXXX	Bio-Statistics	2	0	2	0	3
11	MATXXXX	Reliability and Survival Analysis	2	0	2	0	3
12	MATXXXX	Queuing Theory and Network Analysis	3	0	0	0	3
13	MATXXXX	Stochastic Process and Applications	3	0	0	0	3
14	MATXXXX	Statistical Computing for Data Analysis	0	0	4	0	2
15	MATXXXX	Statistics for Managers	3	0	0	0	3
16	MATXXXX	Data Mining and Information Security	2	0	0	4	3
17	MATXXXX	Exploratory Data Analysis and Visualization	3	0	2	0	4
18	MATXXXX	Actuarial statistics	2	2	0	0	3

University Core

Course Code	Course Title	L	T	P	J	C
MAT5010	Foundations of Data Science	3	0	0	0	3
Pre-Requisite		Syllabus Version				
		1.1				

Course Objectives :

The course is aimed at

- Building the fundamentals of data science.
- Imparting design thinking capability to build big-data.
- Developing design skills of models for big data problems.
- Gaining practical experience in programming tools for data sciences.
- Empowering students with tools and techniques used in data science.

Expected Course Outcome:

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

- Apply data visualisation in big-data analytics.
- Utilise EDA, inference and regression techniques.
- Utilize Matrix decomposition techniques to perform data analysis.
- Apply data pre-processing techniques.
- Apply Basic Machine Learning Algorithms.

Module: 1	Introduction	4 hours

Big Data and Data Science - Big Data Analytics, Business intelligence vs Big data, big data frameworks, Current landscape of analytics, data visualisation techniques, visualisation software.

Module: 2	EDA	6 hours

Exploratory Data Analysis (EDA), statistical measures, Basic tools (plots, graphs and summary statistics) of EDA, Data Analytics Lifecycle, Discovery.

Module: 3	Basic Statistical Inference	6 hours

Developing Initial Hypotheses, Identifying Potential Data Sources, EDA case study, testing hypotheses on means, proportions and variances.

Module: 4	Regression models	6 hours

Regression models: Simple linear regression, least-squares principle, MLR, logistic regression, Multiple correlation, Partial correlation.

Module: 5	Linear Algebra Basics	6 hours

Matrices to represent relations between data, Linear algebraic operations on matrices – Matrix decomposition: Singular Value Decomposition (SVD) and Principal Component Analysis (PCA).

Module: 6	Data Pre-processing and Feature Selection	7 hours

Data cleaning - Data integration - Data Reduction - Data Transformation and Data Discretization, Feature Generation and Feature Selection, Feature Selection algorithms: Filters- Wrappers - Decision Trees - Random Forests.

Module:7	**Basic Machine Learning Algorithms**	**8 hours**
Classifiers - Decision tree - Naive Bayes - k-Nearest Neighbors (k-NN), k-means – SVM Association Rule mining – Ensemble methods.		
Module: 8	**Contemporary issues**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**45 hours**

Text Book(s)

- Mining of Massive Datasets. v2.1, Jure Leskovek, Anand Rajaraman and Jefrey Ullman., Cambridge University Press, 2019. (free online)
- Big Data Analytics, paperback 2nd ed., Seema Acharya, Subhasini Chellappan, Wiley, 2019.

Reference Book(s)

- Doing Data Science, Straight Talk From The Frontline, Cathy O'Neil and Rachel Schutt, O'Reilly, 2014.
- Data Mining: Concepts and Techniques", Third Edition, Jiawei Han, Micheline Kamber and Jian Pei, ISBN 0123814790, 2011.
- Big Data and Business Analytics, Jay Liebowitz, CRC press, 2013.
- Data mining methods,2nd edition, C. Rajan, Narosa , 2016.

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	Course Title	L	T	P	J	C
ENG5003	English for Science and Technology (for MCA & M.Sc., programmes)	0	0	4	0	2
Pre-Requisite	Cleared EPT	Syllabus Version				
		1.1				

Course Objectives:

- To enable students to communicate effectively in social, academic and professional contexts thereby enhancing their interpersonal, managerial, problem-solving, and presentation skills.
- To facilitate students to develop their listening competency and critically evaluate and review documentaries, talks and speeches.
- To Assist students to read and comprehend News Articles and Scientific Texts; effectively interpret tables and graphs; write and proof-read official correspondences.

Expected Course Outcomes (CO):

- Make effective presentations and display their interpersonal skills in academic and professional contexts.
- Emerge as good listeners and critically evaluate oral communication.
- Excel in reading, comprehending and interpreting technical reports, texts and data.
- Able to write effectively in English and also display their proof-reading abilities.
- Face real interviews and handle personal and professional conflicts effectively.

Module:1	**Career Goals**	**4hours**
Short term and long term career goals Activity: SWOT Analysis/ Comprehending speeches		
Module:2	**Interpersonal Skills**	**4 hours**
Interpersonal Communication in/with Groups (Corporate Etiquette: Journey from Campus to corporate) Activity: Role Plays/Mime/Skit		
Module:3	**Listening Skills**	**4 hours**
Listening to Documentary Activity: Critically evaluate/Review a documentary/TED Talk		
Module:4	**Reading Skills**	**4hours**
Skimming, Scanning, Intensive & Extensive reading Activity: Reading News Papers/Magazines/Scientific Texts		
Module:5	**Report Writing**	**4hours**
Language and mechanics of writing report Activity: Writing a Report/Mini Project		
Module:6	**Study Skills**	**4hours**
Summarizing the report Activity: Abstract, Executive Summary, Digital Synopsis		
Module:7	**Interpreting skills**	**4hours**

Interpret data in tables and graphs Activity: Transcoding		
Module:8	**Editing Skills**	**4hours**
Proof Reading Sequencing Activity: Editing any given text		
Module:9	**Presentation Skills**	**4 hours**
Oral Presentation using digital tools Activity: Oral presentation on the given topic using appropriate non-verbal cues		
Module:10	**Group Discussion**	**4 hours**
Intragroup interaction (avoid, accommodate, compete, compromise, collaborate) Activity: Group discussion on a given topic		
Module:11	**Professional Skills**	**4 hours**
Résumé Writing Activity: Prepare an Electronic Résumé		
Module:12	**Skill-Gap Analysis**	**4 hours**
Tailor your skills to suit the Job needs Activity: Write a SoP for higher Studies/Purpose Statement for job		
Module:13	**Interview Skills**	**4 hours**
Placement/Job Interview Activity: Mock Interview		
Module:14	**Managerial Skills**	**4 hours**
Official Meeting to organize events Activity: Writing Agenda, Minutes of Meeting (video conferencing) and Organizing an event		
Module:15	**Problem Solving Skills**	**4 hours**
Conflict Management & Decision Making Activity: Case analysis of a challenging Scenario		
	Total Lecture hours:	**60 hours**

Text Book(s)

- Kuhnke, E. Communication Essentials For Dummies. (2015). First Edition. John Wiley & Sons.
- Hewings, M. Advanced Grammar in Use Book with Answers and CD-ROM: A Self-Study Reference and Practice Book for Advanced Learners of English. (2013). Third Edition. Cambridge University Press. UK.

