B.Tech - Artificial Intelligence and Data Science

[Offered by KCT | Affiliated to Anna University, Chennai | Approved by AICTE, Govt. of India]

Awarded by

Curriculum & Syllabi

I - VI Semesters

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Course Content for B.Tech AI & DS Program

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PROGRAM EDUCATIONAL OBJECTIVES:

The graduates of this program shall have:

1. A successful professional career in industry, government, and academia with capabilities to build innovative solutions using technology as a tool to solve real-world problems.
2. Research capabilities in advanced technologies and shall contribute to a new body of knowledge.
3. A learning mindset to continuously improve their knowledge, through on the job, formal and informal learning opportunities
4. An ethical attitude and shall exhibit effective skills in communication, management, teamwork and leadership.
5. Engineering, problem-solving and critical thinking skills to create social, economical and sustainable impact.

PROGRAM SPECIFIC OUTCOMES:

After completing their graduation, students of AI & DS will be able to:

1. Apply the principles of artificial intelligence and data science that require problem-solving, inference, perception, knowledge representation, and learning.
2. Demonstrate the ability to create innovative solutions from idea to product, applying scientific methods and tools
3. Exhibit strong professional skills to function effectively in multi-disciplinary and heterogeneous teams with a growth mindset.

PROGRAM OBJECTIVES:

Graduates of AI & DS programme will have the following abilities:

PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis:** Identity, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** Apply to reason informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Curriculum of B.Tech AI & DS Program

Knowledge Disciplines	I - Year		II – Year		III - Year		IV - Year	
	Bridge	Introduction	Foundation	Concentration	Specialization	ProtoSem	Fellowship	Fellowship
	Sem I	Sem II	Sem III	Sem IV	Sem V	Sem VI	Sem VII	Sem VIII
Fundamental Science	Engineering Physics (Physics Practicum) (4)	Advanced Physics (3)				ProtoSem [Core] (12) [Advanced Technology Electives] (6) [Open Elective-II] (3) [Minimum Usable Prototype] (3)	Fellowship (10) [Certification Courses] (4)	Fellowship (9) [Certification Courses] (4I
Math and Statistics	Linear Algebra and Calculus (MATLAB Practicum) (4)	Discrete Mathematics (3) / Probability and Statistics (R Practicum) (4)	Multivariate Calculus and Forecasting (4)	Random Process and Optimization (4)				
Computer Science	Introduction to Python (Python Practicum) (3) / Introduction to Computational Machines (HW Practicum) (3)	Object-Oriented Programming and Data Structures (Python Practicum) (3)	Algorithms and Optimization of Programs (Python Practicum) (4) / Operating System (3)	Computer Networks (3)	Cloud Architecture (AWS Practicum) (4)			
Artificial Intelligence		Introduction to AI & ML (Python Practicum) (3)	Applied Machine Learning(PyTorch/ Tensorflow)(4)	Neural Networks and Deep Learnings (Keras and MXnet Practicum) (4)	Reinforcement Learning (4)			
Data Science		Introduction to Data Science (Sheets Practicum) (3)	Data Collection & Data Management (Oracle and SQL Practicum) (3)	Data Mining & Modeling (Rapid Miner Practicum) (3)	Exploratory Data Analysis and Visualization (4)			
Advanced Technology					Advanced Technology Electives -1 (3)			
Arts and Humanities	Fundamentals of Communication I (English Practicum) (3) / Introduction to Indic Culture and Sciences (1)	Growth Lab I (NC) / Externship I (NC)	Growth Lab II (NC) / Tools and Technologies for Wellness (1)	Growth Lab III (NC) / Externship II (NC)	Open Elective - I (3) / Philosophy of Wellness (1)		Externship III (NC)	
Business & Entrepreneurship			Principles of Economics (2)	Finance for Engineers (3)	Marketing Fundamentals (3)			

Innovation and Design	Engineering Sprints (3)	Innovation Sprints (3)	Design Sprints (3)	Ideation Sprints (3)				
	Credits: 21	**Credits: 22**	**Credits: 24**	**Credits: 20**	**Credits: 22**	**Credits: 24**	**Credits: 14**	**Credits: 13**

Total Credits: 160

Consolidated Course Information

Course Type : *Professional Core (PC), Professional Elective (PE), Humanities and Social Science (HS), Basic Science(BS), Engineering Science(ES), Open Elective(OE), Project Work(PW)*

	Semester I									
S.No	**Course Title**	**Course Code**	**Course Mode**	**Course Type**	**L**	**T**	**P**	**J**	**C**	**Prerequisite**
1	Engineering Physics	U18PHI1202	Embedded - Theory & Lab	BS	3	0	2	0	4	
2	Linear Algebra and Calculus	U18MAI1203	Embedded - Theory & Lab	BS	3	0	2	0	4	
3	Introduction to Computational Machines	U18AII1204	Embedded - Theory & Lab	ES	2	0	2	0	3	
4	Introduction to Python	U18AII1205	Embedded - Theory & Lab	ES	2	0	2	0	3	
5	Fundamentals Of Communication	U18ENI1202	Embedded - Theory & Lab	HS	2	0	2	0	3	
6	Introduction to Indic Culture and Technologies	U18AIC1006	One Credit Course	HS	2	0	0	0	1	
7	Engineering Sprints	U18AII1607	Embedded - Project & Lab	ES	0	0	4	2	3	
	Total Credits				**21**					

	Semester II									
S.No	**Course Title**	**Course Code**	**Course Mode**	**Course Type**	**L**	**T**	**P**	**J**	**C**	**Prerequisite**
1	Advanced Physics	U18PHT2203	Theory	BS	3	0	0	0	3	
2	Discrete Mathematics	U18MAT2001	Theory	BS	3	0	0	0	3	
3	Probability and Statistics	U18MAI2203	Embedded - Theory & Lab	BS	3	0	2	0	4	
4	Object-Oriented Programming and Data Structures	U18AII2204	Embedded - Theory & Lab	PC	2	0	2	0	3	U18AII1205
5	Introduction to AI & ML	U18AII2205	Embedded - Theory & Lab	PC	2	0	2	0	3	U18AII1205
6	Introduction to Data Science	U18AII2206	Embedded - Theory & Lab	PC	2	0	2	0	3	
7	Growth Lab I	U18AIP2607	Embedded - Project & Lab	HS	-	-	-	-	-	
8	Externship I	U18AIP2708	Project	PW	-	-	-	-	-	
9	Innovation Sprints	U18AII2609	Embedded - Project & Lab	ES	0	0	4	2	3	
	Total Credits				**22**					

Course Type : *Professional Core (PC), Professional Elective (PE), Humanities and Social Science (HS), Basic Science(BS), Engineering Science(ES), Open Elective(OE), Project Work(PW)*

	Semester III									
S.No	**Course Title**	**Course Code**	**Course Mode**	**Course Type**	**L**	**T**	**P**	**J**	**C**	**Prerequisite**
1	Multivariate Calculus and Forecasting	U18MAI3201	Embedded - Theory & Lab	BS	3	0	2	0	4	U18MAI1203
2	Algorithms and Optimization of Programs	U18AII3202	Embedded - Theory & Lab	PC	3	0	2	0	4	U18AII2204
3	Operating System	U18AII3203	Embedded - Theory & Lab	PC	2	0	2	0	3	---
4	Applied Machine Learning	U18AII3204	Embedded - Theory & Lab	PC	3	0	2	0	4	U18AII2205
5	Data Collection & Data Management	U18AII3205	Embedded - Theory & Lab	PC	2	0	2	0	3	---
6	Tools and Technologies for Wellness	U18AIC3006	One Credit	HS	1	0	0	0	1	---
7	Growth lab II	U18AIP3607	Embedded - Project & Lab	HS		-	-	-	-	---
8	Principles of Economics	U18AIT3008	Theory	ES	2	0	0	0	2	---
9	Design Sprints	U18AII3609	Embedded - Project & Lab	ES	0	0	4	2	3	---
	Total Credits				**24**					

	Semester IV									
S.No	**Course Title**	**Course Code**	**Course Type**	**Course Type**	**L**	**T**	**P**	**J**	**C**	**Prerequisite**
1	Random Process and Optimization	U18MAT4105	Theory	BS	3	1	0	0	4	---
2	Computer Networks	U18AII4201	Embedded - Theory & Lab	PC	2	0	2	0	3	---
3	Neural Networks and Deep Learning	U18AII4202	Embedded - Theory & Lab	PC	3	0	2	0	4	U18AII2205
4	Data Mining & Modeling	U18AII4203	Embedded - Theory & Lab	PC	2	0	2	0	3	U18MAI2203
5	Growth Lab III	U18AII4604	Embedded - Project & Lab	HS	-	-	-	-	-	---
6	Externship II	U18AIP4705	Project	HS	-	-	-	-	-	---
7	Finance for Engineers	U18AIT4006	Theory	ES	2	0	0	0	3	---
8	Ideation Sprints	U18AII4607	Embedded - Project & Lab	ES	0	0	4	2	3	---
	Total Credits				**20**					

Course Type : *Professional Core (PC), Professional Elective (PE), Humanities and Social Science (HS), Basic Science(BS), Engineering Science(ES), Open Elective(OE), Project Work(PW)*

	Semester V									
S.No	**Course Title**	**Course Code**	**Course Mode**	**Course Type**	**L**	**T**	**P**	**J**	**C**	**Pre-requisite**
1	Cloud Architecture	U18AII5201	Embedded - Theory & Lab	PC	3	0	2	0	4	---
2	Exploratory Data Analysis and Visualization	U18AII5202	Embedded - Theory & Lab	PC	3	0	2	0	4	U18MAI2203
3	Reinforcement Learning	U18AII5203	Embedded - Theory & Lab	PC	3	0	2	0	4	U18AII4202
4	Advanced Technology Elective 1	U18AIE520X	Theory	PE	3	0	0	0	3	---
5	Elective 1	U18XXE5XXX	Theory	OE	3	0	0	0	3	---
6	Marketing Fundamentals	U18AIT5004	Theory	ES	3	0	0	0	3	---
7	Philosophy of Wellness	U18AIC5005	One Credit	HS	1	0	1	0	1	---
	Total Credits				**22**					

	Semester VI									
S.No	**Course Title**	**Course Code**	**Course Mode**	**Course Type**	**L**	**T**	**P**	**J**	**C**	**Pre-requisite**
1	Applied Design Thinking	U18AII6201	Embedded - Theory & Lab	PC	3	0	2	0	4	---
1	Prototype Development	U18AII6202	Embedded - Theory & Lab	PC	3	0	2	0	4	---
2	Industrial IoT	U18AII6203	Embedded - Theory & Lab	PC	3	0	2	0	4	---
3	Advanced Technology Elective 2	U18AIE6XXX	Theory	PE	3	0	0	0	3	---
4	Advanced Technology Elective 3	U18AIE6XXX	Theory	PE	3	0	0	0	3	---
5	Elective 2	U18XXEXXXX	Theory	OE	3	0	0	0	3	---
6	Minimum Usage Prototype	U18AIP6604	Project	PW	0	0	0	6	3	---
	Total Credits				**24**					

Course Type : *Professional Core (PC), Professional Elective (PE), Humanities and Social Science (HS), Basic Science(BS), Engineering Science(ES), Open Elective(OE), Project Work(PW)*

	Semester VII									
S.No	**Course Title**	**Course Code**	**Course Mode**	**Course Type**	**L**	**T**	**P**	**J**	**C**	**Pre-requisite**
1	Fellowship	U18AIXXXX		F					10	
2	Advanced Technology Certification	U18AIXXXX		Cer					4	
3	Externship III	U18AIXXXX		ES						
	Total Credits								**14**	

	Semester VIII									
Course Discipline	**Course Title**	**Course Code**	**Course Mode**	**Course Type**	**L**	**T**	**P**	**J**	**C**	**Pre-requisite**
Innovation and Design	Fellowship	U18AIXXXX		F					9	
Innovation and Design	Advanced Technology Certification	U18AIXXX		Cer					4	
	Total Credits								**13**	

List of Electives and Certification Courses

III year

Advanced Technology Electives

1. Natural Language Processing with Deep Learning
2. Introduction to Spatial Computing
3. Computer Vision with Convolution Neural Networks
4. Recommendation system for e-commerce
5. Mining Massive Data Sets
6. Neural Computation
7. Human-Centered Systems
8. Speech Processing
9. Startup Fundamentals

Certification Courses

1. IBM Cyber Security Analyst Professional Certificate
2. Deeplearning.ai TensorFlow Developer Professional Certification
3. Google IT Automation with Python Professional Certification
4. Cloud Architecture with Google Cloud Professional Certification
5. IBM AI Engineering Professional Certification
6. IBM Applied AI Professional Certification
7. Data Engineering with Google Cloud Professional Certification
8. SAS Programmer Professional Certification
9. Cloud Engineering with Google Cloud Professional Certification
10. SAS Visual Business Analytics Professional Certificate
11. Professional Certificate program in Digital Transformation
12. Professional Certificate Program in Innovation & Technology
13. Professional Certificate Program in Legal Tech in the Digital Era
14. AWS Certified Cloud Practitioner
15. AWS Certified Solution Architect (Associate)
16. AWS Certified Developer (Associate)
17. AWS Certified Data Analytics (Speciality)
18. AWS Certified Database (Specialty)
19. AWS Certified Machine Learning (Specialty)
20. Tensorflow Certification (TF)

Syllabi - 1st Year
Semester I

U18PHI1202	ENGINEERING PHYSICS	L	T	P	J	C
		3	0	2	0	4

Course Objectives:

- To explain principles of optics.
- To make students understand the basic concepts of Principles of Physics in a broader sense
- To enable a view to lay the foundation for the various engineering courses
- To demonstrate competency and understanding of the concepts found in quantum mechanism, laser, Optical fiber, Waves in one dimension, Wave Optics, Lasers, Fiber Optics and a broad base of knowledge in physics.

Course Outcomes:

After successful completion of this course, the students should be able to

CO 1:	Enhance the fundamental knowledge in properties of matter and its applications relevant to various applications of Engineering
CO 2:	Understanding the phenomenon of heat transfer mechanisms in engineering systems.
CO 3:	Acquire knowledge in the basic concepts of quantum mechanics and electron microscopy.
CO 4:	Imbibe the concept of lasers, optical fibers and their applications in engineering.
CO 5:	Introduce and provide a broad view of acoustics.
CO 6:	Apply the NDT techniques and modern engineering tools necessary for Engineering practice.

Pre-requisite courses: Not applicable

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	M									M
CO2	S	M	M									M
CO3	S	M		M								M
CO4	S	M		M								M
CO5	S	M										M

CO6	S	M	M									M

Course Assessment Methods:

DIRECT

1.Continuous Assessment Test I, II (Theory component)
2.Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3.Demonstration etc (as applicable) (Theory component)
4.Pre/Post - Experiment Test/Viva; Experimental Report for each Experiment (lab Component)
5.Model Examination (lab component)
6.End Semester Examination (Theory and lab components)

INDIRECT

1. Course-end survey

Topics covered:

PROPERTIES OF MATTER **9 Hours**

Hooke's Law - Elastic moduli - Relation between elastic constants - Poisson's Ratio – Stress - Strain Diagram and its uses – factors affecting elastic modulus – Bending of beams – Expression for bending moment and depression - Cantilever - Depression of a cantilever - experimental determination of Young's modulus by Non uniform bending – I shape girders

THERMAL PHYSICS **9 Hours**

Transfer of heat energy – conduction, convection and radiation – thermal expansion of solids and liquids – expansion joints – bimetallic strips – theory of heat conduction in solids – rectilinear flow of heat – determination of thermal conductivity of a bad conductor - Lee's & Charlton's disc method - Thermal Insulation – classification and properties – heat exchangers - applications – domestic refrigerator – microwave oven.

MODERN PHYSICS **9 Hours**

Planck's concept (hypothesis) - Compton effect - Expression for Compton shift - Concept of matter waves - Physical significance of wave function - Schrödinger's wave equation - Time independent and time dependent equation - Eigenvalues and Eigenfunction - Particle in a box (one dimension)- Scanning electron microscope (SEM)- Transmission electron microscope (TEM).

APPLIED OPTICS **9 Hours**

LASERS: Absorption and emission - Spontaneous emission - Stimulated emission - Population inversion - Sources of excitation - Active medium - Resonant cavity - Einstein's theory of stimulated emission - Nd-YAG laser - CO_2 laser - Semiconductor lasers - Applications – holography, cutting welding , drilling.
Fibre optics: Structure of optical fiber -principle and propagation of light in optical fibers - Numerical aperture and acceptance angle - - Types of optical fibers - Applications - Fiber optic communication system, Fiber endoscope.

ACOUSTICS AND ULTRASONICS	9 Hours

Acoustics: Sound basic definitions - Reverberation - Reverberation time - Sabine's formula - Absorption coefficient and its determination - Factors affecting the acoustics of the buildings and their remedies.
Ultrasonics: Production of ultrasonic waves- Magneto-striction and Piezoelectric methods - Properties -Detection - Thermal and Knut’s methods, Determination of velocity of ultrasonic waves in liquids using acoustic grating – applications - A, B, C scan.

Theory: 30 Hrs	Tutorial: 0	Total Hours: 45 Hrs

Lab component Contents:

LIST OF EXPERIMENTS

1. Non-uniform bending – Determination of Young's modulus
2. Compound Pendulum – Determination of acceleration due to gravity
3. Spectrometer – Determination of wavelength of mercury source using grating
4. Air wedge - Determination of thickness of thin sheet
5. Semiconductor Laser:
    a. Determination of wavelength of laser
    b. Determination acceptance angle and numerical aperture of an optical fibre.
    c. Determination of particle size
6. Melde's string – Determination of frequency of a tuning fork
7. Determination of band gap of a semiconductor
8. Luxmeter – Determination of efficiency of solar cell
9. Lee's disc – Determination of thermal conductivity of a bad conductor
10. B-H Curve apparatus – Determination of magnetic susceptibility of a solid material.

Experiments for Demonstration:

1. Hall effect
2. Hardness Test
3. Four probe experiment
4. Ultrasonic interferometer

Practical: 30 hrs	**Tutorial: 0**	**Total Hours : 30 Hrs**

Textbooks:

1. Kumar Senthil G, Revised Edition 2020-21, Engineering Physics, VRB Publishers Pvt Ltd., Chennai.
2. Arthur Besier, Shobhit Mahajan, S. Rai Choudhury, 7th Edition, 2015, Concepts of Modern Physics, Mcgraw Hill Education, New Delhi.

Reference Books:

1. Avadhanulu M N , 1992, A textbook of Engineering Physics, S. Chand Publishing
2. Dr. Aparna Y & Dr. Venkateswara Rao K, Laboratory Manual of Engineering Physics, V.G.S Publishers.
3. Brijlal and Subharamaniam, 2004, Properties of matter, S. Chand & Co Ltd., New Delhi.
4. Prakash Satya , 2015, Quantum Mechanics, Pragati Prakashan Publishers.
5. Thyagarajan K, Ghatak Ajoy, 2010, Lasers: Fundamentals and Applications, Springer Science & Business Media.
6. Introduction to Fiber Optics, K. Thyagarajan, Ajoy Ghatak, Second Edition, Springer New York Dordrecht Heidelberg London, 2010.
7. Dale Ensminger and Leonard J. Bond, Ultrasonics: Fundamentals, Technology, Applications, Second Edition, 1988, Marcel Dekker, New York.
8. C. C. Ouseph, U. J. Rao, V. VijayendranS, Practical Physics and Electronics, Viswanathan (Printers & Publishers), Pvt., Ltd.

Crafted By : Dr Arul H, M.Sc., PhD., Department of Physics, KCT

U18MAI1203	LINEAR ALGEBRA AND CALCULUS	L	T	P	J	C
		3	0	2	0	4

Course Objectives:

- To explain the main concepts of linear algebra that are used in data analysis and machine learning.
- To improve the student's practical skills of using linear algebra methods in machine learning and data analysis.
- To learn the fundamentals of working with data in vector and matrix form, acquire skills for solving systems of linear algebraic equations and finding the basic matrix decompositions and general understanding of their applicability.

Course Outcomes:

After successful completion of this course, the students should be able to

CO 1:	Identify eigenvalues and eigenvectors, apply Cayley Hamilton theorem to Matrix Manipulation and apply orthogonal diagonalization to convert quadratic form to canonical form which will form the basis for Principal Component Analysis.
CO 2:	Understand the concept of vector spaces and perform LU Decomposition and Singular Value Decomposition, that are essential for dimensionality reduction.
CO 3:	Apply suitable techniques of differentiation and integration to various functions and identify the maxima and minima of functions of one variable.
CO 4:	Solve first order ordinary differential equations and apply them to certain physical situations.
CO 5:	Solve higher order ordinary differential equations arising in real world situations.
CO 6:	Determine Rank, Inverse, Eigenvalues, Eigenvectors of the given matrix, solve Differential equations and locate Maxima-Minima of the function using MATLAB

Pre-requisite courses:Nil

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S										M
CO2	M	M										
CO3	W	W										
CO4	W	W										
CO5	W	W										

CO6					S							S

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. Pre/Post - Experiment Test/Viva; Experimental Report for each Experiment (lab Component)
5. Model Examination (lab component)
6. End Semester Examination (Theory and lab components)

b)Indirect

1. Course-end survey

Topics covered:

MATRICES	**12 Hours**

Rank of a matrix – Consistency of a system of linear equations - Rouche's theorem -Solution of a system of linear equations - Linearly dependent and independent vectors–Eigenvalues and Eigenvectors of a real matrix – Properties of eigenvalues and eigenvectors – Cayley Hamilton theorem (excluding proof) - Orthogonal matrices – Orthogonal transformation of a symmetric matrix to diagonal form – Reduction of quadratic form to canonical form by orthogonal transformation.

VECTOR SPACES	**12 Hours**

Vector spaces and subspaces – Linear independence and dependence – Basis and Dimension - Null spaces, column spaces and Linear transformations - LU decomposition method - Singular Value Decomposition method.

DIFFERENTIAL AND INTEGRAL CALCULUS	**9 Hours**

Representation of functions -Limit of a function-Continuity -Derivatives -Differentiation rules - Maxima and Minima of functions of one variable - Definite and Indefinite integrals - Techniques of Integration: Substitution rule, Integration by parts, Trigonometric integrals, Trigonometric substitutions, Integration of rational functions by partial fraction.

FIRST ORDER ORDINARY DIFFERENTIAL EQUATIONS	**3 Hours**

Linear differential equations (Leibnitz equation and Bernoulli's equation)

HIGHER ORDER ORDINARY DIFFERENTIAL EQUATIONS	**9 Hours**

Linear, homogeneous and non- homogeneous differential equations of second and higher order with constant coefficients - Non-homogeneous term of the type e^{ax}, sin ax, cos ax, and x^n, e^{ax} V(x)

Theory: 45 Hrs	**Tutorial: 0 Hrs**	**Total Hours: 45 Hrs**

Lab component Contents:

List of MATLAB Programmes:

1. Introduction to MATLAB.
2. Matrix Operations - Addition, Multiplication, Transpose, Inverse
3. Rank of a matrix and solution of a system of linear equations
4. Characteristic equation of a Matrix and Cayley-Hamilton Theorem.
5. Eigenvalues and Eigenvectors of Higher Order Matrices
6. Curve tracing
7. Differentiation and Integration
8. Solving first and second order ordinary differential equations.
9. Determining Maxima and Minima of a function of one variable.

Practical: 30 Hrs	Tutorial: 0	Total Hours : 30 Hrs

Textbooks:

1. Grewal B.S., , 41st Edition, 2011, "Higher Engineering Mathematics", Khanna Publishers, New Delhi.
2. Ramana B.V., 11th Reprint, 2010, "Higher Engineering Mathematics", Tata McGraw Hill Co. Ltd., New Delhi
3. David C. Lay, "Linear Algebra and its Applications", Pearson Education Asia, New Delhi, 5 th Edition, 2016.

Reference Materials:

1. Kreyzig E., "Advanced Engineering Mathematics", 10th Edition, John Wiley and sons, 2011
2. Venkataraman M.K., "Engineering Mathematics", The National Publishing Co., Chennai, 2003
3. Weir, MD, Hass J, Giordano FR, 12th Edition, 2015, Thomas' Calculus, Pearson education.
4. Thomas G.B. and Finney R.L., "Calculus and Analytic Geometry", 11th Edition, Pearson Education, 2006.
5. Seymour Lipschutz , Marc Lipson, "Schaum Outline of Linear Algebra", McGraw Hill Trade; New Delhi, 6th Edition, 2017

Crafted By : Dr. Vijeta Iyer, M.Sc., PhD., Department of Mathematics, KCT & Gokul Kumar M.Sc (BITS Pilani),
MBA, Co-Founder & CTO, Vusar - AR 3D Design Visualization

U18AII1204	INTRODUCTION TO COMPUTATIONAL MACHINES	L	T	P	J	C
		2	0	2	0	3

Course Objectives:

- To acquire the basic knowledge of digital logic levels and application of knowledge to understand digital electronics circuits
- To prepare students to perform the analysis and design of various digital electronic circuits
- To introduce students to the design issues of embedded systems.
- To provide experience to integrate hardware and software for an embedded system

Course Outcomes:

After successful completion of this course, the students should be able to

CO 1:	Understand the basics of combinational and sequential circuits
CO 2:	Explain the hardware and software architecture of embedded systems
CO 3:	Understand the network operations and the transport protocols
CO 4:	Demonstrate the I/O operations from the basic embedded systems hardware

Pre-requisite courses:

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S									M	M
CO2	S	M	S	M	M	M					M	M
CO3	S		S	S	S	M					M	M
CO4	S		M	S	S	M					M	M

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. Pre/Post - Experiment Test/Viva; Experimental Report for each Experiment (lab Component)
5. Model Examination (lab component)
6. End Semester Examination (Theory and lab components)

b)Indirect

1. Course-end survey

Topics covered:

BASICS OF DIGITAL ELECTRONICS	7 Hours

Introduction to logic gates: Boolean Algebra Theorems - De Morgan's theorem - Logic Gates-Design procedure of Combinational circuits: Adders- Subtractors - Design of sequential circuits, Asynchronous/Ripple counters- Shift registers

EMBEDDED SYSTEM AND ITS ARCHITECTURE	8 Hours

Introduction to Embedded Systems- Architecture of Embedded Systems- Programming for Embedded Systems- The Process of Embedded System Development - Hardware Platforms- Communication Interfaces- Future Trends

RASPBERRY PI	7 Hours

Hardware aspects- Board details - Operating systems - Programming the Pi : Compilers - Python programming for Pi - Hardware interfacing: GPIO interfacing through Python - LED, buzzer, switch and Sensors Interfacing: Pressure, Temperature, Speed

NETWORKS AND PROTOCOL	8 Hours

Introduction to Networks –Components, Categories and Types of Connections – Topologies- ISO/OSI model- Comparison of the OSI and TCP/IP Reference Model- Protocol- Internet Transport (IP)- IP addressing- Transport layer protocols : TCP and UDP-Duties of TCP & UDP-TCP Connection Management-Congestion Control- Quality of Services- Real Time Transport Protocols - Raspberry Pi Interface: Ethernet.

Theory: 30 Hrs	Tutorial: 0	Total Hours: 30 Hrs

Lab Component:

List of Experiments:

1. Realization of logical expression using gates
2. Verification of Half adder and Full adder
3. Verification of Half Subtractor and Full Subtractor
4. Asynchronous Decade Counter
5. Interfacing Input & Output devices with RPi
6. Interfacing sensors with RPi
7. Serial Communication using RPi
8. Ethernet Communication using RPis
9. Network Protocol packet Analysis

Practical: 30 Hrs	Tutorial: 0	Total Hours : 30 Hrs

Textbooks:

1. Mano Morris M, 2008, "Digital Design", 4th Edition, Pearson Education.
2. Dr. K.V.K.K. Prasad, 2003, “Embedded/Real Time Systems Programming Black Book”Behrouz A. Forouzan, 2013, "Data Communications and Networking", 5th Edition, TMH.

Reference Materials:

1. Andrew S Tanenbaum, 4th Edition, 2003, "Computer Networks" Pearson Education.
2. Wolfram Donat, , 2014, "Learn Raspberry Pi Programming with Python", Technology in Action Publications.
3. Alex Bradbury and Ben Everard, 2014, "Learning Python with Raspberry Pi",Wiley Publications Pvt., Ltd..

Crafted By : Vivek Poovalingam, B.E (GCT), Program Manager, Forge

Reviewed By : Gokul Kumar, M.Sc (BITS Pilani), MBA, Co-Founder & CTO, Vusar - AR 3D Design Visualization, California

U18AII1205	INTRODUCTION TO PYTHON	L	T	P	J	C
		2	0	2	0	3

Course Objectives:

- To learn core Python scripting elements such as variables and flow control structures
- To learn how to use lists, tuples, and dictionaries in Python programs.
- To learn how to identify Python object types.
- To learn how to use indexing and slicing to access data in Python programs.

Course Outcomes:

After successful completion of this course, the students should be able to

CO 1:	Understand the basics of algorithm building for computing and programming
CO 2:	Understand the basics of python programming language
CO 3:	Apply modularization techniques for problem solving through python
CO 4:	Outline the concepts of Lists, Dictionaries and Files

Pre-requisite courses:

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M									
CO2	S	S	S		S	M			M		M	S
CO3	S	S	S	S	S	M			M		S	S
CO4	S	S	S	S	S						S	S

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. Pre/Post - Experiment Test/Viva; Experimental Report for each Experiment (lab Component)
5. Model Examination (lab component)
6. End Semester Examination (Theory and lab components)

b)Indirect

1. Course-end survey

Topics covered:

INTRODUCTION TO COMPUTING	6 Hours

Algorithms, Building blocks of algorithms (Instructions/statements, state, control flow, functions), Notation (pseudo code, flow chart, programming language), Algorithmic problem solving.

INTRODUCTION TO PYTHON	8 Hours

Python programming language - Debugging - Variables, expressions and statements - Input/Output Statements - Conditional operators and statements - Looping statements - for - while- break and continue statement - Iterations - Strings - String manipulations: subscript operator, indexing, slicing a string

MODULAR PROGRAMMING	8 Hours

Functions- function call- Flow of execution- Parameters and Arguments- Return values - Incremental development - Composition - Recursion - Boolean functions - Checking types - Case study-Interface Designing -Word Play.

LISTS, DICTIONARIES AND FILES	8 Hours

Lists - Basic list operators- Replacing- inserting- removing an element- searching and sorting lists- Dictionaries dictionary literals- adding and removing keys- accessing and replacing values - traversing dictionaries - Tuples - tuples as lists and dictionaries - Comparing tuples - Files - Reading and Writing - Format operator - Filenames and Paths - Catching Exceptions

Theory : 30 Hrs	Tutorial: 0	Total Hours: 30 Hrs

Lab Component:

List of Experiments:

1. Introduction to Algorithms, flowcharts and pseudocode
2. Programs for variables and expressions
3. Programs using conditional statements and iterations
4. Programs using string operations
5. Programs using functions with parameters
6. Programs using recursion and Boolean functions
7. Programs using list operations
8. Programs using dictionaries & tuples
9. Programs using files
10. Programs using exceptions

Practical: 30 Hrs	Tutorial: 0 Hrs	Total Hours : 30 Hrs

Textbooks:

1. Downey Allen , 2002, ”Think Python- How to think like a Computer Scientist”, O'Reilly Media Inc.
2. Dusty Phillips, 2015, "Python 3 - Object Oriented Programming", 2nd Edition, Packet Publishing Ltd.

Reference Materials:

1. Ashok Namdev Kamthane, Amit Ashok Kamthane, 2018, “Programming and Problem Solving with Python” , Mc-Graw Hill Education.
2. T Jeyapoovan, 2015, “Fundamentals of computing and programming in C”, Vikas Publishing.

Crafted By : Dorai Thodla, B.E (CEG, Guindy), Founder & CTO, iMORPH, California

Reviewed By : Gokul Kumar, M.Sc (BITS Pilani), MBA, Co-Founder & CTO, Vusar - AR 3D Design Visualization, California

U18AIC1006	INTRODUCTION TO INDIC CULTURE AND TECHNOLOGIES	L	T	P	J	C
		2	0	0	0	1

Course Objectives:

- To develop a broad understanding of Indian society and intercultural literacy through cultural immersion.
- To deepen knowledge on Indian development, environmental, and cultural issues through coursework, local engagement, and independent projects.