Reference Book(s)

- Churches, R. Effective Classroom Communication Pocketbook. Management Pocketbooks. (2015). First Edition. USA.
- Wallwork, A. English for Writing Research Papers. (2016). Second Edition. Springer.

•	Wood, J. T. Communication in Our Lives. (2016). Cengage Learning. Boston. USA.
•	Anderson, C. TED Talks: The Official TED Guide to Public Speaking. (2016). First Edition.Boston. Houghton Mifflin. New. York.
•	Zinsser, William. On writing well. HarperCollins Publishers. 2016. Thirtieth Edition. New York.
•	Tebeaux, Elizabeth, and Sam Dragga. The essentials of Technical Communication. 2015. First Edition Oxford University Press. USA.

Mode of Evaluation: Mini Project, Flipped Class Room, Lecture, PPT's, Role play, Assignments Class/Virtual Presentations, Report and beyond the classroom activities

List of Challenging Experiments (Indicative)		
1.	Setting short term and long term goals	**2 hours**
2.	Mime/Skit/ Activities through VIT Community Radio	**6 hours**
3.	Critically evaluate / review a documentary/ Activities through VIT Community Radio	**4 hours**
4.	Mini Project	**10 hours**
5.	Digital Synopsis	**4 hours**
6.	Case analysis of a challenging Scenario	**4 hours**
7.	Intensive & Extensive reading of Scientific Texts	**4 hours**
8.	Editing any given text	**8 hours**
9.	Group discussion on a given topic / Activities through VIT Community Radio	**8 hours**
10.	Prepare a video résumé along with your video introduction and then create a website (in Google Sites/Webly/Wix) showcasing skills and achievements.	**10 hours**
Total Laboratory Hours		**60 hours**

Mode of evaluation: Mini Project, Flipped Class Room, Lecture, PPT's, Role play, Assignments Class/Virtual Presentations, Report and beyond the classroom activities

Recommended by Board of Studies	22-07-2017		
Approved by Academic Council	No. 47	Date	24.08.2017

Course Code	Course Title	L	T	P	J	C
FRE5001	Francais Fonctionnel	2	0	0	0	2
Pre-Requisite	Nil	Syllabus Version				
		1.0				

Course Objectives:

The course gives students the necessary background to:

- demonstrate competence in reading, writing, and speaking basic French, including knowledge of vocabulary (related to profession, emotions, food, workplace, sports/hobbies, classroom and family).
- achieve proficiency in French culture-oriented viewpoint.

Expected Course Outcome: Students will be able to

- Remember the daily life communicative situations via personal pronouns, emphatic pronouns, salutations, negations, interrogations etc.
- Create communicative skill effectively in the French language via regular/irregular verbs.
- Demonstrate comprehension of the spoken/written language in translating simple sentences.
- Understand and demonstrate the comprehension of some particular new range of unseen written materials.
- Demonstrate a clear understanding of the French culture through the language studied.

Module:1	Saluer, Se présenter, Etablir des contacts	3 hours

Les Salutations, Les nombres (1-100), Les jours de la semaine, Les mois de l'année, Les Pronoms Sujets, Les Pronoms Toniques, La conjugaison des verbes réguliers, La conjugaison des verbes irréguliers- avoir / être / aller / venir / faire etc.

Module:2	Présenter quelqu'un, Chercher un(e) correspondant(e), Demander des nouvelles d'une personne.	3 hours

La conjugaison des verbes Pronominaux, La Négation, L'interrogation avec *'Est-ce que ou sans Est-ce que'*.

Module:3	Situer un objet ou un lieu, Poser des questions	4 hours

L'article (défini/ indéfini), Les prépositions (à/en/au/aux/sur/dans/avec etc.), L'article contracté, Les heures en français, La Nationalité du Pays, L'adjectif (La Couleur, l'adjectif possessif, l'adjectif démonstratif/ l'adjectif interrogatif (quel/quelles/quelle/quelles), L'accord des adjectifs avec le nom, L'interrogation avec Comment/ Combien / Où etc.,

Module:4	Faire des achats, Comprendre un texte court, Demander et indiquer le chemin.	6 hours

La traduction simple :(français-anglais / anglais –français)

Module:5	Trouver les questions, Répondre aux questions générales en français.	5 hours

L'article Partitif, Mettez les phrases aux pluriels, Faites une phrase avec les mots donnés, Exprimez les phrases données au Masculin ou Féminin, Associez les phrases.

Module:6	**Comment ecrire un passage**	**3 hours**
Décrivez : La Famille /La Maison, /L'université /Les Loisirs/ La Vie quotidienne etc.		
Module:7	**Comment ecrire un dialogue**	**4 hours**
Dialogue: a) Réserver un billet de train b) Entre deux amis qui se rencontrent au café c) Parmi les membres de la famille d) Entre le client et le médecin		
Module:8	**Invited Talk: Native speakers**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

- Echo-1, Méthode de français, J. Girardet, J. Pécheur, Publisher CLE International, Paris 2010.
- Echo-1, Cahier d'exercices, J. Girardet, J. Pécheur, Publisher CLE International, Paris 2010.

Reference Books

- CONNEXIONS 1, Méthode de français, Régine Mérieux, Yves Loiseau,Les Éditions Didier, 2004.
- CONNEXIONS 1, Le cahier d'exercices, Régine Mérieux, Yves Loiseau, Les Éditions Didier, 2004.
- ALTER EGO 1, Méthode de français, Annie Berthet, Catherine Hugo, Véronique M. Kizirian, Béatrix Sampsonis, Monique Waendendries , Hachette livre 2006.

Mode of Evaluation: CAT / Assignment / Quiz / FAT			
Recommended by Board of Studies	26.2.2016		
Approved by Academic Council	No 41	Date	17.6.2016

Course Code	Course Title	L	T	P	J	C
GER5001	Deutsch für Anfänger	2	0	0	0	2
Pre-Requisite	NIL	Syllabus Version				
		1.0				

Course Objectives:

The course gives students the necessary background to:

- enable students to read and communicate in German in their day to day life
- become industry-ready
- make them understand the usage of grammar in the German Language.

Expected Course Outcome: Students will be able to

- Create the basics of the German language in their day to day life.
- Understand the conjugation of different forms of regular/irregular verbs.
- Understand the rule to identify the gender of the Nouns and apply articles appropriately.
- Apply the German language skill in writing corresponding letters, E-Mails etc.
- Create the talent of translating passages from English-German and vice versa and to frame simple dialogues based on given situations.

Module:1	**3 hours**

Einleitung, Begrüssungsformen, Landeskunde, Alphabet, Personalpronomen, Verb Konjugation, Zahlen (1-100), W-fragen, Aussagesätze, Nomen – Singular und Plural

Lernziel:

Elementares Verständnis von Deutsch, Genus- Artikelwörter

Module:2	**3 hours**

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

Lernziel :

Sätze schreiben, über Hobbys erzählen, über Berufe sprechen usw.

Module:3	**4 hours**

Possessivpronomen, Negation, Kasus- AkkusatitvundDativ (bestimmter, unbestimmterArtikel), trennnbare verben, Modalverben, Adjektive, Uhrzeit, Präpositionen, Mahlzeiten, Lebensmittel, Getränke

Lernziel :

Sätze mit Modalverben, Verwendung von Artikel, über Länder und Sprachen sprechen, über eine Wohnung beschreiben.

Module:4	**6 hours**

Übersetzungen : (Deutsch – Englisch / Englisch – Deutsch)

Lernziel :

Grammatik – Wortschatz – Übung

Module:5	**5 hours**

Leseverständnis,Mindmap machen,Korrespondenz- Briefe, Postkarten, E-Mail

Lernziel :

Wortschatzbildung und aktiver Sprach gebrauch		
Module:6	.	**3 hours**
Aufsätze : Meine Universität, Das Essen, mein Freund oder meine Freundin, meine Familie, ein Fest in Deutschland usw		
Module:7		**4 hours**
Dialoge: e) Gespräche mit Familienmitgliedern, Am Bahnhof, f) Gespräche beim Einkaufen ; in einem Supermarkt ; in einer Buchhandlung ; g) in einem Hotel - an der Rezeption ;ein Termin beim Arzt. Treffen im Cafe		
Module:8	**Contemporary issues**	**2 hours**
Lecture by Industry Experts.		
	Total Lecture hours:	**30 hours**

Text Book(s)	
•	Studio d A1 Deutsch als Fremdsprache, Hermann Funk, Christina Kuhn, Silke Demme : 2012
Reference Books	
•	Netzwerk Deutsch als Fremdsprache A1, Stefanie Dengler, Paul Rusch, Helen Schmtiz, Tanja Sieber, 2013
•	Lagune ,Hartmut Aufderstrasse, Jutta Müller, Thomas Storz, 2012.
•	Deutsche SprachlehrefürAUsländer, Heinz Griesbach, Dora Schulz, 2011
•	ThemenAktuell 1, HartmurtAufderstrasse, Heiko Bock, MechthildGerdes, Jutta Müller und Helmut Müller, 2010
	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	Course Title	L	T	P	J	C
STS4001	Essentials of Business Etiquettes	3	0	0	0	1
Pre-Requisite		Syllabus Version				
		2.0				

Course Objectives:

- To develop the students' logical thinking skills
- To learn the strategies of solving quantitative ability problems
- To enrich the verbal ability of the students
- To enhance critical thinking and innovative skills

Expected Course Outcome:

- Enabling students to use relevant aptitude and appropriate language to express themselves
- To communicate the message to the target audience clearly

Module:1	Business Etiquette: Social and Cultural Etiquette and Writing Company Blogs and Internal Communications and Planning and Writing press release and meeting notes	9 hours

Value, Manners, Customs, Language, Tradition, Building a blog, Developing brand message, FAQs', Assessing Competition, Open and objective Communication, Two-way dialogue, Understanding the audience, Identifying, Gathering Information, Analysis, Determining, Selecting plan, Progress check, Types of planning, Write a short, catchy headline, Get to the Point –summarize your subject in the first paragraph., Body – Make it relevant to your audience.

Module:2	Study skills – Time management skills	3 hours

Prioritization, Procrastination, Scheduling, Multitasking, Monitoring, Working under pressure and adhering to deadlines

Module:3	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:4	Quantitative Ability -L1 – Number properties and Averages and Progressions and Percentages and Ratios	11 hours

Number of factors, Factorials, Remainder Theorem, Unit digit position, Tens digit position, Averages, Weighted Average, Arithmetic Progression, Geometric Progression, Harmonic Progression, Increase & Decrease or successive increase, Types of ratios and proportions.

Module:5	Reasoning Ability-L1 – Analytical Reasoning	8 hours

Data Arrangement(Linear and circular & Cross Variable Relationship), Blood Relations, Ordering/ranking/grouping, Puzzle test, Selection Decision table

Module:6	Verbal Ability-L1 – Vocabulary Building	7 hours

Synonyms & Antonyms, One-word substitutes, Word Pairs, Spellings, Idioms, Sentence completion, Analogies		
	Total Lecture hours:	**45 hours**

Reference Books	
1.	Kerry Patterson, Joseph Grenny, Ron McMillan, Al Switzler(2001) Crucial Conversations: Tools for Talking When Stakes are High. Bangalore. McGraw-Hill Contemporary
2.	Dale Carnegie,(1936) How to Win Friends and Influence People. New York. Gallery Books
3.	Scott Peck. M(1978) Road Less Travelled. New York City. M. Scott Peck.
4.	FACE(2016) Aptipedia Aptitude Encyclopedia. Delhi. Wiley publications
5.	ETHNUS(2013) Aptimithra. Bangalore. McGraw-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, 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

Course Code	Course Title	L	T	P	J	C
STS4002	Preparing for Industry	3	0	0	0	1
Pre-Requisite		Syllabus Version				
		2.0				

Course Objectives:

- To develop the students' logical thinking skills
- To learn the strategies of solving quantitative ability problems
- To enrich the verbal ability of the students
- To enhance critical thinking and innovative skills

Expected Course Outcome:

- Enabling students to simplify, evaluate, analyze and use functions and expressions to simulate real situations to be industry-ready.