Course Outcomes:

After successful completion of this course, the students should be able to

CO 1:	Understand the various dimensions of Indian Culture and Philosophy
CO 2:	Develop appreciation for the contribution of Indians to various science and technologies

Pre-requisite courses: Nil

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1							M	M	M			
CO2							M	M	M			

Course Assessment methods:

a) Direct

1. Continuous Assessment Test
2. Quiz

b)Indirect

1. Course-end survey

Topics covered:

Foundations of Indic Knowledge	3 Hours

Branches of Indian Knowledge - Six Foundational Philosophies of Indian Sciences - Indian Big History: Cosmology - Evolutionary Life Sciences

Indic Perspective on Health and Well-being	3 Hours

Body-Mind-Cognition according to Indian health systems - Technologies used by ancient Indians for

well-being of people

Indic Ecology and Sustainability	**3 Hours**
Purpose of life and sustainable development - Traditional Indian tools and practices for sustainability: agriculture, energy, waste management, construction	
Indic Values and Modern Technology	**3 Hours**
Value frameworks from the Indian tradition - evaluating modern technology through Indic frameworks - Digital dharma: ethics and responsibility in technology age	
Ancient Indian Technologies	**3 Hours**
Technologies used in Ancient India: Computation, Astronomy, Architecture	

Theory: 15 Hrs	**Tutorial: 0**	**Total Hours: 15 Hrs**

Textbooks:

1. Excel Health Journals, First edition, 2016, Certification of yoga professionals official guidebook, Excel books Pvt Ltd.
2. Vasant Lad, UK ed. edition, 2002, Textbook of Ayurveda: Volume 1 - Fundamental Principles of Ayurveda, Ayurvedic Press.

Reference Books:

1. Neeltje Huppes, 2017, Indian Psychology - an experiential approach, Indian Psychology Institute, Puducherry, India.
2. S Balachandar rao, 1999, Indian Astronomy: An Introduction, Universities Press.
3. Swami Harshananda, The Six Systems of Hindu Philosophy, (http://rkmathbangalore.org/Books/TheSixSystemsofHinduPhilosophy.pdf)

Crafted By : Smrithi Rekha Adinarayanan, MS (State University of New York), co-founder of Anaadi Foundation, Palani

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U18ENI1202	FUNDAMENTALS OF COMMUNICATION	L	T	P	J	C
		2	0	2	0	3

Course Objectives:

- To understand and evaluate key theoretical approaches used in the interdisciplinary field of communication
- To communicate effectively orally and in writing
- To understand and apply knowledge of human communication and language processes as they occur across various contexts, e.g., interpersonal, intrapersonal, small group, organizational, media, gender, family, intercultural communication, technologically mediated communication, etc. from multiple perspectives.
- To understand the research methods associated with the study of human communication, and apply at least one of those approaches to the analysis and evaluation of human communication.

Course Outcomes:

After successful completion of this course, the students should be able to

CO 1:	Demonstrate their ability to write effectively with the optimum use of formats and writing strategies of appropriate grammar and vocabulary.
CO 2:	Develop active listening strategies to enhance language skills.
CO 3:	Speak fluently with effective delivery strategies.

Pre-requisite courses: Nil

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									**S**	**S**		**S**
CO2									**S**	**S**		**S**
CO 3									**S**	**S**		**S**

Course Assessment methods:

Direct

1. Continuous Assessment of Skills
2. Assignment
3. Written Test
4. End Semester Examination

Topics covered:

UNIT 1	**12 Hours**

Glimpses of Essential English for Engineers (General Overview) - Word Classification - Articles - Word Formation (Prefixes & Suffixes) – Different grammatical forms of the same word – Phrasal Verbs – Nominal Compounds

Listening: Listening to Weather Forecast - Listening for Specific Information, Numbers, Time, Duration

Speaking: Self-Introduction with goal setting and SWOT

UNIT 2	**12 Hours**

Sentences and its kinds (Framing Questions) - Cause and Effect Expressions - Purpose and Function Expressions - Subject Verb Agreement - Writing Instructions - Mother Tongue Influence in relation to Pronunciation and Redundancy

Listening: Listening to Social & Cultural Contexts - Listening to Facts & Opinions

Speaking: Proverbs with prompts and cues

UNIT 3	**12 Hours**

Skimming & Scanning - Reading Passages, Newspaper articles, blogs - Reading Comprehension - Cloze test, Note-making - Summary Writing - Formal Letter writing (Enquiry, Complaint & Clarification, Invitation, Acceptance, Rejecting)

Listening: Listening to Scientific Inventions

Speaking: Pair Activity (Negotiation / Pitching opinion)

UNIT 4	**12 Hours**

Tenses – Voice - Reading Advertisement & Graphical representation - Creating Advertisements - Email Etiquettes, Structure, Writing and Responding to Emails
Listening: Listening to News Story

Speaking: Formal Presentation

UNIT 5	**12 Hours**

Discourse Markers - Preparing Checklist and Itinerary - Paragraph Writing (Descriptive, Compare & Contrast, Narrative) - Blog Writing - Proof Reading (Spelling, punctuation, grammar)

Listening: Listening to Documentary

Speaking: Integrated Speaking (Listening, Video & Reading)

Theory: 30 Hrs	**Practical: 30 Hrs**	**Total Hours: 60 Hrs**

Text Books:

1. Basic Communication Skills for Technology, by Andrea J Rutherfoord, Pearson Publishers.
2. English Language Skills by Aruna Koneru, Tata Mc Graw Hills Publications.

Reference Materials:

1. Word Power Made Easy, by Norman Lewis, Simon and Schuster.
2. Effective Technical Communication, by Ashraf Rizvi, Tata Mc Graw Hills Publications.
3. English Grammar in Use, by Murphy, Raymond Ernst Klett Sprachen,
4. Oxford Guide to Effective Writing & Speaking by John Seely, Oxford University Press
5. British Council LearnEnglish Teens Website https://learnenglishteens.britishcouncil.org/

Semester II

U18PHT2203	ADVANCED PHYSICS	L	T	P	J	C
		3	0	0	0	3

Course Objectives:

- To impart knowledge on the concepts of Faraday‘s law, induced emf and Maxwell‘s equations
- To discuss and explain the key concepts and principles of quantum physics
- To impart knowledge on the concepts of magnetostatics, magnetic flux density, scalar and vector potential and its applications.

Course Outcomes:

After successful completion of this course, the students should be able to

CO 1:	Impart knowledge on the concepts of electrodynamics for various conditions and its applications
CO 2:	Understand the behaviour of magnetostatics conditions, materials and its applications
CO 3:	Study the importance of various operators and its application in quantum computing
CO 4:	Infer the nuclear reactions and its impact in energy models for data processing
CO 5:	Explore the types of high energy particles and its characteristic effects
CO 6:	Understand the various materials aspects for identify modelling using various tools

Pre-requisite courses: U18PHI1202

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	M									M
CO2	S	M	M									M
CO3	S	M		M								M
CO4	S									M		M
CO5	S	M								M		M
CO6	S	M	M		M							M

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. End Semester Examination (Theory components)

b)Indirect

1. Course-end survey

Topics covered:

ELECTRODYNAMICS	**9 Hours**

Poisson's and Laplace's Equations – Electric Polarization – Nature of Dielectric Materials- Maxwell's displacement current – Maxwell's equations – vector and scalar potentials – Gauge invariant – wave equation and plane wave solutions

MAGNETODYNAMICS	**9 Hours**

Energy Density in Magnetic Fields – Types of Magnetic Materials - Magnetization and Permeability – Magnetic boundary conditions. Hysteresis – Soft and Hard Magnetic Materials – Ferrites-Storage of Magnetic Data, Floppy, tapes and Magnetic Disc Drives

QUANTUM PHYSICS	**9 Hours**

Introduction to Quantum States - Observables and Operators- Herminian operators-Hamiltonian operators Angular momentum-Spin-orbit coupling- Simon's Algorithm - Grover Search Algorithm

NUCLEAR AND PARTICLE PHYSICS	**9 Hours**

Nuclear Mass and Binding energy- Stability of the nucleus- Mass defect and packing factor-Introduction to Particle physics- particle accelerators and detectors-Antiparticles properties- Symmetry Functions-Quark model-

MATERIALS MODELLING	**9 Hours**

Crystal systems-Symmetry in crystals-Plane and Space groups- Types and effects of defects and imperfections-Bonding and Chemical interactions-Reciprocal lattice-Brillioun zone

Theory: 45 Hrs	**Tutorial: 0 Hrs**	**Total Hours: 45 Hrs**

Textbooks:

1. D.J. Griffiths, 2016, Introduction to Electromagnetic Theory, Prentice Hall, USA.
2. N. Zettili, 2009, Quantum Mechanics Concepts and Applications, Wiley, USA.
3. P M Mathews and K Venkatesan, A Textbook of Quantum Mechanics (2016), Tata McGraw-Hill, India

Reference Books:

1. B. B. Cohen, 2014, “Concepts of Nuclear Physics”, TMGH , India
2. C. Kittel, 7th Edn, 1995, Introduction to Solid state Physics. John Wiley & Sons
3. D. Griffiths, 2nd Ed., 2008, “Introduction to Elementary Particles”, Wiley-Vch
4. Neil W. Ashcroft, N.David Mermin, 1st Ed., 2003, Solid State Physics, Cengage Learning.

Crafted By : Dr Arul H, M.Sc., PhD., Department of Physics, KCT

U18MAT2001	DISCRETE MATHEMATICS	L	T	P	J	C
		3	0	0	0	3

Course Objectives:

- To introduce concepts of mathematical logic for analyzing propositions and proving theorems.
- To use sets for solving applied problems, and use the properties of set operations algebraically.
- To work with relations and investigate their properties.
- To investigate functions as relations and their properties.
- To introduce basic concepts of graphs, digraphs and trees

Course Outcomes:

After successful completion of this course, the students should be able to

CO 1:	Understand the concepts of set theory and apply them to situations involving inclusion and exclusion.
CO 2:	Acquire the knowledge of relations, and analyse equivalence relations and their properties.
CO 3:	Understand and analyse the properties of different kinds of functions and solve recurrence relations.
CO 4:	Evaluate the validity of logical arguments and construct simple mathematical proofs.
CO 5:	Determine whether given graphs are isomorphic and apply Dijkstra's algorithm to find the shortest path.

Pre-requisite courses:Nil

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	M										
CO2	M											
CO3	M	M										
CO4	S	S										S
CO5	S	S										S

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. End Semester Examination (Theory components)

b)Indirect

1. Course-end survey

Topics covered:

SET THEORY	**5 Hours**
Algebra of sets – The power set – Ordered pairs and Cartesian product – principle of inclusion and exclusion.	
RELATIONS	**6 Hours**
Relations on sets –Types of relations and their properties - Equivalence relations –Relational matrix and the graph of relation – Operations on relations.	
FUNCTIONS AND RECURRENCE RELATIONS	**11 Hours**
Functions –Type of functions – Injective, surjective and bijective functions –Composition of functions – Inverse functions –Permutation functions - Recurrence relations-Solving linear recurrence relations.	
LOGIC	**12 Hours**
Propositions- Logical operators- Normal forms –Rules of inference-Consistency and inconsistency-Propositional logic- Proofs-Predicates- Quantifiers- Universe of discourse – Logical equivalences and implications for quantified statements-Rules of specification and generalization – Validity of arguments.	
GRAPH THEORY	**11 Hours**
Graphs- Types of graphs- Matrix representation of graphs- Graph isomorphism- Walk – Path - Cycles- Eulerian graphs -Hamiltonian graphs- Planar graphs- Euler formula- Shortest path algorithm: Dijkstra's algorithm	

Theory: 45 Hrs	**Tutorial: 0**	**Total Hours: 45 Hrs**

Textbooks:

1. Kenneth H. Rosen, “Discrete Mathematics and its applications: With Combinatorics and Graph Theory (7th Edition)”, Tata McGraw-Hill, 2015.
2. Tremblay J.P., Manohar R., “Discrete Mathematical Structures with applications to Computer Science”, Tata McGraw-Hill, International Edition, 2017

Reference Books:

1. Liu C.L, “Elements of Discrete Mathematics”, 4th Edition, McGraw Hill, 2017.
2. Grimaldi, R.P. “Discrete and Combinatorial Mathematics: An Applied Introduction”, 5 th Edition, Pearson Education Asia, Delhi, 2016.
3. Mott J.L, Kandel A. and Baker T.P., “Discrete Mathematics for Computer Scientists and Mathematicians”, 2nd Edition, Prentice Hall India, 2015.
4. Narsingh Deo, “Graph Theory with Applications to Engineering and Computer Science”, Courier Dover Publications, 2017.

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U18MAI2203	PROBABILITY AND STATISTICS	L	T	P	J	C
		3	0	2	0	4

Course Objective:

- To introduce the basic concepts of probability and random variables
- To introduce the basic concepts of two dimensional random variables
- To acquire the knowledge of testing hypotheses for small and large samples which plays an important role in real life problems.
- To introduce the basic concepts of classifications of design of experiments which plays very important roles in the field of engineering and statistical quality control.

Course Outcomes:

After successful completion of this course, the students should be able to

CO 1:	Understand and apply the concept of probability and random variables and predict probabilities of events in models following normal distribution.
CO 2:	Apply the concepts of two dimensional random variables, central limit theorem and estimation, which lay the foundation for Machine Learning and Data Science.
CO 3:	Perform hypothesis testing and interpret the results which will form the basis for Data Analysis
CO 4:	Understand the principles of design of experiments and perform analysis of variance which will help in Data Analysis.
CO 5:	Learn and apply multivariate analysis necessary for Principal Component Analysis.
CO 6:	Use R software to solve problems in the above topics

Pre-requisite courses:Nil

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S										
CO2	S	S										
CO3	S	M										W
CO4	S	S										M
CO5	M	S										M
CO6					S							S

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. Pre/Post - Experiment Test/Viva; Experimental Report for each Experiment (lab Component)
5. Model Examination (lab component)
6. End Semester Examination (Theory and lab components)

b)Indirect

1. Course-end survey

Topics covered:

PROBABILITY AND RANDOM VARIABLES	**13 Hours**

Axioms of probability - Conditional probability – Total probability – Bayes' theorem Random variable – Distribution function – properties – Probability mass function – Probability density function – moments - Standard Distributions - Binomial, Poisson and Normal distributions

TWO DIMENSIONAL RANDOM VARIABLES AND ESTIMATION	**9 Hours**

Joint distributions – Marginal and conditional distributions – Expected values of functions of two variables– Correlation and regression (for discrete data only) - Central limit theorem – Statement

TESTING OF HYPOTHESIS	**10 Hours**

Large sample tests for single mean and difference of means-Small samples tests based on t and F distributions (single mean, difference of means, paired t- test and variance ratio test) – Chisquare test for independence of attributes and goodness of fit.

DESIGN OF EXPERIMENTS	**5 Hours**

Analysis of Variance (ANOVA) – Completely Randomized Design (CRD) – Randomized Block Design (RBD)

MULTIVARIATE ANALYSIS	**8 Hours**

Random vectors and matrices – Mean vectors and covariance matrices –Principal components – Population principal components – Principal components from standardized variables.

Theory: 45 Hrs	**Tutorial: 0**	**Total : 45 Hrs**

Lab component Contents:

List of R Programmes:

1. Introduction to R programming
2. Application of descriptive statistics – Mean, Median, Mode and standard deviation, Skewness and Kurtosis
3. Applications of Correlation and Regression
4. Application of Normal distribution
5. Application of Student – t test

6. Application of F test
7. Application of Chi-square test
8. ANOVA – one way classification
9. ANOVA - two way classification
10. Box Plots

Practical: 30 Hrs	Tutorial: 0	Total Hours : 30 Hrs

Text Books:

1. Johnson R. A., Miller & Freund's, Sixth Edition, 2000, "Probability and Statistics for Engineers", Pearson Education, Delhi.
2. Gupta.S.C and Kapoor.V.K, 11th extensively revised edition, 2007 Fundamentals of Mathematical Statistics,, Sultan Chand & Sons.