Module:1	Interview skills – Types of interview and Techniques to face remote interviews and Mock Interview	3 hours

Structured and unstructured interview orientation, Closed questions and hypothetical questions, Interviewers' perspective, Questions to ask/not ask during an interview, Video interview, Recorded feedback, Phone interview preparation, Tips to customize preparation for personal interview, Practice rounds

Module:2	Resume skills – Resume Template and Use of power verbs and Types of resume and Customizing resume	2 hours

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

Module:3	Emotional Intelligence - L1 – Transactional Analysis and Brain storming and Psychometric Analysis and Rebus Puzzles/Problem Solving	12 hours

Introduction, Contracting, ego states, Life positions, Individual Brainstorming, Group Brainstorming, Stepladder Technique, Brain writing, Crawford's Slip writing approach, Reverse brainstorming, Star bursting, Charlette procedure, Round robin brainstorming, Skill Test, Personality Test, More than one answer, Unique ways

Module:4	Quantitative Ability-L3 – Permutation-Combinations and Probability and Geometry and mensuration and Trigonometry and Logarithms and Functions and Quadratic Equations and Set Theory	14 hours

Counting, Grouping, Linear Arrangement, Circular Arrangements, Conditional Probability, Independent and Dependent Events, Properties of Polygon, 2D & 3D Figures, Area & Volumes, Heights and distances, Simple trigonometric functions, Introduction to logarithms, Basic rules of logarithms, Introduction to functions, Basic rules of functions, Understanding Quadratic Equations, Rules & probabilities of Quadratic Equations, Basic concepts of Venn Diagram.

Module:5	Reasoning ability-L3 – Logical reasoning and Data Analysis	7 hours

	and Interpretation	
Syllogisms, Binary logic, Sequential output tracing, Crypto arithmetic, Data Sufficiency, Data interpretation-Advanced, Interpretation tables, pie charts & bar chats		
Module:6	**Verbal Ability-L3 – Comprehension and Logic**	**7 hours**
Reading comprehension, Para Jumbles, Critical Reasoning (a) Premise and Conclusion, (b) Assumption & Inference, (c) Strengthening & Weakening an Argument		
	Total Lecture hours:	**45 hours**

Reference Books

- Michael Farra and JIST Editors(2011) Quick Resume & Cover Letter Book: Write and Use an Effective Resume in Just One Day. Saint Paul, Minnesota. Jist Works
- Daniel Flage Ph.D(2003) The Art of Questioning: An Introduction to Critical Thinking. London. Pearson
- David Allen(2002) Getting Things done : The Art of Stress -Free productivity. New York City. Penguin Books.
- FACE(2016) Aptipedia Aptitude Encyclopedia.Delhi. Wiley publications
- ETHNUS(2013) Aptimithra. Bangalore. McGraw-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

Course Code	Course Title	L	T	P	J	C
SET5001	Science, Engineering and Technology Project– I	0	0	0	0	2
Pre-Requisite		Syllabus Version				
Anti-Requisite		1.10				

Course Objectives:

- To provide opportunity to involve in research related to science / engineering
- To inculcate research culture
- To enhance the rational and innovative thinking capabilities

Expected Course Outcome: Student will be able to

- Identify a research problem and carry out literature survey
- Analyse the research gap and formulate the problem
- Interpret the data and synthesize research findings
- Report research findings in written and verbal forms

Modalities / Requirements

1. Individual or group projects can be taken up
2. Involve in literature survey in the chosen field
3. Use Science/Engineering principles to solve identified issues
4. Adopt relevant and well-defined / innovative methodologies to fulfill the specified objective
5. Submission of scientific report in a specified format (after plagiarism check)

Student Assessment : Periodical reviews, oral/poster presentation

Recommended by Board of Studies	17.08.2017		
Approved by Academic Council	No. 47	Date	05.10.2017

Course Code	Course Title	L	T	P	J	C
SET5002	Science, Engineering and Technology Project– II	0	0	0	0	2
Pre-Requisite		Syllabus Version				
Anti-Requisite		1.10				

Course Objectives:

- To provide an opportunity to involve in research related to science/engineering
- To inculcate research culture
- To enhance the rational and innovative thinking capabilities

Expected Course Outcome: Student will be able to

- Identify a research problem and carry out a literature survey
- Analyse the research gap and formulate the problem
- Interpret the data and synthesize research findings
- Report research findings in written and verbal forms

Modalities / Requirements

6. Individual or group projects can be taken up
7. Involve in literature survey in the chosen field
8. Use Science/Engineering principles to solve identified issues
9. Adopt relevant and well-defined / innovative methodologies to fulfill the specified objective
10. Submission of scientific report in a specified format (after plagiarism check)

Student Assessment : Periodical reviews, oral/poster presentation

Recommended by Board of Studies	17.08.2017		
Approved by Academic Council	No. 47	Date	05.10.2017

Course Code	Course Title	L	T	P	J	C
SET5003	Science, Engineering and Technology Project– III	0	0	0	0	2
Pre-Requisite		Syllabus Version				
Anti-Requisite		1.10				

Course Objectives:

- To provide an opportunity to involve in research related to science/engineering
- To inculcate research culture
- To enhance the rational and innovative thinking capabilities

Expected Course Outcome: Student will be able to

- Identify a research problem and carry out a literature survey
- Analyse the research gap and formulate the problem
- Interpret the data and synthesize research findings
- Report research findings in written and verbal forms

Modalities / Requirements

11. Individual or group projects can be taken up
12. Involve in the literature survey in the chosen field
13. Use Science/Engineering principles to solve identified issues
14. Adopt relevant and well-defined/innovative methodologies to fulfil the specified objective
15. Submission of a scientific report in a specified format (after plagiarism check)

Student Assessment: Periodical reviews, oral/poster presentation

Recommended by Board of Studies	17.08.2017		
Approved by Academic Council	No. 47	Date	05.10.2017

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Course Code	Course Title	L	T	P	J	C
RES5001	Research Methodology	2	0	0	0	2
Pre-Requisite	Nil	Syllabus Version				
		1.0				

Course Objectives:

- Impart skills to develop a research topic and design
- Define a purpose statement, a research question or hypothesis, and a research objective
- Analyze the data and arrive at a valid conclusion
- Compile and present research findings

Expected Course Outcome: student will be able to

- Explain the basic aspects of research and its ethics
- Outline research problems, their types and objectives
- Formulate good research designs and carry out statistically relevant sampling
- Collect, collate, analyze and interpret data systematically
- Experiment with animals ethically
- Make use of literature and other search engines judiciously for research purposes

Module:1	Introduction and Foundation of Research	2 hours

Meaning, Objectives, Motivation, Utility for research. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method –Understanding the language of research.

Module:2	Problem identification and formulation	4 hours

Scientific Research: Problem, Definition, Objectives, Types, Purposes and components of Research problem

Module:3	Research Design	4 hours

Concept and Importance in Research : Features of a good research design, Exploratory Research Design and Descriptive Research Designs

Module:4	Sampling	6 hours

Sampling methods, Merits and Demerits. Observation methods, Sampling Errors (Type I and Type II). Determining size of the sample. Experimental Design: Concept of Independent & Dependent variables.

Module:5	Data analysis and Reporting	6 hours

Fundamentals of Statistical Analysis and Inference, Multivariate methods, Concepts of Correlation and Regression; Research Reports: Structure, Components, Types and Layout of Research report and articles, Writing and interpreting research results, Figures and Graphs

Module:6	Animal handling	2 hours

Guidelines-animal ethical committee, animal models, various routes of drug administrations, LD_{50}, ED_{50}

Module:7	Use of encyclopedias and tools in research	4 hours

Research Guides, Handbook, Academic Databases for Biological Science Discipline. Methods to search required information effectively.

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

Text Book(s)

- Catherine Dawson, Introduction to research methods : a practical guide for anyone undertaking a research project, Oxford : How To Books, Reprint 2010
- Julius S. Bendat, Allan G. Piersol, Random Data: Analysis and Measurement Procedures, 4th Edition, ISBN: 978-1-118-21082-6, 640 pages, September, 2011
- Research in Medical and Biological Sciences, 1st Edition, From Planning and Preparation to Grant Application and Publication, Editos: Petter Laake Haakon Benestad Bjorn Olsen, ISBN: 9780128001547, Academic Press, March 2015

Reference Book(s)

- John Creswell, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, Fourth Edition March, 2013

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

Recommended by Board of Studies	03.08.2017		
Approved by Academic Council	No. 46	Date	24.08.2017

Course Code	Course Title	L	T	P	J	C
MDT6099	Master's Thesis	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: Students 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.
- Develop a suitable solution methodology for the problem
- Conduct experiments / Design & Analysis / solution iterations and document the results
- Perform error analysis / benchmarking/costing
- Synthesise the results and arrive at scientific conclusions/products/solution
- Document the results in the form of technical report/presentation

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

Recommended by Board of Studies	10.09.2019		
Approved by Academic Council	No. 56	Date	24.09.2019

Programme Core

Course Code	Course Title	L	T	P	J	C
MAT 5011	Matrix theory and Linear Algebra	3	0	0	0	3
Pre-Requisite		Syllabus Version				
		1.1				

Course Objectives:

- Understand the basic concepts of matrix algebra and its applications.
- Solving computational problems of linear algebra.

Expected Course Outcomes:

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

- Understand basic matrix properties like rank, determinant, inverse and a special type of matrices
- Introduce Gaussian / Gauss-Jordan elimination methods, LU factorisation technique
- Use computational techniques for singular value decomposition (Computational and Algebraic Skills).
- Understand the concepts of vector space and subspaces.
- Find the matrix representation of a linear transformation given bases of the relevant vector spaces.
- Compute inner products on a real vector space and compute angle and orthogonality in inner product spaces.
- Understand the use of linear algebra and matrices in several important, modern applications of research and industrial problems involving statistics.

Module: 1	Matrix theory	6 hours

Algebra of Matrices, Trace and Rank of a Matrix and their properties, Determinants, Inverse, Eigen values and Eigen vectors, symmetric, orthogonal and idempotent matrices and their properties

Module:2	Matrix Factorization	6 hours

Gauss elimination, row canonical form, diagonal form, triangular form, Gauss-Jordan-LU decomposition, solving systems of linear equations.

Module:3	Decomposition of Matrices	6 hours

Spectral decomposition, singular value decomposition, Quadratic forms, definiteness and related results with proofs.

Module:4	Vector Spaces	6 hours

Vector Spaces, Subspaces, Basis and dimension of a vector space, linear dependence and linear independence, spanning set.

Module:5	Linear transformation	6 hours

Linear transformation, kernel, range, Matrix Representation of a linear transformation, rank-nullity theorem, change of basis and similar matrices.

Module:6	Inner product spaces	6 hours

Inner-product spaces, orthogonal sets and bases, Orthogonal Projection, Gram-Schmidt orthogonalization process.

Module:7	**Applications in Statistics**	**7 hours**
Generalized inverses (g-inverses), Methods of constructing g-inverses, general solution to a system of linear equations. Sparse matrices, Linear Discriminant Analysis and Canonical Correlation Analysis.		
Module:8	**Contemporary issues**	**2 hours**
Lecture by Industry Experts.		
	Total Lecture hours:	**30 hours**
Tutorial	• A minimum of 5 problems to be worked out by student in every tutorial class. • Another 5 problems per tutorial class to be given as home work.	**15 hours**

Text Book(s)

- Gilbert Strang, *Introduction to linear algebra, 5/e.*, Wellesley-Cambridge, 2016.
- David C. Lay, Linear Algebra and Its Applications, Pearson, 5/e 2019.

Reference Book(s)

- G. Allaire and S. M. Kaber. Numerical Linear Algebra, Texts in Applied Mathematics, Springer, 2008.
- L. Hogben, Handbook of Linear Algebra, CRC Press/Taylor & Francis Group, 2014.
- Friedberg, S., Insel, A., and Spence, L., Linear Algebra, 5/e, Pearson, 2019.
- Nick Fieller, "Basics of Matrix Algebra for Statistics with R", CRC Press, 2015.