Reference Books:

1. Walpole R. E., Myers S.L. & Keying Ye, 9th edition, 2012, "Probability and Statistics for Engineers and Scientists", Pearson Education Inc.
2. Gupta S.C, and KapurV.K, 4th Edition, 2014, "Fundamentals of Applied Statistics", Sultan Chand, New Delhi.
3. Charles Henry Brase and Corrinne Pellillo Brase , 9th edition, 2007, "Understandable Statistics", D.C. Heath and Company, Toronto.
4. Gareth M. James, Daniela Witten, Trevor Hastie, Robert Tibshirani, 7th edition, "An Introduction to Statistical Learning: With Applications in R".
5. Richard A. Johnson and Dean W. Wichern, 5th Edition, 2012, Applied Multivariate Statistical Analysis, Pearson Education, Asia.
6. Anderson, T. W , 2003, An Introduction to Multivariate Statistical Analysis, John Wiley and Sons

Crafted By : Dr. Vijeta Iyer, M.Sc., PhD., Department of Mathematics, KCT & Gokul Kumar M.Sc (BITS Pilani), MBA, Co-Founder & CTO, Vusar - AR 3D Design Visualization

U18AII2204	OBJECT-ORIENTED PROGRAMMING AND DATA STRUCTURES	L	T	P	J	C
		2	0	2	0	3

Course Objectives:

- To understand the importance of Classes & objects along with constructors
- To discuss the principles of inheritance and Class and interface and demonstrate though problem analysis
- assignments how they relate to the design of methods, abstract classes and interfaces and packages
- To introduce the fundamental concept of data structures and to emphasize the importance of data structures in developing and implementing efficient algorithms
- Understand and remember algorithms and its analysis procedure.
- To introduce the concept of data structures through ADT including List, Stack, Queues

Course Outcomes:

After successful completion of this course, the students should be able to

CO 1:	Understand the object oriented programming concepts and GUI
CO 2:	Apply Overloading and concept of handling exceptions
CO 3:	Demonstrate the concepts of data structures using python
CO 4:	Develop the graph, sorting and search techniques of data structures

Pre-requisite courses: Introduction to Python

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	M	S						S	S
CO2	S	S	S	S	S						S	S
CO3	S	S	S	M	S						S	S
CO4	S	S	S	S	S						S	S

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)

4. Pre/Post - Experiment Test/Viva; Experimental Report for each Experiment (lab Component)
5. Model Examination (lab component)
6. End Semester Examination (Theory and lab components)

b)Indirect

1. Course-end survey

Topics covered:

OBJECT ORIENTED CONCEPTS IN PYTHON	**8 Hours**

Introduction - Classes and Objects - Creating Python Classes - Classes and Functions - Pure Functions- Classes and Methods - Inheritance: Basic Inheritance, Multiple Inheritance - Polymorphism - Class Diagrams - Data Encapsulation - GUI - Event-driven programming paradigm; tkinter module, creating simple GUI; buttons, labels, entry fields, dialogs; widget attributes - sizes, fonts, colors layouts, nested frames.

EXCEPTIONS	**7 Hours**

Operator Overloading - The Basics- Indexing and Slicing- Index Iteration-Iterable Objects- Membership- Attribute AccessObject Destruction- Exceptions - Exception Basics-Catching Exceptions- Raising Exceptions- UserDefined ExceptionsThe try/except/else Statement- The try/finally Statement- Unified try/except/finally- The Raise Statement- Exception Objects- Nesting Exception.

DATA STRUCTURES	**7 Hours**

Abstract Data Types (ADT) - Linked List Implementation - Doubly-Linked Lists - Circularly Linked Lists - Applications of Lists - Stack ADT - Implementation of Stack and its Applications - Queue ADT - Implementation of Queue and its Applications - Tree ADT - Tree Traversals - Binary Tree ADT - Expression Trees - Applications of Trees - Binary Search tree ADT .

GRAPHS, SORTING AND SEARCHING TECHNIQUES	**8 Hours**

Graph and its Representations - Graph Traversals - Heap - Binary Heap - Applications of Priority Queues, Preliminaries - Insertion Sort - Shell sort - Heap sort - Merge sort - Quick sort - Linear Search - Binary Search

Theory: 30 Hrs	**Tutorial: 0**	**Total: 30 Hrs**

Lab Component:

List of Experiments:

1. Class & Object
2. Inheritance
3. Access Specifier and Abstract Class
4. Exception
5. Constructor Overloading, Operator Overloading
6. Implementation of Stack and Queue
7. Implementation Linked list, Circular Linked List, Double Linked

8. Implementation of Binary Search Tree
9. Implementation of Sorting Algorithms

Practical: 30 Hrs	Tutorial: 0	Total Hours : 30 Hrs

Textbooks:

1. Allen Downey , 2002, ”Think Python- How to think like a Computer Scientist”, O'Reilly Media, Inc.
2. Dusty Phillips, 2nd Edition, 2015, "Python 3 - Object Oriented Programming", Packet Publishing Ltd.

Reference Books:

1. Kenneth Lambert, 2nd Edition, 2018, “Fundamentals of Python: Data Structures” .
2. Thomas H. Cormen, Charles E. Leiserson, 3rd Edition, 2009, “ Introduction to Algorithms”.
3. Eric Matthes, 2nd Edition, 2019, “Python Crash Course: A Hands-On, Project-Based Introduction to Programming”.

Crafted By : Dorai Thodla, B.E (CEG, Guindy), Founder & CTO, iMORPH, California and Gokul Kumar, M.Sc (BITS Pilani), MBA, Co-Founder & CTO, Vusar - AR 3D Design Visualization, California

U18AII2205	INTRODUCTION TO AI & ML	L	T	P	J	C
		2	0	2	0	3

Course Objective:

- To introduce the basic concepts, theories and state-of-the-art techniques of artificial intelligence.
- To introduce basic concepts and applications of machine learning.
- To learn the application of machine learning /A.I algorithms in the different fields of engineering, science, medicine, finance etc.

Course Outcomes:

After successful completion of this course, the students should be able to

CO 1:	Understand the basic concepts of machine learning and some typical applications
CO 2:	Understanding how to build and validate models and improve them iteratively
CO 3:	Understand the core concepts of Artificial Intelligence and Applications
CO 4:	Apply knowledge representation with artificial intelligence using FOL and Predicate logic

Pre-requisite courses: Introduction to Python

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	M	S						S	S
CO2	S	S	S	S	S						S	S
CO3	S	S									M	S
CO4	S	S	S	M							S	S

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. Pre/Post - Experiment Test/Viva; Experimental Report for each Experiment (lab Component)
5. Model Examination (lab component)
6. End Semester Examination (Theory and lab components)

b)Indirect

1. Course-end survey

Topics covered:

INTRODUCTION TO MACHINE LEARNING	8 Hours

Introduction - Machine Learning Process - Supervised Learning - Regression - Linear Regression - Predicting - Polynomial Regression - Classification - Feature Engineering - Logistic Regression - kNN classification - SVM - Naive bayes - Decision tree and Random forest classifier - Unsupervised Learning - Clustering techniques.

ANALYSIS OF MODELS	8 Hours

Model representation, decision boundary, cost function, gradient descent, regularization, evaluating a hypothesis (Model selection), training/validation/testing procedures, bias/variance, learning curves, Accuracy and Error measures, evaluating the accuracy of a classifier or predictor, Confusion metric, precision, recall, ROC curve and AUC score, Parameter Tuning.

ARTIFICIAL INTELLIGENCE : PROBLEM SOLVING	6 Hours

Introduction to AI, Control strategies, Search strategies, Production system characteristics - Specialized production system- Problem solving methods - Problem graphs, Matching, Indexing and Heuristic functions -Hill Climbing-Depth first and Breadth first, Constraints satisfaction Problem.

KNOWLEDGE REPRESENTATION AND REASONING	8 Hours

Game playing - Knowledge representation, Knowledge representation using Predicate logic, Introduction to predicate calculus, Resolution, Use of predicate calculus, Knowledge representation using other logic-Structured representation of knowledge.- First order logic – Syntax and Semantics – Knowledge Engineering in First Order Logic – Inference in First Order Logic.

Theory: 30 Hrs	Tutorial: 0 Hrs	Total Hours: 30 Hrs

Lab Component:

List of Experiments:

1. Implement python program to perform operations like mean, median, mode, standard deviation, percentile and various data distributions
2. Try to open a csv file and sort the content with respect to one column using python
3. Implement a python program to perform linear regressions for a dataset that prevails in csv format
4. Implement a python program to perform logistic regression
5. Write a program to implement k-Nearest Neighbour algorithm to classify any dataset. Print both correct and wrong predictions. Python ML library classes can be used for this problem.
6. Assume that K=3
7. Write a program to construct a Support Vector Machine considering medical data. Use this model to demonstrate the diagnosis of heart patients using the standard Heart Disease Data Set. You can use Python ML library classes/API.
8. Assuming a set of documents that need to be classified, use the naïve Bayesian Classifier model to perform this task. Built-in Java classes/API can be used to write the program. Calculate the accuracy, precision, and recall for your data set.
9. Assuming a set of data that need to be classified, use a decision tree model to perform this task. Preferably use any dataset like medical, titanic dataset or others to evaluate the accuracy
10. Implement a python program to perform Hill climbing algorithm

Practical: 30 Hrs	Tutorial: 0	Total: 30 Hrs

Textbooks:

1. Alexey Grigorev, 2020, “Machine Learning Bookcamp”, MEAP.
2. Shai Shalev-Shwartz, Shai Ben-David, 2014, “Understanding Machine Learning From Theory to Algorithms”, Cambridge University Press

Reference Book:

1. Kevin Night and Elaine Rich, Nair B., 2008, “Artificial Intelligence (SIE)”, McGraw Hill.

Crafted By : Dorai Thodla, B.E (CEG, Guindy), Founder & CTO, iMORPH, California and Gokul Kumar, M.Sc (BITS Pilani), MBA, Co-Founder & CTO, Vusar - AR 3D Design Visualization, California

Reviewed By : Derrick Jose, B.E (BITS Pilani), CEO & Founder, Flutura, Texas

U18AII2206	INTRODUCTION TO DATA SCIENCE	L	T	P	J	C
		2	0	2	0	3

Course Objective:

- To introduce the basic concepts of data science
- To enable students to handle various dataset
- To train the applications of data science and perform data transformations

Course Outcomes:

After successful completion of this course, the students should be able to

CO 1:	Understand the various aspects of data science and the skill sets necessary for a data scientist
CO 2:	Explain the concepts of data storage and Big Data
CO 3:	Illustrate the different types of process and tools used in data science
CO 4:	Apply the principles of Data Science for analysis using Google Sheets and Excel

Pre-requisite courses:Nil

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											M
CO2	S	S		M							S	S
CO3	S	S	S	M	S						S	S
CO4	S	S	S		S						S	S

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. Pre/Post - Experiment Test/Viva; Experimental Report for each Experiment (lab Component)
5. Model Examination (lab component)
6. End Semester Examination (Theory and lab components)

b)Indirect

1. Course-end survey

Topics covered:

BASICS OF DATA SCIENCE	10 Hours

Data Science: Steps in doing Data Science - Data Science relation to other fields- Data Science and Information Science- Computational Thinking - Skills and tools needed to do Data Science - Storing data - Combining bytes into larger structures - Creating data sets - Identifying data problem - Understanding data sources - Exploring data models- Introduction to Big Data

DATA HANDLING	**10 Hours**

Structured and unstructured data - Challenges with unstructured data - Data collection: Open data - multimodal data - Data Preprocessing: Data Cleaning - Data Integration, Data Transformation - Data Reduction - Data Discretization

EXCEL FOR DATA SCIENCE	**10 Hours**

Elementary data handling: Types - Data Transformation - Filtering -Pivot tables - Graphical Methods - Descriptive statistics - Random sampling - Probability distributions using functions- Binomial - poisson - Normal - Geometric - Negative binomial - exponential - gamma - beta- lognormal - pmf and cmd- Hypothesis testing using Data Analysis Pack - Z test and t-test.

Theory: 30 Hrs	**Tutorial: 0 Hrs**	**Total Hours: 30 Hrs**

Lab Component:

List of Experiments:

1. Basic Statistics and Visualization
2. Data distribution
3. Reading and Writing different types of dataset
4. Correlation and Covariance
5. Regression Model
6. Implementation of Pivot table
7. Implementation of Probability Distribution using Function
8. Implementation of Hypothesis

Practical: 30 Hrs	**Tutorial: 0**	**Total Hours: 30 Hrs**

Textbooks:

1. Jeffrey S. Saltz, Jeffrey M. Stanton, 2018, An Introduction to Data Science, SAGE Publications
2. Chirag Shah, 2020, A Hands-On Introduction to Data Science, Cambridge University Press

Reference Books:

1. Ash Narayan Sah, 2009, Data Analysis Using Microsoft Excel, Excel books
2. Joel Grus, 2015, “Data Science from Scratch”.

Crafted By : Gokul Kumar, M.Sc (BITS Pilani), MBA, Co-Founder & CTO, Vusar - AR 3D Design Visualization, California
Reviewed By : Adarsh Natarajan, MBA (IIM B), CEO & Founder, AIndra Systems

Syllabi - 2nd Year
Semester III

U18MAI3201	MULTIVARIATE CALCULUS AND FORECASTING	L	T	P	J	C
		3	0	2	0	4

Course Objectives:

- To enable learning of Multivariate calculus as it's one of the most important data science skills and multivariate calculus is used everywhere in Machine Learning Projects.
- To demonstrate an understanding of Calculus beyond the manipulation of symbols,
- To enable classification or regression when operations are related with multiple variables
- To understand the theory and methods of Calculus to solve a variety of problems in terms of multivariate dataset

Course Outcomes:

After successful completion of this course, the students should be able to

CO 1:	Evaluate the total derivative of a function, expand the given function as a series and locate the maximum and minimum for multivariate functions which is an important part of data science.
CO 2:	Solve higher order partial differential equations arising in real world situations.
CO 3:	Evaluate double and triple integrals in Cartesian coordinates and apply them to calculate area and volume.
CO 4:	Evaluate gradient, divergence and curl which form the basis of gradient descent and apply them to real life problems.
CO 5:	Analyze and apply the knowledge of time series and interpolation to predict the future values.
CO 6:	Determine multiple integrals, vector differentials, vector integrals using MATLAB.

Pre-requisite courses: NIL

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S										M
CO2	W											
CO3	W	W										W
CO4	M	M										
CO5	M											M

CO6					S							S

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. Pre/Post - Experiment Test/Viva; Experimental Report for each Experiment (lab Component)
5. Model Examination (lab component)
6. End Semester Examination (Theory and lab components)

b)Indirect

1. Course-end survey

Topics covered:

FUNCTIONS OF SEVERAL VARIABLES	**9 Hours**

Partial derivatives – Homogeneous functions and Euler's theorem –Total derivative – Taylor's series expansion – Maxima and minima of functions of two variables – Constrained maxima and minima: Lagrange's multiplier method with single constraints – Jacobians.

PARTIAL DIFFERENTIAL EQUATIONS	**5 Hours**

Linear Homogeneous partial differential equations of second and higher order with constant coefficients

MULTIPLE INTEGRALS	**9 Hours**

Double integration – Cartesian coordinates – Change of order of integration – Triple integration in Cartesian coordinates – Applications: Area as double integral and Volume as triple integral.

VECTOR CALCULUS	**10 Hours**

Gradient, divergence and curl – Directional derivative – Irrotational and Solenoidal vector fields - Green's theorem in a plane, Gauss divergence theorem and Stoke's theorem (Only statements excluding proofs)

TIME SERIES AND INTERPOLATION	**12 Hours**

Time series - components - Trend-Determination of trend by moving averages – Least square method-Seasonal Variations-Ratio to moving average method.

Interpolation – Newton's forward and backward interpolation – Newton's divided difference interpolation – Lagrange's interpolation.

Theory : 45 Hrs	**Tutorial : 0**	**Total Hours: 45 Hrs**

Lab component Contents:

List of MATLAB Programmes:

1. Determining Maxima and Minima of a function of two variables.

2. Evaluating double integral with constant and variable limits.
3. Area as double integral
4. Evaluating triple integral with constant and variable limits
5. Volume as triple integral
6. Evaluating gradient, divergence and curl
7. Evaluating line integrals and work done
8. Verifying Green's theorem in the plane

Practical : 30 Hrs	Tutorial : 0	Total Hours: 30 Hrs

Textbooks:

1. Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, New Delhi, 44th Edition, 2014.
2. Ramana B.V., "Higher Engineering Mathematics", Tata McGraw Hill Co. Ltd., New Delhi, 11th Reprint, 2010.
3. Grewal B.S. and Grewal J.S., "Numerical methods in Engineering and Science", 9th Edition, Khanna Publishers, New Delhi, 2007.
4. Montgomery D.C., Johnson. L.A., Gardiner J.S., "Forecasting and Time series Analysis", McGraw Hill, 1990.

Reference Books:

1. Kreyzig E., "Advanced Engineering Mathematics", 10th Edition, John Wiley and sons, 2011.
2. Venkataraman M.K., "Engineering Mathematics", The National Publishing Co., Chennai,2003
3. Weir, MD, Hass J, Giordano FR: Thomas' "Calculus", Pearson education 12th Edition, 2015.
4. Thomas G.B. and Finney R.L., "Calculus and Analytic Geometry", 11th Edition, Pearson Education, 2006.
5. Gerald, C. F. and Wheatley, P. O.,"Applied Numerical Analysis", 7th Edition, Pearson Education Asia, New Delhi, 20073.
6. Grewal B.S. and Grewal J.S., "Numerical methods in Engineering and Science", 9th Edition, Khanna Publishers, New Delhi, 2007.
7. Montgomery D.C., Johnson. L.A., Gardiner J.S., "Forecasting and Time series Analysis", McGraw Hill, 1990..

Crafted By : Dr. K. Maheswari, M.Sc., PhD., Department of Mathematics, KCT

U18AII3202	ALGORITHMS AND OPTIMIZATION OF PROGRAMS	L	T	P	J	C
		2	0	2	0	3

Course Objectives:

- To teach paradigms and approaches used to analyze and design algorithms and to appreciate the impact of algorithm design in practice.
- To make students understand how the worst-case time complexity of an algorithm is defined, how asymptotic notation is used to provide a rough classification of algorithms.
- To explain different computational models (e.g., divide-and-conquer), order notation and various complexity measures (e.g., running time, disk space) to analyze the complexity/performance of different algorithms.
- To teach various advanced design and analysis techniques such as greedy algorithms, dynamic programming & Know the concepts of tractable and intractable problems and the classes P, NP and NP-complete problem

Course Outcomes:

After successful completion of this course, the students should able to

CO 1:	Understand techniques for effective problem solving in computing
CO 2:	Design different paradigms of problem solving to illustrate clever and efficient ways to solve a given problem.
CO 3:	Identify and apply for rigorously proving correctness of the algorithm for a variety of problems.
CO 4:	Implement to show the efficiency of the algorithm over the naive techniques

Pre-requisite courses: U18AII2204

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											M
CO2	S	S		M							S	S
CO3	S	S	S	M	S						S	S
CO4	S	S	S		S						S	S

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. Pre/Post - Experiment Test/Viva; Experimental Report for each Experiment (lab Component)
5. Model Examination (lab component)
6. End Semester Examination (Theory and lab components)

b)Indirect

1. Course-end survey

Topics covered:

ANALYSIS OF ALGORITHMS	**7 Hours**

Introduction Role of Algorithms in computing, Analyzing algorithms and Designing algorithms, Algorithm Design techniques: Divide and Conquer – Merge Sort and Quicksort. **Time complexity:** Growth of Function: Asymptotic notation, Standard notations and common functions Complexity analysis-Time and space tradeoffs in algorithms, Using recurrence relations to analyze recursive algorithms, Master Theorem(Without Proof).

ADVANCED DESIGN AND OPTIMIZATION	**8 Hours**

Algorithm design techniques - Brute-force – Sequential search, Dynamic Programming – Rod cutting problem, Greedy algorithms – Activity Selection Problem; Divide-and-conquer – Strassen's Matrix Multiplication; Backtracking – 8 queens problem; Branch and- bound – Traveling Salesman Problem, 0/1 Knapsack Problem-String Matching Algorithms - Geometric algorithms - Approximation algorithms.

TREES, GRAPHS AND HASHING	**8 Hours**

Non-Linear Data Structures: General Tree; Binary trees, Binary Search Tree: Traversals Graphs: Introduction, Representations of graphs (adjacency list, adjacency matrix)
Hashing: Hash tables, including collision-avoidance strategies, MD5 Hashing, Hashing in SSH. DFS and BFS, Shortest-path algorithms (Single source shortest path. Dijkstra's and Floyd's algorithms); Minimum spanning tree (Prim's and Kruskal's algorithms)

COMPLEXITY CLASS	**7 Hours**

COMPLEXITY CLASS: P, NP and NP -Completeness Problems (without proofs). **Case Study**: Implement a program that resolves any real time problem and optimize the same script in which its time and space complexity is reduced linearly or exponentially.

Theory : 30 Hrs	**Tutorial : 0**	**Total Hours: 30 Hrs**

Lab component Contents:

List of Experiments:

1. Implementation of Sorting algorithms
2. Implementation of Warshall's algorithm
3. Designing Knapsack problem

4. Shortest paths Algorithm
5. Minimum cost spanning tree
6. Implementation of travelling salesman problem
7. Implement N Queens problem using Backtracking

Practical : 30 Hrs	Tutorial : 0	Total Hours: 30 Hrs

Textbooks:

1. Design and Analysis of Algorithms by Sartaj Sahni and Ellis Horwitz, Galgotia Publications 2015.
2. Anany Levitin, Introduction to the Design and Analysis of Algorithms, Pearson Education , 2012
3. Thomas H Cormen, Charles E Leiserson, Ronald L Rivest and Clifford Stein, Introduction to Algorithms, Third Edition, Prentice Hall of India,New Delhi, 2010

Reference Books:

1. J. Klienberg and E. Tardos, Algorithm Design, Pearson Education Limited , 2014
2. Algorithms, by Dasgupta, Papadimitrou and Vazirani, McGraw-Hill Education, 2006.
3. Computer Algorithms, by Horowitz, Sahni, and Rajasekaran, Silicon Press, 2007.

U18AII3203	OPERATING SYSTEM	L	T	P	J	C
		2	0	2	0	3

Course Objective

- •To learn the mechanisms of OS to handle processes and threads and their Communication
- •To learn the mechanisms involved in memory management in contemporary OS
- •To gain knowledge on distributed operating system concepts that includes architecture, Mutual exclusion algorithms, deadlock detection algorithms and agreement protocols
- •To know concept and working principle of open-source OS

Course Outcomes:

After successful completion of this course, the students should be able to

CO 1:	Apply the concepts of CPU scheduling and Process synchronization
CO 2:	Experiment creation of different virtual machines in a hypervisor
CO 3:	Simulate the principles of memory management
CO 4:	Examine the features of various open source operating systems

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. Pre/Post - Experiment Test/Viva; Experimental Report for each Experiment (lab Component)
5. Model Examination (lab component)
6. End Semester Examination (Theory and lab components)

b)Indirect

1. Course-end survey

Pre-requisite courses:Nil

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											M
CO2	S	S			M			S			S	S
CO3	S	S		S	M	S					S	S
CO4	S	S		S		S					S	S

Topics covered:

INTRODUCTION AND PROCESS CONCEPT	7 Hours

Operating System Structure - Operating System Operations - Process Management - Memory Management - Storage Management - Protection and Security - System Structures: Operating System Services - User and Operating System Interface - System Calls - Types of System Calls - Process Scheduling - Operations on Processes - Inter-process Communication.

MULTITHREADED PROGRAMMING AND PROCESS SCHEDULING	8 Hours

Overview of threads - Multicore programming - Multithreading Models - Threading Issues - Basic Concepts of process scheduling - Scheduling Criteria - Scheduling Algorithms - Multiple Processor Scheduling - Synchronization - The Critical-Section Problem - Peterson's Solution Synchronization Hardware - Semaphores - Classic problems of Synchronization - Monitors

DEADLOCK AND MEMORY MANAGEMENT STRATEGIES	7 Hours

System Model - Deadlock Characterization - Methods for Handling Deadlock - Deadlock Prevention - Deadlock Avoidance - Deadlock Detection - Recovery from Deadlock. Swapping - Contiguous Memory Allocation - Paging - Structure of the Page Table- Segmentation.

OPEN SOURCE SOFTWARE SYSTEMS	8 Hours

Basic UNIX Commands - File Filters: File Related Commands - Piping -Joining - awk and backup Commands - Processes in Linux: User Process and Terminal Handling. Users and Account Management: Configuration - Creating - Testing - Removing - Allocating - System Logging: Logging – Accounting. Compiling and Debugging: Compiling C and C++ Programs under Linux - GNU Debugger: Debugger using GDB - Make: Syntax of makefiles - Automake and Autoconf.

Theory : 30 Hrs	Tutorial : 0	Total Hours: 30 Hrs

Lab component Contents:

List of Experiments:

1. Develop programs for process creation and communication.
2. To Creation of process and child process
3. Demonstration of inter-process communication Creation of Zombie and Orphan process Creation of threads
4. Demonstration of shared memory concept
5. Simulation of the CPU scheduling algorithms
6. Demonstration of Semaphores
7. Implementation of Producer-Consumer problem
8. Simulation of Bankers algorithm for deadlock avoidance
9. Creation of virtual machine in a hypervisor

Practical : 30 Hrs	Tutorial : 0	Total Hours: 30 Hrs

Textbooks:

1. William Stallings, “Operating Systems – Internals and Design Principles”, 7th Edition, Prentice Hall, 2011.
2. Andrew S. Tanenbaum, “Modern Operating Systems”, Second Edition, Addison Wesley, 2001.

Reference Books:

1. Charles Crowley, “Operating Systems: A Design-Oriented Approach”, Tata Mc Graw Hill Education”, 1996.
2. D M Dhamdhere, “Operating Systems: A Concept-Based Approach”, Second Edition, Tata Mc Graw-Hill Education, 2007.

U18AII3204	APPLIED MACHINE LEARNING	L	T	P	J	C
		3	0	2	0	4

Course Objectives:

· To train in terms of Machine Learning Problems and its forms

· To make students understand statistical analysis for classification

· To explain different fuzzy inference systems

· To teach various advanced techniques in business intelligent systems

Course Outcomes:

After successful completion of this course, the students should able to

CO 1:	Understand different methodologies to create application using statistical models
CO 2:	Design the test procedures to assess the efficacy of the developed model.
CO 3:	Identify and apply appropriate machine learning models for analyzing the data for a variety of problems.
CO 4:	Implement different algorithms for business intelligence

Pre-requisite courses: U18AII2205

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S				M		M					M
CO2	S	S		M				S			S	S
CO3	S	S	S	M	S			S		M	S	S
CO4	S	S	S		S						S	S

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. Pre/Post - Experiment Test/Viva; Experimental Report for each Experiment (lab Component)
5. Model Examination (lab component)
6. End Semester Examination (Theory and lab components)

b)Indirect

1. Course-end survey

Topics covered:

INTRODUCTION	**8 Hours**

Real-world use cases of Machine Learning. Introduction to SciKit-Learn. Machine learning LifeCycle and implement a multi-variable regression problem with the scikit-learn library

LINEAR REGRESSION AND LOGISTIC REGRESSION	**18 Hours**

Understanding cost function and gradient descent. Overfitting and Underfitting K-Nearest Neighbours Classification and Regression Linear Regression: Least Squares, Ridge, Lasso and Polynominal Regression Logistic Regression: SVM and Hyperparameter tuning and Implementing SVM using scikit-learn

MODEL EVALUATION	**7 Hours**

How and why should we evaluate models? Model Evaluation and Selection methods, Precision-Recall and ROC Curves Confusion Matrices, Regression Evaluation, Optimizing Classifiers for Different Evaluation Metrics

NAIVE BAYES, DECISION TREES AND RANDOM FOREST	**12 Hours**

Naive Bayes Classifiers, Decision Tree, Training and Visualizing a Decision Tree, Entropy and The CART Training Algorithm, Random Forests, Implement Random forest with a real-world use case and understand the basics of random forest, Boosting - AdaBoost and Gradient Boosting, Capstone Project

Theory: 45 Hrs	**Tutorial : 0**	**Total Hours: 45 Hrs**

Lab component Contents:

List of Experiments:

1. Implementing multi variable regression problem
2. Evaluating cost function and gradient descent
3. Implementing K NN
4. Implementing SVM
5. Evaluating Precision, Recall
6. Implementing Decision Tree
7. Implementing Random forest
8. Implementing Adaboost
9. Implementing Gradient boosting

Practical : 30 Hrs	**Tutorial : 0**	**Total Hours: 30 Hrs**

Textbooks:

1. 1.Aurélien Géron "Hands-On Machine Learning with Scikit-Learn and TensorFlow" Publisher(s): O'Reilly Media, Inc 2017.

Reference Books:

1. M.Gopal, “Applied Machine Learning”, McGraw Hill Education (15 May 2018).
2. David Forsyth “Applied Machine Learning” Springer; 1st edition (12 July 2019).
3. Mohd. Shafi Pathan, Nilanjan Dey, Parikshit N. Mahalle, Sanjeev Wagh, "Applied Machine Learning for Smart Data Analysis", CRC Press, 2019.

U18AII3205	DATA COLLECTION AND DATA MANAGEMENT	L	T	P	J	C
		2	0	2	0	3

Course Objectives:

- To learn and practice data modelling using the entity relationship and developing database designs.
- To understand the concept of non structured data handling in data science
- To introduce the tools required to manage and analyze big data like Hadoop, NoSql MapReduce
- To enable students to have skills that will help them to solve complex real-world problems in for decision support

Course Outcomes:

After successful completion of this course, the students should be able to

CO 1:	Explain basic database concepts, applications, data models, schemas and instances
CO 2:	Understand the concept of handling unstructured data
CO 3:	Explain the various data collection methodologies such as map ,filter and List comprehension
CO 4:	Apply mapreduce in real world applications

Pre-requisite courses:

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											M
CO2	S	S			M			S			S	S
CO3	S	S		S	M	S						
CO4	S	S		S		S			M			S

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. Pre/Post - Experiment Test/Viva; Experimental Report for each Experiment (lab Component)
5. Model Examination (lab component)
6. End Semester Examination (Theory and lab components)

b)Indirect

1. Course-end survey

Topics covered:

INTRODUCTION TO DATABASE AND RELATIONAL DATABASE	9 Hours

Introduction - Purpose of database systems - Views of data - Database Development Life cycle - Architecture of DBMS - Key Principles of RDBMS- Database Design and Relational Database- ETL Concepts - ER Model - Constraints - ER-Diagrams - Design Issues - Weak Entity Sets - UML - Converting ER Model to Relational Database Design - Normalization - NF - 2NF - 3NF - multivalued dependency and 4 NF

UNSTRUCTURED DATA HANDLING	7 Hours

Introduction to unstructured data - XML and JSON - NoSQL databases - MongoDB - Web crawling and web APIs - Regular expressions- Information retrieval - Scoring - weighting - vector space

DATA COLLECTION AND PROCESSING	7 Hours

Map - Filter - List manipulations - List Comprehensions - Nested Data and Nested Iterations- Structuring Nested Data - Shallow Copies - Deep Copies - Extracting from Nested Data - Example of Nested Iteration

INTRODUCTION TO MAPREDUCE	7 Hours

Cloud computing and data centers - Hadoop API - Mapreduce programming model- Algorithms Using MapReduce - Extensions to MapReduce - The Communication Cost Model - Complexity Theory for MapReduce

Theory: 30 Hrs	Tutorial : 0	Total Hours: 30 Hrs

Lab component Contents:

List of Experiments:

1. Processing CSV Data using python(Kaggle data)
2. Processing JSON Data using python
3. Processing XLS Data using python
4. Implementation of MongoClient using python
5. Implementation of Map & Filter
6. Implementation of List Comprehension
7. File Management tasks in Hadoop
8. Analyse time-temperature statistics and generate report with max/min temperature in Hadoop

Practical : 30 Hrs	Tutorial : 0	Total Hours: 30 Hrs

Textbooks:

1. Abraham Silberschatz, Henry F. Korth and S. Sudarshan, Database System Concepts , McGraw -Hill, 2015
2. C.J.Date, A.Kannan and S.Swamynathan, “An Introduction to Database Systems”, Eighth Edition, Pearson Education, 2006.