Mode of Evaluation: CAT, Quiz, Assignment and 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
MAT5012	Probability Theory and Distributions	3	0	2	0	4
Pre-Requisite	Basic knowledge of sets, sample space, probability space, measure space, probability measure and calculus.	Syllabus Version				
		1.1				

Course Objectives:

- To incorporate the concepts of probability theory and its applications as the core material in building theoretical ideas along with the practical notion.
- To integrate the intrinsic ideas of preliminary and advanced distributions to correlate with the real-world scenarios.

Expected Course Outcome:

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

- Develop problem-solving techniques needed to calculate probability and conditional probability.
- Formulate fundamental probability distribution and density functions, as well as functions of random variables, derive the probability density function of transformations.
- Derive the expectation and conditional expectation, and describe their properties.
- Understand various types of generating functions used in statistics.
- Describe commonly used univariate discrete and continuous probability distributions.
- Apply sampling distributions to testing of hypotheses.
- Translate and correlate the statistical problems into Statistical analysis

Module:1	Probability and Random variables	8 hours

Introduction – Random Experiments, Empirical basis of probability, Algebra of events, laws of probability; Conditional Probability, Independence, Bayes' law; Application of probability to business and economics. One-dimensional Random variable- Discrete and Continuous; Distribution functions and its properties; Bivariate Random Variables- Joint Probability functions, marginal distributions, conditional distribution functions; Notion of Independence of Random variables

Module:2	Functions of Random Variables	6 hours

Functions of random variables: introduction, distribution function technique, transformation technique: one variable, transformation technique: several variables, theory and applications.

Module:3	Mathematical Expectation	6 hours

Expectation, Variance, and Co-variance of random variables; Conditional expectation and conditional variance; Markov, Holder, Jensen and Chebyshev's Inequality; Weak Law of Large numbers, Strong law of large numbers and Kolmogorov theorem; Central Limit Theorem.

Module:4	Generating Functions	5 hours

Probability generating function (p.g.f.), moment generating function (m.g.f.), characteristic function (c.f.); Properties and Applications. Probability distributions of functions of random variables: one and two dimensions.

Module:5	Discrete Distributions	7 hours

Bernoulli, Binomial, Poisson, Geometric, Hypergeometric, Negative Binomial, Multinomial, distributions and Discrete Uniform distribution - definition, properties and applications with numerical problems.

Module:6	**Continuous Distributions**	**7 hours**
Uniform, Normal distribution function, Exponential, Gamma, Beta distributions (First and Second kind), Weibull, Cauchy and Laplace distributions, lognormal, logistic, Pareto and Rayleigh distribution functions - definition, properties and applications; concept of truncated distributions.		
Module:7	**Sampling Distributions**	**4 hours**
Introduction, The sampling distribution of the Mean: Finite Populations, Sampling distribution of the proportion: Finite Populations, distribution of sample variance, the chi-square distribution, the t distribution, the F distribution, order statistics: properties, and applications, procedure of hypothesis testing.		
Module:8	**Contemporary issues**	**2 hours**
Lecture by Industry Experts.		
	Total Lecture hours:	**45 hours**

Text Book(s)

- Sheldon Ross; A First Course in Probability, Pearson, 2014.
- Parimal Mukhopadhyay; An Introduction to the Theory of Probability, World scientific, 2012.
- Irwin Miller, Marylees Miller, John E. Freund's; Mathematical Statistics, Pearson, 2017

Reference Book(s)

- FetsjeBijma, Marianne Jonker and Aad van der Vaart; Introduction to Mathematical Statistics, Amsterdam University Press, 2018.
- Krishnamoorthy, K., Handbook of Statistical Distributions with Applications, Chapman & Hall/CRC, 2006.
- Rohatgi, V.K. and Ebsanes Saleh, A.K. Md., An introduction to Probability and Statistics, 2nd Ed., John Wiley & Sons, 2002.
- Shanmugam, R., Chattamvelli, R. Statistics for scientists and engineers, John Wiley, 2015.

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

List of Challenging Experiments (Indicative): Using Computational software's like MS-Excel/MS-Solver/R/Python/Minitab etc.

1.	Introduction to computational procedure, import and export of data, data processing, tabulation and visualization of data and charts, Diagrammatical Presentation of data.	4 hours
2.	Various plots and graphical Presentation of Statistical Data	4 hours
3.	Computation of descriptive Statistics and summarizing the data	4 hours
4.	Computational methods of discrete distributions and generating random numbers using standard distributions.	2 hours
5.	Normal distribution : calculation of probabilities, fitting of normal data and related applications	4 hours
6.	Binomial distribution: Calculation of probabilities, fitting of binomial data and related applications on real time data.	4 hours
7.	Poisson distribution: Calculation of probabilities, fitting of Poisson data and related applications on real time data.	2 hours
8.	Exponential distribution: Calculation of probabilities, fitting of exponential data and related applications on real time data.	2 hours
9.	Gamma distribution: Calculation of probabilities, fitting of Gamma data and related applications on real time data.	2 hours

10.	Beta distribution: Calculation of probabilities, fitting of Beta data and related applications on real time data.	2 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	Course Title	L	T	P	J	C
MAT5013	Statistical Inference	3	0	2	0	4
Pre-requisite	Nil	Syllabus Version				
		1.1				

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 Outcomes:

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, applications of Lehmann-Scheffe's Theorem, 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), Large sample properties of ML estimator(without proof)- applications , Method of moments, method of least squares, method of minimum chi-square and modified minimum chi-square-Asymptotic Maximum Likelihood Estimation and applications

Module:3	Interval Estimation	4 hours

Confidence limits 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 variance,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, $\chi 2$ test for testing variance of a normal distribution		
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 ,Kruskal – Wallis H 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.
- Robert V Hogg, Elliot A Tannis and Dale L.Zimmerman, Probability and Statistical Inference,9th edition,Pearson publishers, 2013.

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.
- Bansilal, Sanjay Arora and Sudha Arora, Introducing Probability and Statistics, 2/e, Satya Prakash Publications, 2006.
- George Casella and Roger L.Berger: , Statistical Inference, 2nd edition,Casebound Engelska, 2002.