Reference Books:

1. Atul Kahate, “Introduction to Database Management Systems”, Pearson Education, New Delhi, 2006.
2. Alexis Leon and Mathews Leon, “Database Management Systems”, Vikas Publishing House Private Limited, New Delhi,
3. Raghu Ramakrishnan, “Database Management Systems”, Fourth Edition, Tata McGraw Hill, 2010.
4. G.K.Gupta,”Database Management Systems”, Tata McGraw Hill, 2011.
5. Rob Cornell, “Database Systems Design and Implementation”, Cengage Learning, 2011.

U18AIC3006	TOOLS AND TECHNOLOGIES FOR WELLNESS	L	T	P	J	C
		1	0	0	0	1

Course Objectives:

- To understand the concept of ayurveda
- To explain how Asana, Pranayama, Ayurvedic knowledge and Mindfulness for well-being is useful in day to day life

Course Outcomes:	
After successful completion of this course, the students should be able to	
CO 1:	Understand the various tools like Asana, Pranayama, Ayurvedic knowledge and Mindfulness for well-being
CO 2:	Develop a practical understanding of the various tools

Pre-requisite courses: Nil

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1							M	M	M			
CO2							M	M	M			

Course Assessment methods:

a) Direct

1. Continuous Assessment Test
2. Quiz

b)Indirect

1. Course-end survey

Topics covered:

FOUNDATIONS OF WELLNESS	3 Hours

What is wellness- Looking at wellness from various viewpoints of Body - Emotions and Cognition and across cultures- Introduction to tools: Yogic practices - Mindfulness and other contemplative practices

PHYSICAL DIMENSION	3 Hours

Understanding the various aspects of the physical body - problems and issues and tools for physical well-being

EMOTIONAL DIMENSION	3 Hours

Understanding emotions - stress - mental health - Tools for emotional well-being

ENERGY AND COGNITIVE DIMENSION	3 Hours

Understanding Cognitive executive functions, cognitive biases and challenges and tools for enhanced cognitive capabilities

TRANSCENDENTAL DIMENSION	3 Hours

Understanding the science of happiness and transcending the limitations of the physical, emotional and cognitive dimensions.

Theory: 15 Hrs	Tutorial: 0	Total Hours: 15 Hrs

Text Books:

1. Certification of yoga professionals official guidebook- First edition, Excel books Pvt Ltd., 2016
2. Harvard Medical School Guide to Yoga, Marlynn Wei, James E. Groves

Crafted By : Smrithi Rekha Adinarayanan, MS (State University of New York), co-founder of Anaadi Foundation, Palani

U18AIT3008	PRINCIPLES OF ECONOMICS	L	T	P	J	C
		2	0	0	0	2

Course Objectives:

- To familiarize the students with the basic concept of microeconomics
- To make student understand the demand and supply analysis in business applications
- To familiarise students with the production and cost structure under different stages of production
- To understand the pricing and output decisions under various market structure
- To help students understand and apply the various decision tools to understand the market structure

Course Outcomes:

After successful completion of this course, the students should be able to

CO 1:	Understand the conceptual foundations and analytical methods used in micro economics
CO 2:	Explain the basics of consumer behavior, behavior of firms and market equilibrium
CO 3:	Understand the market structures of perfect competition, oligopoly and monopolies

Pre-requisite courses: Nil

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1							M	M	M			
CO2							M	M	M			
CO3							M	M	M			

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. End Semester Examination (Theory)

b)Indirect

1. Course-end survey

Topics covered:

INTRODUCTION OF ECONOMICS	**4 hours**
Scope - Relationship with other Disciplines	
MICROECONOMICS	**7 hours**
Firms and Managerial Objectives - Demand - Law of Demand - Determinants of demand - Elasticity of demand - Law of diminishing marginal utility - Exceptions of Demand - Demand forecasting techniques (only theory) - Supply - Law of Supply - Elasticity of Supply	
PRODUCTION FUNCTIONS	**6 hours**
Short and long run laws of production - law of returns 6 to scale - Cost - types of cost - Short and long run cost output relationship - Economies and diseconomies of Scale	
MARKET STRUCTURE	**6 hours**
Perfect Competition- monopoly- duopoly - oligopoly - 6 Monopolistic market structures - characteristics & Price - Output determination- Pricing Methods	
MACROECONOMICS	**7 hours**
Nature & importance. National Income - concepts - GNP - GDP - NNP - Business cycle - Phases of Business Cycle - Controlling Trade Cycle - Inflation - Indian Financial System - Fiscal Policy - Monetary Policy	

Theory: 30 Hrs	**Tutorial: 0**	**Total Hours: 30 Hrs**

Textbooks:

1. Piyali Ghosh Geetika, Purba Roy Chowdhury (2017),Managerial Economics, 3 e, McGraw- Hill Education D N Diwedi (2009). Managerial Economics. Seventh Edition, Vikas Publication

Reference Books:

1. D. N. Gujarati and D.C. Porter, Essentials of Econometrics, McGraw Hill, 4th edition, International Edition, 2009.
2. Christopher Dougherty, Introduction to Econometrics, Oxford University Press, 3rd edition, Indian edition, 2007.
3. Jan Kmenta, Elements of Econometrics, Indian Reprint, Khosla Publishing House,2nd edition, 2008.

Semester 4

U18MAT4105	RANDOM PROCESS AND OPTIMIZATION	L	T	P	J	C
		3	1	0	0	4

Course Objectives:

- To make students understand Discrete and Continuous Random
- variables, Random Processes and their applications in data science
- To Understand about the correlation Functions
- To understand the functional relationship between random inputs and outputs with the use of Random Process Techniques

Course Outcomes:

After successful completion of this course, the students should be able to

CO 1:	Analyze various random processes with practical applications
CO 2:	Analyze correlation related to various random processes and establish the properties of spectral densities
CO 3:	Analyze and apply appropriate queuing models in domain specific situations
CO 4:	Apply linear programming models to domain specific situations.
CO 5:	Determine the extreme values of functions without constraint and with equality constraints

Pre-requisite courses:Nil

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	M										
CO2	S	S										S
CO3	M	M										M
CO4	S	M										
CO5	M	M										

Topics covered:

RANDOM PROCESSES	9+3 Hours

Random Process – Stationary Process – Wide sense stationary and Ergodic processes– Gaussian Random Process – Markov process–Markov chain–Poisson process

CORRELATION AND SPECTRAL DENSITIES	9+3 Hours

Auto correlation - Cross correlation - Properties – Power spectral density – Cross spectral density - Properties – Wiener-Khinchine relation – Relationship between cross power spectrum and cross correlation function

QUEUEING MODELS	**9+3 Hours**

Markovian Queues – Single and Multi-server Models – Little's formula – Machine Interference Model – Self Service Queue.

LINEAR PROGRAMMING	**9+3 Hours**

The phases of OR study – formation of an L.P model – graphical solution – simplex algorithm – artificial variables technique -Big M method

CLASSICAL OPTIMIZATION THEORY	**9+3 Hours**

Unconstrained extremal problems – Equality constraints – Lagrange's method – Inequality constraints - Kuhn -Tucker conditions – Quadratic programming – Simple problems.

Theory: 45 Hrs	**Tutorials: 15 Hrs**	**Total Hours: 60 Hrs**

Text Book:

1. Taha H.A., "Operations Research: An Introduction", 10th Edition, Pearson Education, 2017.
2. Peebles. P.Z., "Probability, Random Variables and Random Signal Principles", Tata McGraw Hill, 4th Edition, New Delhi, 2002.

Reference Books:

1. Cooper. G.R., Mc Gillem. C.D., "Probabilistic Methods of Signal and System Analysis", 3 rd Indian Edition, Oxford University Press, New Delhi, 2012.
2. Miller S.L. and Childers D.G., "Probability and Random Processes with Applications to Signal Processing and Communications", 2nd Edition, Academic Press, 2012.
3. Stark H, and Woods J.W., "Probability and Random Processes with Applications to Signal Processing", 3rd Edition, Pearson Education, Asia, 2002.
4. Wagner H.M., "Operations Research", Prentice Hall of India, 2011.
5. Bhaskar S., "Operations Research", Anuradha Agencies, 2 nd Edition, 2014.

U18AII4201	COMPUTER NETWORKS	L	T	P	J	C
		2	0	2	0	3

Course Objectives:

- To study the basic taxonomy and terminology of the computer networking and enumerate the layers of OSI model and TCP/IP model.
- To acquire knowledge of Application layer and Presentation layer paradigms and protocols
- To study Session layer design issues, Transport layer services, and protocols
- To gain core knowledge of Network layer routing protocols and IP addressing.
- To study data link layer concepts, design issues, and protocols
- To study the fundamentals and basics of Physical layer, and will apply them in real time applications.

Course Outcomes:

After successful completion of this course, the students should be able to

CO 1:	Understand the functionality and protocols operating in each layer of OSI reference model
CO 2:	Design error control, flow control and routing protocols
CO 3:	Construct network traffic characteristics and congestion control mechanism
CO 4:	Apply terror control, flow control and routing protocols

Pre-requisite courses:Nil

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											M
CO2	S	S			M			S		S		S
CO3	S	S		S	M	S				S		
CO4	S			S		S						S

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. Pre/Post - Experiment Test/Viva; Experimental Report for each Experiment (lab Component)
5. Model Examination (lab component)
6. End Semester Examination (Theory and lab components)

b)Indirect

1. Course-end survey

Topics covered:

DATA COMMUNICATIONS AND DATA LINK LAYER	8 Hours

Data Communication – The OSI Model – TCP/IP Protocol Suite – Addressing – Transmission Media – Networking devices – Network Topologies. Encoding - Error Detection – Reliable Transmission – MAC protocols – CSMA/CD – CSMA/CA

NETWORK LAYER	8 Hours

Circuit Switching – Packet Switching – Bridges and LAN Switches: Spanning Tree algorithm – Internetworking – IPv4 - Subnetting – IPv6 – Routing Techniques: Distance vector (RIP) – Link state (OSPF) — Interdomain Routing (BGP).

TRANSPORT LAYER	8 Hours

UDP – TCP – Congestion Control and Resource Allocation: TCP Congestion Control – Congestion Avoidance Mechanisms – Quality of Service: Integrated Services – Differentiated Services – Network Traffic Analysis Bidirectional Protocols: Piggybacking - User Datagram Protocol - Transmission Control Protocol - Congestion Control

APPLICATION LAYER	6 Hours

Domain Name System – Electronic Mail (SMTP, MIME, IMAP) – File Transfer (FTP) – WWW (HTTP) -TLS/SSL -IP Security

Theory: 30 Hrs	Tutorial : 0	Total Hours: 30 Hrs

Lab component Contents:

List of Experiments:

1. Develop client server based TCP applications using UNIX socket programming functions.
2. Develop client server based UDP applications using UNIX socket programming functions.
3. Simulation of data link and network layer protocols.
4. Performance analysis of TCP and UDP protocol using simulation tool.
5. Performance analysis of routing protocols using simulation tool.
6. Demonstrate the working of network tools such as Ping, TCPDump, Traceroute, Netstat, IPconfig.
7. Analyze the network traffic using Wireshark tool/Packet tracer tool.

Practical : 30 Hrs	Tutorial : 0	Total Hours: 30 Hrs

Textbooks:

1. Larry L. Peterson, Bruce S. Davie, “Computer Networks: A Systems Approach”, Fifth edition, Morgan Kaufmann Publishers Inc., 2011.
2. William Stallings, “Data and Computer Communications”, Tenth edition, Pearson Education, 2013.

Reference Books:

1. Behrouz A Forouzan, “Data Communications and Networking”, Fifth edition, Tata McGraw–Hill, New Delhi, 2013.
2. James F. Kurose, Keith W. Ross, “Computer Networking, A Top–Down Approach Featuring the Internet”, Sixth edition, Pearson Education, 2012.

U18AII4202	Neural Networks and Deep Learning	L	T	P	J	C
		3	0	2	0	4

Course Objectives:

· To teach paradigms and approaches representations and classifications

· To make students understand architectural designs and propagation algorithms

· To explain different belief networks and convolution neural networks

· To teach various advanced techniques in Recurrent Neural Networks, BPTT, Natural language Processing, Regression and deep networks

Course Outcomes:

After successful completion of this course, the students should able to

CO 1:	Understand different methodologies to create application using deep nets
CO 2:	Design the test procedures to assess the efficacy of the developed model.
CO 3:	Identify and apply appropriate deep learning models for analyzing the data for a variety of problems.
CO 4:	Implement different deep learning algorithms

Pre-requisite courses:U18AII2205

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S								M			M
CO2	S	S		M							S	S
CO3	S	S	S	M	S		M		M		S	S
CO4	S	S	S		S						S	S

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. Pre/Post - Experiment Test/Viva; Experimental Report for each Experiment (lab Component)
5. Model Examination (lab component)
6. End Semester Examination (Theory and lab components)

b)Indirect

1. Course-end survey

Topics covered:

CONVOLUTIONAL NEURAL NETWORKS	10 Hours

Architectural Overview, Motivation, Layers, Filters, Parameter sharing, Regularization, Popular CNN Architectures: ResNet, AlexNet – Applications

RECURRENT AND RECURSIVE NETS	12 Hours

Recurrent Neural Networks, Bidirectional RNNs, Encoder-decoder sequence to sequence architectures - BPTT for training RNN, Long Short Term Memory Networks, Computer Vision - Speech Recognition - Natural language Processing, Case studies in classification, Regression and deep networks.

DEEP LEARNING ARCHITECTURES	12 Hours

Machine Learning and Deep Learning, Representation Learning, Width and Depth of Neural Networks, Learning Algorithms: Capacity - Overfitting - Underfitting - Bayesian Classification - Activation Functions: RELU, LRELU, ERELU, Unsupervised Training of Neural Networks, Restricted and Deep Boltzmann Machines , Auto Encoders

ADVANCED NEURAL NETWORKS	11 Hours

Deep Feedforward Networks : Gradient based learning - Hidden Units - Architectural design – Back Propagation algorithms - Regularization for deep learning: Dataset Augmentation - Noise Robustes –Semi supervised learning -Multitask learning - Deep Belief networks -Generative Adversial Networks by Keras MXnet

Theory : 45 Hrs	Tutorial: 0	Total Hours: 45 Hrs

Lab component Contents:

List of Experiments:

1. Develop programs for data representation.
2. Estimating depth and width of Neural Networks
3. Training of Unsupervised Neural Networks
4. Implementing Gradient based learning
5. Implementing Backpropagation algorithms
6. Implementing Deep Belief networks
7. Visualize data by Computer Vision
8. Implementing RNN

Practical : 45 Hrs	Tutorial : 0	Total Hours: 30 Hrs

Text Books:

1. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, “Deep Learning”, First Edition, MIT Press, 2016.
2. Nikhil Buduma and Nicholas Lacascio, “Fundamentals of Deep Learning”, First Edition, O.Reilly, 2017

Reference Books:

1. Josh Patterson, Adam Gibson "Deep Learning: A Practitioner's Approach", O'Reilly Media, 2017
2. Laura Graesser, Wah Loon Keng "Foundations of Deep Reinforcement Learning: Theory and Practice in Python" Addison-Wesley Professional -2020
3. Jon Krohn, Grant Beyleveld, Aglaé Bassens "Deep Learning Illustrated: A Visual, Interactive Guide to Artificial Intelligence", 1st edition Addison-Wesley Professional 2019

U18AII4203	DATA MINING AND MODELING	L	T	P	J	C
		2	0	2	0	3

Course Objectives:

· To train the basic concepts and techniques of Data Mining.

· To introduce mathematical statistics foundations of the Data Mining Algorithms.

· To include a wide range of clustering, estimation, prediction, and classification algorithms.

· To experiment basic principles, concepts and applications of cluster analysis

Course Outcomes:	
After successful completion of this course, the students should be able to	
CO 1:	Understand about data mining basics,issues and the working principle of classification technique.
CO 2:	Explain the basic concepts of Association Rule Mining and evaluate the working of various Association Rule Mining algorithms
CO 3:	Implement classification and prediction techniques
CO 4:	Analyze the working of different clustering algorithms

Pre-requisite courses:U18MAI2203

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	**Programme Outcomes (POs)**											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											M
CO2	S	S			M			S			S	S
CO3	S	S		S	M	S					S	S
CO4	S	S		S		S					S	S

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. Pre/Post - Experiment Test/Viva; Experimental Report for each Experiment (lab Component)
5. Model Examination (lab component)
6. End Semester Examination (Theory and lab components)

b)Indirect

1. Course-end survey

Topics covered:

INTRODUCTION TO DATA MINING	7 Hours

Data Mining Goals Stages of the Data Mining Process - Data Mining Techniques - Knowledge Representation Methods Applications Data preprocessing: Data cleaning - Data transformation - Data reduction - Discretization and generating concept hierarchies - Real time data processing in Kaggle - OLAP - OLTP.

MINING FREQUENT PATTERNS, ASSOCIATION AND CORRELATIONS	8 Hours

Mining Frequent Patterns - Associations and Correlations - Mining Methods - Mining various Kinds of Association Rules - Correlation Analysis - Constraint Based Association Mining

CLASSIFICATION	7 Hours

Classification and Prediction - Basic Concepts - Decision Tree Induction - Bayesian Classification - Rule Based Classification - Classification by Backpropagation - Associative Classification - Lazy Learners - Other Classification Methods - Prediction CaseStudies: Implementation in Rapidminer, Weka

CLUSTER ANALYSIS	8 Hours

Cluster Analysis - Types of Data - Categorization of Major Clustering Methods - K-means - Partitioning Metho Hierarchical Methods - Density-Based Methods - Grid Based Methods - Model-Based Clustering Methods - Cluste High Dimensional Data - Constraint - Based Cluster Analysis - Outlier Analysis and Data Mining Applications.

Theory : 30 Hrs	Tutorial : 0	Total Hours: 30 Hrs

Lab component Contents:

List of Experiments:

1. Demonstration of preprocessing on different dataset
2. Demonstration of preprocessing on different dataset
3. Demonstration of Association rule process using apriori algorithm
4. Demonstration of classification rule process using decision tree algorithm
5. Demonstration of classification rule process using naïve bayes algorithm
6. Demonstrate performing Regression on data sets
7. Demonstration of clustering rule process using simple k-means

Practical : 30 Hrs	Tutorial : 0	Total Hours: 30 Hrs

Text Books:

1. Pang-Ning Tan, Michael Steinbach, Vipin Kumar: Introduction to Data Mining, Pearson, I impression,2014
2. Jiawei Han, Micheline Kamber, Jian Pei: Data Mining -Concepts and Techniques, 3rd Edition, Mor Kaufmann Publisher, 2012

Reference Books:

1. Sam Anahory, Dennis Murray: Data Warehousing in the Real World, Pearson, Tenth Impression, 2012.
2. Michael.J.Berry, Gordon.S.Linoff: Mastering Data Mining, Wiley Edition, second edtion, 2012.
3. Hand, Mannila, and Smyth,Principles of Data Mining, MIT Press, 2001.
4. Hastie,Tibshirani, and Friedman, Springer,The Elements of Statistical Learning- Data Mining, Infere and Prediction, 2001.
5. Chakrabarti, Morgan Kaufmann, Mining the Web - Discovering Knowledge from Hypertext Data, 2003
6. I. H. Witten and E. Frank, Data Mining: Practical Machine Learning Tools and Techniques with J Implementations,2005.

U18AIT4006	FINANCE FOR ENGINEERS	L	T	P	J	C
		3	0	0	0	3

Course Objectives:

- To acquire knowledge of economics to facilitate the process of economic decision making
- To acquire knowledge on basic financial management aspects
- To develop the skills to analyze financial statements

Course Outcomes:

After successful completion of this course, the students should be able to

CO 1:	Understand key accounting concepts, terms, and principles.
CO 2:	Learn complex accounting transactions and how they relate to accounting principles.
CO 3:	Implement software development budgeting

Pre-requisite courses: Nil

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1							M	M	M			
CO2							M	M	M			
CO3							M	M	M			

Topics covered:

BASICS OF ACCOUNTING	9 hours

Introduction to basic accounting concepts. Accounting terminologies, Accounting fundamentals, debits & credits Accounts payable & Receivables, Accounting cycle,Inventory accounting & Cost accounting

FINANCIAL REPORTS	9 hours

Overview of financial reporting. Types of financial reports. The balance sheet equation - Assets, Liabilities, and Stockholders' Equity. Bookkeeping and managing transactions into book entry.

CLASSIFICATION	8 hours

Classification of cash flows into operating, investing, and financing activities. Preparing and

analyzing the Statement of Cash Flows. Earnings, Cash from Operations, EBITDA,and Free Cash Flow.

ACCOUNTING VERTICALS	**9 hours**

Links between accounting, measurement, and financial statements.Key business ratios that can be calculated using your Income Statement and Balance Sheet. Interpret two key financial statements (Income Statement and Balance Sheet) that drive business decisions.

AGILE S/W DEVELOPMENT BUDGETING	**10 hours**

Types of budget estimate, Requirements definition and analysis, Recommended technological stack, Functional and nonfunctional requirements, Project plan, Cost estimation, dos and don'ts of software development budgeting

Theory : 45 Hrs	**Tutorial : 0**	**Total Hours: 45 Hrs**

Textbooks:

1. “An Easy Introduction to Financial Accounting: A Self-study Guide” by V.G. Narayanan

Reference Books:

1. Christopher Dougherty, Introduction to Econometrics, Oxford University Press, 3rd edition, Indian edition, 2007.
2. Jan Kmenta, Elements of Econometrics, Indian Reprint, Khosla Publishing House,2nd edition, 2008.

SEMESTER 5

U18AII5201	CLOUD ARCHITECTURE	L	T	P	J	C
		3	0	2	0	4

Course Objectives:

- To make students understand the concept of cloud computing.
- To have knowledge on the various issues in cloud computing
- To understand the functional relationship between cloud computing and stakeholders
- To appreciate the emergence of cloud as the next generation computing paradigm.

Course Outcomes:

After successful completion of this course, the students should able to

CO1:	Analyze the main concepts, key technologies, strengths and limitations of cloud
CO2:	Analyze and understand various queuing models
CO3:	To understand and use the architecture of compute and storage cloud, service and delivery models.
CO4:	Apply the core issues of cloud computing such as resource management and security.

Pre-requisite courses: Nil

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcome (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M			M								
CO2	S			S		S						S
CO3	M	S		M								M
CO4	S			M							M	

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation,Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. End Semester Examination (Theory component)

b) Indirect

1. Course-end survey

Topics covered:

INTRODUCTION	**10 Hrs**

Introduction to Cloud Computing – Definition of Cloud – Evolution of Cloud Computing – Underlying Principles of Parallel and Distributed Computing – Cloud Characteristics – Elasticity in Cloud – On-demand Provisioning.

CLOUD ENABLING TECHNOLOGIES	**10 Hrs**

Service Oriented Architecture – REST and Systems of Systems – Web Services – Publish- Subscribe Model – Basics of Virtualization – Types of Virtualization – Implementation Levels of Virtualization – Virtualization Structures – Tools and Mechanisms – Virtualization of CPU – Memory – I/O Devices –Virtualization Support and Disaster Recovery.

QUEUEING MODELS	**12 Hrs**

Layered Cloud Architecture Design – NIST Cloud Computing Reference Architecture – Public, Private and Hybrid Clouds - laaS – PaaS – SaaS – Architectural Design Challenges – Cloud Storage – Storage-as-a-Service – Advantages of Cloud Storage – Cloud Storage Providers – S3.

CLOUD ARCHITECTURE, SERVICES AND STORAGE	**13 Hrs**

Inter Cloud Resource Management – Resource Provisioning and Resource Provisioning Methods – Global Exchange of Cloud Resources – Security Overview – Cloud Security Challenges – Software-as-a-Service Security – Security Governance – Virtual Machine Security – IAM – Security Standards. Hadoop – MapReduce – Virtual Box - Google App Engine – Programming Environment for Google App Engine — Open Stack- Federation Services

Theory: 45 Hrs	**Tutorial: 0**	**Total Hours: 45 Hrs**

Lab Experiments:

1. Install Virtualbox/VMware Workstation with different flavours of linux or windows OS on top of windows7 or 8.
2. Install a C compiler in the virtual machine created using virtual box and execute Simple Programs
3. Install Google App Engine. Create hello world app and other simple web applications using python/java.
4. Use GAE launcher to launch the web applications.
5. Simulate a cloud scenario using CloudSim and run a scheduling algorithm that is not present in CloudSim.
6. Find a procedure to transfer the files from one virtual machine to another virtual machine.
7. Find a procedure to launch virtual machine using trystack (Online Openstack Demo Version)
   Install Hadoop single node cluster and run simple applications like wordcount

Practical: 30 Hrs	**Tutorial: 0**	**Total Hours: 30 Hrs**

Text Books:

1. Kai Hwang, Geoffrey C. Fox, Jack G. Dongarra, "Distributed and Cloud Computing, From Parallel Processing to the Internet of Things", Morgan Kaufmann Publishers, 2012.
2. Rittinghouse, John W., and James F. Ransome, ―Cloud Computing: Implementation, Management and Security‖, CRC Press, 2017

Reference Books:

1. Rajkumar Buyya, Christian Vecchiola, S. ThamaraiSelvi, ―Mastering Cloud Computing‖, Tata Mcgraw Hill, 2013.
2. Toby Velte, Anthony Velte, Robert Elsenpeter, "Cloud Computing - A Practical Approach‖, Tata Mcgraw Hill, 2009.
3. George Reese, "Cloud Application Architectures: Building Applications and Infrastructure in the Cloud: Transactional Systems for EC2 and Beyond (Theory in Practice), O'Reilly, 2009.

U18AII5202	EXPLORATORY DATA ANALYSIS AND VISUALIZATION	L	T	P	J	C
		3	0	2	0	4

Course Objectives:

- To teach paradigms and approaches used to analyze data
- To make students understand how the analysis is applied
- To explain different visualization techniques
- To implement and experiment various analytic models for visualization

Course Outcomes:

After successful completion of this course, the students should able to

CO1:	Understand the main principles of visual perception
CO2:	Design core skills for visual analysis
CO3:	Identify and apply visualization techniques for various data analysis tasks
CO4:	Apply and implement the visualization concepts in various streams

Pre-requisite courses: U18MAI2203 – Probability and Statistics

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcome (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S			M						M		
CO2	S			S		S						S
CO3	M	S	M				S		M			M
CO4	S			M							M	

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation,Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. End Semester Examination (Theory component)

b) Indirect

1. Course-end survey

Topics covered:

ANALYSIS TECHNIQUES	**10 Hrs**

Elements, Variables, and Data categorization- Levels of Measurement- Data management and indexing- Introduction to statistical learning and R-Programming- Measures of central tendency- Measures of location of dispersions- Practice and analysis with R- Basic Analysis Techniques

SKILLS FOR VISUAL ANALYSIS	**13 Hrs**

Information visualization – effective data analysis – traits of meaningful data – visual perception – making abstract data visible – building blocks of information visualization – analytical interaction – analytical navigation – optimal quantitative scales – reference lines and regions – trellises and crosstabs – multiple concurrent views – focus and context – details on demand – over-plotting reduction – analytical patterns – pattern examples.

TIME-SERIES, RANKING, AND DEVIATION ANALYSIS	**10 Hrs**

Time-series analysis – time-series patterns – time-series displays – time-series best practices – part-to-whole and ranking patterns – part-to-whole and ranking displays – best practices – deviation analysis – deviation analysis displays – deviation analysis best practices

DISTRIBUTION, CORRELATION, AND MULTIVARIATE ANALYSIS	**12 Hrs**

Distribution analysis – describing distributions – distribution patterns – distribution displays –distribution analysis best practices – correlation analysis – describing correlations – correlation patterns – correlation displays – correlation analysis techniques and best practices – multivariate analysis – multivariate patterns – multivariate displays – multivariate analysis techniques and best practices

Theory: 45 Hrs	**Tutorial: 0**	**Total Hours: 45 Hrs**

Lab Experiments:

1. Implementation of data charts
2. Implementation of data visualization techniques
3. Designing multivariate patterns
4. Visual encoding of data
5. Dashboard designing
6. Implementation of multivariate displays
7. Implement over plotting

Practical: 30 Hrs	**Tutorial: 0**	**Total Hours: 30 Hrs**

Text Books:

1. Stephen Few, "Now you see it: Simple Visualization techniques for quantitative analysis",Analytics Press, 2019.
2. Stephen Few, "Information dashboard design: The effective visual communication of data",O'Reilly, 2016.
3. Edward R. Tufte, "The visual display of quantitative information", Second Edition, GraphicsPress, 2019

Reference Books:

1. Nathan Yau, "Data Points: Visualization that means something", Wiley, 2013.
2. Ben Fry, "Visualizing data: Exploring and explaining data with the processing environment",O'Reilly, 2008.
3. Gert H. N. Laursen and Jesper Thorlund, "Business Analytics for Managers: Taking business intelligence beyond reporting", Wiley, 2010.
4. Evan Stubbs, "The value of business analytics: Identifying the path to profitability", Wiley, 2019

U18AII5203	REINFORCEMENT LEARNING	L	T	P	J	C
		3	0	2	0	4

Course Objectives:

- To teach basics purpose and concepts of Reinforcement Learning
- To make students understand the nature of the problems and solve it through Reinforcement Learning
- To make students to utilize Reinforcement Learning Algorithms for solving Uncertainty problems
- To teach the techniques to build system of agents applying deep learning architectures

Course Outcomes:

After successful completion of this course, the students should able to

CO1:	Understand the underpinnings to structure classical solutions for Reinforcement Learning problem
CO2:	Apply deep learning architectures to train agents navigating from virtual world from sensory data.
CO3:	Analyze basic Reinforcement Learning algorithms for simple sequential decision making and control problems in uncertain conditions
CO4:	Build system of agents to demonstrate collaboration or cooperation

Pre-requisite courses: U18AII4202 – Neural Networks and Deep Learning

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcome (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S			M								S
CO2	S			M								S
CO3	S	S	M		S							S
CO4	S	S	S	S	S	S						S

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation,Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. End Semester Examination (Theory component)

b) Indirect

1. Course-end survey

Topics covered:

FOUNDATIONS OFREINFORCEMENT LEARNING	**11 Hrs**
Reinforcement Learning - A Preamble - Reinforcement Learning Frameworks: Problems and Solutions -Dynamic Programming - Monte Carlo Methods - Temporal-Difference Methods - Reinforcement Learning in Continuous Space. Case Study: Classic Problem of Gym's Taxi using openAI & V2 Task	
VALUE-BASED METHODS	**10 Hrs**
Build and Train Neural Networks, Convolutional Neural Networks - Bandit Algorithms - Deep Q-Learning – Deep Q-Network - Double Deep Q-Network - Dueling-DQN - Prioritized Replay. Case Study: Leveraging Neural Networks to predict machine failures that learns intelligent behaviors from sensory data.	
POLICY-BASED METHODS	**13 Hrs**
Theory behind Evolutionary Algorithms, Stochastic Policy Search, REINFORCE Algorithms - Improving Policy Gradient Methods - Generalised Advantage Estimation - Policy Optimization methods: Trust Region Policy Optimization (TRPO), Proximal Policy Optimization (PPO) - Actor-Critic Methods: Deep Deterministic Policy Gradient (DDPG) Case Study: Deep Reinforcement Learning for Robotics (Robotic arm/ four legged creaturewalk)	
MULTI-AGENT REINFORCEMENT LEARNING	**11 Hrs**
Hierarchical Reinforcement Learning - Markov Games for Multiplayer Games -Agent training in Collaborative and Competitive Setting Case Study: Intuition behind DeepMind's Alphazero	

Theory: 45 Hrs	**Tutorial: 0**	**Total Hours: 45 Hrs**

Lab Experiments:

1. Implementation of Markov Decision Process
2. Implementation of Temporal Difference Algorithm for estimating values
3. Implementation of Q-Learning
4. Implementation of Model- Based approach (DYNA)
5. Implementation of Policy-Based approach (actor-critic)
6. Capstone Project

Practical: 30 Hrs	**Tutorial: 0**	**Total Hours: 30 Hrs**

Text Books:

1. Richard S Sutton and Andrew G Barto,"Reinforcement Learning- An Introduction", 2nd Edition, MIT Press, 2018.
2. Laura Graesser, "Foundations of Deep Reinforcement Learning: Theory and Practice in Python", Addison Wesley Data &Analytics series, 2020

Reference Books:

1. Csaba Szepesvári, Morgan & Claypool, "Algorithms for Reinforcement Learning", Morgan & Claypool Publishers, 2010
2. Dimitri Bertsikas and John G. Tsitsiklis , "Neuro Dynamic Programming".Athena Scientific. 1996

U18AIT5004	MARKETING FUNDAMENTALS	L	T	P	J	C
		3	0	0	0	3

Course Objectives:

- To familiarize the students with the basic concept of marketing
- To familiarize with the basic techniques of marketing management
- To help students understand and apply the various digital marketing tools.