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

List of Experiments		
1	Calculating Confidence intervals, *p*-value	2 hours
2	Large Sample Tests- Test for Population mean & Population proportions	4 hours
3	Small Sample Tests – t – test for population mean, Paired t test	4 hours
4	F- test for population variances	2 hours
5	Chi-square test for goodness of fit and Independence of Attributes	4 hours

6	Computation of - consistent estimator, unbiased estimators and their variances.	2 hours
7	Computation of ML estimator by Iterative method/Method of scoring, computation of estimators for grouped data applying the ML.	2 hours
8	Minimum $\chi 2$ and modified minimum $\chi 2$	2 hours
9	Computation of least squares estimator - calculation of standard errors of estimators	2 hours
10	Test for correlation coefficient & Non-parametric Tests	6 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	Course Title	L	T	P	J	C
MAT5016	Time Series Analysis and Forecasting	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	Course Title	L	T	P	J	C
MAT5017	Multivariate Data Analysis	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 T^2 and Mahalanobis D^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 , Quiz , Assignment and FAT.

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 T^2 and Mahalanobis D^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	Course Title	L	T	P	J	C
MAT6002	Regression Analysis and Predictive Modelling	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, Quiz, Assignment and 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. 1	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

Programme Elective

Course Code	Course Title	L	T	P	J	C
MAT6003	Programming for Data Science	0	0	4	0	2
Pre-Requisite	MAT5012 – Probability Theory and Distributions	Syllabus Version				
		1.0				

Course Objectives:

- Formulate simple problems, and code a high-level appropriate programme for data science.
- Acquire knowledge of standard data visualization and formal inference procedures to interpret the results.
- To develop complex statistical models to assess data and apply to real-world contexts.

Expected Course Outcome:

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

- develop relevant programming techniques of moderate complexity and execute in data science.
- demonstrate the proficiency in statistical data analysis of inferential methods and interpret the results contextually.
- apply data science concepts and methods to solve problems in real-world contexts
- integrate data from disparate sources and transform in relational databases.

List of Challenging Experiments (Indicative)

1	Introduction to Python – Keywords, identifiers, I/O statements.	4 hours
2	Sequence and File operations.	4 hours
3	Functions, loops, Modules, errors and exceptions.	4 hours
4	Data Manipulation- Basic Functionalities, Merging, Concatenation of data objects, Exploring a Dataset and Analysing a dataset.	6 hours
5	Data visualization – Graphical and diagrammatical presentation	4 hours
6	Descriptive statistical analysis – evaluation, plotting and interpretation.	4 hours
7	Evaluation of probability using various distribution functions	4 hours
8	Correlation – Simple, Partial and Multiple Correlations for linear and non-linear data.	6 hours
9	Regression – Simple, Multiple Regression and linear models.	6 hours
10	Test for normality and homogeneity of variance-Inferential Statistics for Single through multiple samples.	6 hours
11	Experimental Design: One way ANOVA-two way ANOVA- Multiple comparison tests	6 hours
12	Time series analysis – White noise, AR, MA, ARMA, ARIMA, ACF and PACF.	6 hours
Total Laboratory hours:		60 hours

Text Book(s)

- Jake VanderPlas, Python Data Science Handbook - Essential Tools for Working with Data, O'Reily Media, 2017.
- Zhang.Y, An Introduction to Python and Computer Programming, Springer, 2016.

Reference Book(s)

- Nelli, F., Python Data Analytics: With Pandas, NumPy, and Matplotlib, 2nd Ed., Apress, 2018.
- Samir Madhavan, Mastering Python for Data Science, Packt Publishing Ltd., 2015.

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	**Course Title**	**L**	**T**	**P**	**J**	**C**
MAT6004	**Computational Statistics for Data Science**	**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 (Z, t, F and χ^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	Course Title	L	T	P	J	C
MAT6005	Machine Learning for Data Science	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	Course Title	L	T	P	J	C
MAT6007	Deep Learning	2	0	2	0	3
Pre-Requisite	NIL	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, 2nd edition, 1996.
- Bishop C., neural networks for pattern recognition, Oxford university press, 2015.

Mode of Evaluation: CAT, Quiz, Assignment and 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	Course Title	L	T	P	J	C
MAT6008	Artificial Intelligence for Data Science	2	0	2	0	3
Pre-Requisite	NIL	Syllabus Version				
		1.0				

Course Objectives:

- The main purpose of this course is to provide the most fundamental knowledge to the students so that they can understand AI.
- To provide the foundations for AI problem-solving techniques and knowledge representation formalisms.

Expected Course Outcome:

On completion of the course, students will be able to

- Ability to identify and formulate appropriate AI methods for solving a problem
- Ability to implement AI algorithms
- Ability to Identify the type of AI problem (search, inference, decision making under uncertainty, game theory, etc).
- Ability to compare the difficulty of different versions of AI problems, in terms of computational complexity and the efficiency of existing algorithms.

Module:1	**Introduction**	**3 hours**
The AI problems, AI technique, philosophy and development of Artificial intelligence.		
Module:2	**Problem Spaces and Search**	**4 hours**
State-space search, Uninformed and informed search techniques: BFS, A*, variations of A*. Local search and optimization: hill-climbing, simulated annealing.		
Module:3	**Adversarial Search and Game Playing**	**4 hours**
Minimax algorithm, alpha-beta pruning, stochastic games, Constraint- satisfaction problems.		
Module:4	**Knowledge and Reasoning**	**5 hours**
Logical agents, Propositional logic, First-order logic, Inference in FoL: forward chaining, backward chaining, resolution, Knowledge representation: Frames, Ontologies, Semantic web and RDF.		
Module:5	**Introduction to PROLOG**	**4 hours**
Facts and predicates, data types, goal finding, backtracking, simple object, compound objects, use of cut and fail predicates, recursion, lists, simple input/output, dynamic database.		
Module:6	**Uncertain knowledge and reasoning**	**4 hours**
Probabilistic reasoning, Bayesian networks, Fuzzy logic		
Module:7	**Natural Language Processing**	**4 hours**
An Introduction to Natural language Understanding, Perception, Learning.		
Module:8	**Contemporary issues**	**2 hours**

Lecture by Industry Experts.		
Total Lecture hours:		**30 hours**
Text Book(s)		
• Elaine Rich, Kevin Knight, Artificial Intelligence, 3/Ed., Tata McGraw Hill, 2017. • Dan W. Patterson, Introduction to AI and ES, Pearson Education, 2015.		
Reference Book(s)		
• Deepak Khemani, Artificial Intelligence, Tata Mc Graw Hill Education, 2017. • Stuart Russel, Peter Norvig, Artificial Intelligence, 3/Ed, Perason, 2015. • N.P. padhy: Artificial Intelligence and Intelligent Systems, Oxford Higher Education, OxfordUniversity Press, 2005. • Ivan Bratko, PROLOG Programming, 4/Ed. Pearson Education, 2020.		
Mode of Evaluation: CAT, Quiz, Digital Assignment and FAT.		
List of Challenging Experiments (Indicative)		
1	Study of facts, objects, predicates and variables in PROLOG	2 hours
2	Study of Rules and Unification in PROLOG	2 hours
3	Study of "cut" and "fail" predicate in PROLOG	2 hours
4	Study of arithmetic operators, simple input/output and compound goals in PROLOG	4 hours
5	Study of recursion in PROLOG	4 hours
6	Study of Lists in PROLOG	2 hours
7	Study of dynamic database in PROLOG	2 hours
8	Study of string operations in PROLOG (Implement string operations like substring, string position, palindrome etc.)	4 hours
9	Write a prolog program to maintain family tree	4 hours
10	Write a prolog program to implement all set operations (Union, intersection, complement etc.)	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	Course Title	L	T	P	J	C
MAT6009	Design and Analysis of Experiments	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	Course Title	L	T	P	J	C
MAT6010	Optmization Techniques	3	2	0	0	4
Pre-Requisite	NIL	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 Outcome:

Student will be able to

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

Module:1	Introduction to Operations 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)

- Hamdy Taha, Operations Research, 10th edition, Prentice Hall India, 2019.
- P. K. Gupta and D. S. Hira, Operations Research, S. Chand & co., 2007.

Reference Books

- S.D. Sharma, Operations Research, Nath & Co., Meerut, 2000.
- Maurice Solient, Arthur Yaspen, Lawrence Fridman, OR methods and Problems, New Age International Edition, 2003.
- J K Sharma, Operations Research Theory & Applications, 3e, Macmillan India Ltd., 2007.
- P. Sankara Iyer, Operations Research, Tata McGraw-Hill, 2008.
- A Ravindran, Don T Philips and James J Solberg, Operations Research: Principles and Practice, 2nd edition, John Wiley and sons, 2007.

Mode of Evaluation: CAT, Quiz, Assignment and 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
MAT6011	Statistical Quality Control	3	0	2	0	4
Pre-Requisite	NIL	Syllabus Version				
		1.0				

Course Objectives:

- To understand different control charts for analyzing industrial quality experiments.
- To amalgamate the intellectual facts of the quality characteristics to implement in the Industrial experiments scientifically.
- To link and analyse the various sampling schemes to find the plan for quality inspection.

Expected Course Outcome:

On completion of the course, students will be able to

- understand the fundamental advantages and apply essential of Control charts
- apply appropriate Charts for the industrial experiments.
- apply some standard distributions for construction of sampling plans.
- able to construct the AOQL plans for normal inspection scheme.
- learn and apply variance transformation techniques.
- understand the difference between sampling plans for attributes and variables.

Module:1	Control Charts	4 hours

Introduction to Quality control; control charts for mean – CUSUM chart – technique of V-mask – Weighted Moving average charts – multivariate control charts – Hotelling's T^2-control charts and Economic design of X-bar chart.

Module:2	Process Capability analysis	8 hours

Process Capability analysis: Meaning, Estimation technique for capability of a process –Capability Indices: Process capability ratios Cp; Cpk, Cpm, Cmk, Cpc – Process capability analysis using a control chart – Process capability analysis using design of experiments.

Module:3	Acceptance Sampling	6 hours

Acceptance sampling – Terminologies – Attribute sampling plan by attributes – Single sampling plan and Double sampling plan – OC, ASN, AOQ, AOQL and ATI curves –MILSTD -105E Tables.

Module:4	Acceptance sampling variables	6 hours

Acceptance sampling variables for process parameter – Sequential plans for process parameter (σ known and unknown) – Sampling variables for proportion non-conforming – □ method, K method.

Module:5	Double Sampling methods	6 hours

Double specification limits – M-method, Double sampling by variables - MILSTD -414 Tables – Continuous Sampling plan – CSP-1, CSP-2, CSP-3, Wald and Wolfowitz SP-A.

Module:6	Attribute Sampling plans	6 hours

Producers risk, Consumers Risk, designing single sampling plan for stipulated Producers and consumers risk,OC curves under Normal,Tightened and reduces inspection,Single, Double and Multiple sampling plans in AQL systems.

Module:7	Six-Sigma	7 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)

- Eugene L.Grant Richard S. Leavenworth, Statistical Quality Control,7 edition,McGraw Hill Education,India, 2017.
- Douglas C. Montgomery, Introduction to Statistical Quality Control, Seventh Edition, John Wiley and Sons, New York. 2013.

Reference Book(s)

- Edward G. Schilling, Dean V. Neubauer, Acceptance Sampling in Quality Control, Second Edition, Taylor & Francis, 2009.
- Poornima M.Charantimath,Total quality Management, 3/e, Pearson India Limited, 2017.

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

List of Challenging Experiments (Indicative)

1	Mean and Range charts: Experimental control charts for process control.	4 hours
2	Control chart for nonconformities.	4 hours
3	A control chart for nonconformities per unit with variable subgroup size.	4 hours
4	C chart used to control errors on forms.	2 hours
5	Acceptance decisions based on plotted frequency distributions.	4 hours
6	AOQL inspection to produce quality improvement.	4 hours
7	Construction of rectifying inspection using AOQL normal inspection plans	4 hours
8	Acceptance sampling under standard sampling plans.	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	Course Title	L	T	P	J	C
MAT6012	Programming for Data Analysis	2	0	4	0	4
Pre-Requisite	NIL	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**

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.

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'	4 hours

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.	
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	4 hours

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: $OIL = A (WTI^B) (HH^C) (MB^D)$	
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: Continuous Assessment and FAT	

Recommended by Board of Studies	24.06.2020		
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