Course Outcomes:	
After successful completion of this course, the students should able to	
CO1:	Understand the basic concepts, and techniques of marketing management
CO2:	Explain the basics of marketing mix elements
CO3:	Understand and solve marketing problems in the complex and fast changing business environment.

Pre-requisite courses: Nil

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcome (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S		M						M			
CO2		S	M						M			
CO3			M						M			

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation,Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. End Semester Examination (Theory component)

b) Indirect

1. Course-end survey

Topics covered:

INTRODUCTION TO MARKETING	**10 Hrs**
Introduction to Marketing and Marketing Management, Difference between Marketing & Selling, Customer Value, Customer satisfaction & Delight, Value Chain.	
MARKET OPPORTUNITIES	**12 Hrs**
Marketing Plan, Demand Forecasting – Techniques, 7P's of Marketing, MIS, Environmental Scanning, Market Segmenting-Targeting-Positioning, Target Marketing.	
PRODUCT CONCEPTS	**10 Hrs**
Product Decisions - concept of a Product - Product mix decisions – Product Line- Width-Depth, Differentiation Strategies, Integrated Marketing Communication, CRM	
DIGITAL MARKETING	**13 Hrs**
SEO, SEM, Social Media and Content Marketing, Branding, Marketing Analytics	

Theory: 45 Hrs	**Tutorial: 0**	**Total Hours: 45 Hrs**

Text Book:

1. Marketing Management Text and Cases, Tapan K Panda, Excel Books, 2020.

Reference Books:

1. Philip Kotler, marketing management- analysis planning and control, Prentice Hall of India, New Delhi, 2018.
2. Ramaswamy. V S & Namakumari. S, marketing management-planning implementation and control, Macmillan Business Books, New Delhi, 2012.

U18AIC5005	PHILOSOPHY OF WELLNESS	L	T	P	J	C
		1	0	0	0	1

Course Objectives:

- Understand the underlying Philosophy of Wellness
- Look at connections between Modern science and Yogic Sciences

Course Outcomes:

After successful completion of this course, the students should able to

CO1:	Understand the fundamental concepts of physical education, health and fitness
CO2:	Analyze and provide a general understanding on nutrition, first aid and stress management.
CO3:	Understand the awareness regarding hypo-kinetic diseases, and various measures of mental fitness and health assessment.

Pre-requisite courses: Nil

CO/PO Mapping
(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcome (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S			S					M			
CO2		S							M			
CO3						M			M			

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I
2. Open Book Test; Cooperative Learning Report, Assignment;
3. Demonstration etc (as applicable) (Theory component)

b) Indirect

1. Course-end survey
2.

Topics covered:

COGNITION & LEARNING AND YOGIC PSYCHOLOGY - MODERN TOOLS FOR YOGIC RESEARCH	8 Hrs

Introduction to Wellness Management- Dimensions of Wellness-Healthy People- Introduction to Fitness Management Muscular Fitness for Body and Mind- Getting the Jump on Nutrition-Maintaining a Healthy Emotional

UNDERLYING PHILOSOPHICAL CONTEXT & ANALYSING YOGIC DATA	7 Hrs

Aging and Longivity- Live in the Present - Think About Tomorrow- Personal Motivation- Goal Setting- happiness- Analysis of yogic data.

Theory: 15 Hrs	Tutorial: 0	Total Hours: 15 Hrs

Text Book:

1. Cognitive Psychology: theory, process and methodology, Dawn McBride and Cooper Cutting, Second Edition, Neuroscience by Dale Purves, 2018.

SEMESTER 6

U18AII6201	APPLIED DESIGN THINKING	L	T	P	J	C
		3	0	2	0	4

Course Objectives:

- To apply a scientific method to define & test various hypotheses to mitigate the inherent risks in product innovations.
- To design the solution concept based on the proposed value defined for the target customer exploring various alternate solutions to achieve value-price fit.
- To develop skills in empathizing, critical thinking, analysing, storytelling & pitching.
- To apply system thinking to reverse engineer a product/prototype and understand its internal components and their correlations

Course Outcomes:

After successful completion of this course, the students should able to

CO1:	Apply and define hypotheses to mitigate the risks in product innovations
CO2:	Design proposed value for the target customer exploring various alternate solutions to achieve value-price fit.
CO3:	Develop skills in empathizing, critical thinking, analysing, storytelling & pitching.
CO4:	Apply system thinking to reverse engineer a product/prototype and understand its internal components and their correlations

Pre-requisite courses: Nil

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcome (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M			M								W
CO2		S	S	M								W
CO3		S		M					M			W
CO4	S		S	M	M				M			W

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. End Semester Examination (Theory component)

b) Indirect

1. Course-end survey

Topics covered:

DESIGN THINKING PRINCIPLES	**10 Hrs**

Exploring Human centered Design - Understanding the Innovation process, Discovering areas of opportunity, Interviewing & empathy building techniques, Mitigate validation risk - Case studies

CUSTOMER CENTRIC INNOVATION	**12 Hrs**

Importance of customer centric innovation - Problem Validation and Customer Discovery - Understanding problem significance and problem incidence - Customer Validation. Target user, User persona & user stories. Activity: Customer development process - Customer interviews and field visits

APPLIED DESIGN THINKING TOOLS	**10 Hrs**

Concept of Minimum Usable Prototype [MUP] - MUP challenge brief - Designing & Crafting the value proposition - Deriving the Solution concept [MUP] iteratively - Activity: Ideate, Prototype and Test

SYSTEM THINKING & REVERSE ENGINEERING	**13 Hrs**

System Thinking, Understanding Systems, Examples and Understandings, Complex Systems, Reverse Engineering Methodology, Identify building blocks/Components - Re-Engineering a complex system

Theory: 45 Hrs	**Tutorial: 0**	**Total Hours: 45 Hrs**

Lab Component:

Choose any real time use case, apply and experiment the following:

1. Develop empathy with target users
2. Define the problem statement
3. Ideate through brain storming and reverse engineering
4. Create prototype
5. Test the model

Practical : 30 Hrs	**Tutorial: 0**	**Total Hours: 30 Hrs**

Text Books:

1. Daren J. Eich, “Innovation Step-by-Step How to create & develop ideas for your challenge”, Amazon Asia-Pacific Holdings Private Limited, 2014.

Reference Books:

1. Roger Martin , “The Design of Business- Why design thinking is the next competitive advantage”, Harvard Business Review Press, 2009.

U18AII6202	PROTOTYPE DEVELOPMENT	L	T	P	J	C
		3	0	2	0	4

Course Objectives:

- Create quick UI/UX prototypes for customer needs
- Develop web application to test product traction / product feature
- Develop 3D models for prototyping various product ideas
- Tools and Techniques to create prototypes in a quick iterative methodology

	Course Outcomes:
	After successful completion of this course, the students should able to
CO1:	Create quick UI/UX prototypes for customer needs
CO2:	Develop web application to test product traction / product feature
CO3:	Develop 3D models for prototyping various product ideas
CO4:	Tools and Techniques to create prototypes in a quick iterative methodology

Pre-requisite courses: Nil

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcome (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M			S								W
CO2	M	S	S	S								W
CO3	M	S		S					W			W
CO4	M		S	S	S				W			W

Course Assessment methods:

a) Direct

a. Continuous Assessment Test I, II (Theory component)
b. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
c. Demonstration etc (as applicable) (Theory component)
d. End Semester Examination (Theory component)

b) Indirect

e. Course-end survey

Topics covered:

UI/UX	**12 Hrs**
Fundamental concepts in UI & UX - Tools - Fundamentals of design principles - Psychology and Human factors for User Interface Design - Layout and composition for Web, Mobile and Devices - Typography - Information architecture - Colour theory - Design process flow, wireframes, best practices in industry - User engagement ethics - Design alternatives	
APP DEVELOPMENT	**12 Hrs**
SDLC - Introduction to App Development - Types of Apps - web Development - understanding Stack - Frontend - backend - Working with Databases - Introduction to API - Introduction to Cloud services - Cloud environment Setup- Reading and writing data to cloud - Embedding ML models to Apps - Deploying application.	
INDUSTRIAL DESIGN	**11 Hrs**
Introduction to Industrial Design - Points, lines and planes - Sketching and concept generation - Sketch to CAD - Introduction to CAD tools - Types of 3D modeling - Basic 3D Modeling Tools - Part creation - Assembly - Product design and rendering basics - Dimensioning & Tolerancing	
RAPID PROTOTYPING	**10 Hrs**
Need for prototyping - Domains in prototyping - Difference between actual manufacturing and prototyping - Rapid prototyping methods - Tools used in different domains - Mechanical Prototyping: 3D Printing and classification - Laser Cutting and engraving - RD Works - Additive manufacturing - Electronic Prototyping: Basics of electronic circuit design - lumped circuits - Electronic Prototyping - Working with simulation tool - simple PCB design with EDA	

Theory: 45 Hrs	**Tutorial: 0**	**Total Hours: 45 Hrs**

Lab Component:

1. Prepare SRS report
2. Prepare SAR report
3. Create sketches and diagrams for UseCase
4. Design a prototype for the UseCase
5. Building proof of concept
6. Create test cases

Practical : 30 Hrs	**Tutorial: 0**	**Total Hours: 30 Hrs**

Text Book:

1. Peter Fiell, Charlotte Fiell , “Industrial Design A-Z”, TASCHEN America Llc, 2006.

Reference Book:

1. Steve Krug, “Don’t Make Me Think”, Revisited, Third edition, Pearson, 2015.

U18AII6203	INDUSTRIAL IoT	L	T	P	J	C
		3	0	2	0	4

Course Objectives:

· To teach basics purpose and the evolution and types of Autonomous Vehicles

· To enable students to understand the characteristics of technology involved in building Autonomous vehicles

· To make the students to analyze various automation levels

	Course Outcomes:
	After successful completion of this course, the students should able to
CO1:	Identify appropriate AI techniques to solve industrial automation problems through sensors and actuators.
CO2:	Understand the Industrial IoT Architecture.
CO3:	Understand the idea of business transformation using connected cars.
CO4:	Demonstrate and explore the concepts behind Connected Motions.

Pre-requisite courses: Nil

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	**Programme Outcomes (POs)**											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S		M								S
CO2	S	S		M								S
CO3	S	S	S	M					W			S
CO4	S	S	S									S

Course Assessment methods:

a) Direct

f. Continuous Assessment Test I, II (Theory component)

g. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation,Project Report, Poster Preparation, Prototype or Product

h. Demonstration etc (as applicable) (Theory component)

i. End Semester Examination (Theory component)

b) Indirect

j. Course-end survey

Topics covered:

INDUSTRY 4.0	**10 Hrs**

Automation- Principles and Strategies of Automation - Basic Elements- Levels of Automation- Smart Automation- introduction to Industry 4.0- Reason for Adopting Industry 4.0 - Definition -Main Concepts and Components of Industry 4.0-Technologies of Industry 4.0 - Big Data - Artificial Intelligence (AI) - Industrial Internet of Things - Cyber Security - Cloud -Augmented Reality-Robotics

INTRODUCTION TO INDUSTRIAL IoT	**12 Hrs**

Basics of Industrial IoT - IIoT Architecture Layers - Introduction to IIoT End Point Gateway, Fog Layer and iSMAC Layers - Difference between traditional SCADA/DCS architectures and IIoT architectures - Business Transformation Potential – Case Study: Connected Cars.

COMPONENTS OF IoT	**10 Hrs**

Control Units - Sensors - Basics of Sensors and actuators - Examples and working principles of sensors and actuators - Communication modules - Power Sources - Communication Technologies - RFID - Bluetooth - Zigbee - Wifi - Rflinks - Mobile Internet - Wired Communication - Locomotion - key issues for locomotion, leg configurations and stability, wheeled mobile robots, wheeled locomotion-the design space.

ROBOTICS AND VISION SYSTEMS	**13 Hrs**

Introduction - Transformations - Forward Kinematics - Inverse Kinematics - Design considerations: Motor sizing, selection of motors based on torque and speed characteristics - Hardware Interface & Assembly - Introduction to ROS framework and prerequisites - ROS Tools and Utilities - Simulation - ROS Motion - Image basics - Image Processing - Histograms - Smoothing and blurring/filtering - Thresholding - Gradients and Edge detection - Contours - Camera calibration - Integration of image processing tool with ROS - Applications.

Theory: 45 Hrs	**Tutorial: 0**	**Total Hours: 45 Hrs**

Lab Experiments:

1. Usage of Sensors and Actuators
2. Lane Detection
3. Gesture Controlled Robots
4. Smart Home Automation
5. Fruit Detection

Practical : 30 Hrs	**Tutorial: 0**	**Total Hours: 30 Hrs**

Text Books:

1. Michael J. Hamill, "Industrial Communications and Control Protocols", PDH center, 2011.
2. Charalampos Doukas , "Building Internet of Things with the Arduino", Create space, 2012.
3. Qusay F.Hassan, Atta ur Rehman Khan and Sajjid A. Madani, "Internet of things - Challenges, Advances and Applications", CRC Press, 2018.

Reference Books:

1. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand, David Boyle, "From Machine-to-Machine to the Internet of Things", Academic Press, 2014.
2. Marco Schwartz, "Internet of Things with Arduino Cookbook", Packt Publishing, 2016.
3. James Anderson, Kalra Nidhi, Karlyn Stanly, "Autonomous Vehicle Technology: A Guide for Policymakers", Rand Co, 2014.
4. Lawrence. D. Burns, Christopher Shulgan, "Autonomy - The quest to build the driverless car and how it will reshape our world", Harper Collins Publishers, 2018.

Advanced Technology Electives

Sl. No	Course code	Course title	L	T	P	J	C
1	U18AIEX001	Natural Language Processing	3	0	0	0	3
2	U18AIEX002	Introduction to Spatial Computing	3	0	0	0	3
3	U18AIEX003	Computer Vision Techniques	3	0	0	0	3
4	U18AIEX004	Recommendation system for e-commerce	3	0	0	0	3
5	U18AIEX005	Mining BigData	3	0	0	0	3
6	U18AIEX006	Neural Computation	3	0	0	0	3
7	U18AIEX007	Human-Centered Systems	3	0	0	0	3
8	U18AIEX008	Speech Processing	3	0	0	0	3
9	U18AIEX009	Startup Fundamentals	2	0	2	0	3

U18AIEX001	NATURAL LANGUAGE PROCESSING	L	T	P	J	C
		3	0	0	0	3

Course Objectives:

· To teach basics of natural language processing

· To make students understand Convolutional Neural Net architecture

· To make students understand architectural designs of Recurrent Neural Networks

· To teach various advanced techniques Generative Adversarial Nets, Deep Generative models

Pre-requisite courses: U18AII4202 Neural Networks and Deep Learning

Course Outcomes:	
After successful completion of this course, the students should able to	
CO1 :	Understand the basics of natural language processing using statistical approach
CO2 :	Understand to use neural networks in natural language processing
CO3 :	Apply appropriate deep learning models for text analytics
CO4 :	Understand advanced neural networks in language analytics

CO/PO Mapping
(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	**Programme Outcome (POs)**											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S		M								S
CO2	S	S		M								S
CO3	S	S	S	M					W			S
CO4	S	S	S									S

Course Assessment methods:
a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation,Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. End Semester Examination (Theory component)

b) Indirect

1. Course-end survey

Topics covered:

NATURAL LANGUAGE PROCESSING	10 Hours

Natural Language Processing Basics: Syntax – Semantics – Introduction to Statistical NLP, Operations on a corpus, word vector, word embeddings, Glove, Probability and NLP, Vector Space models, Sequence learning, Machine translation, Preprocessing, Statistical properties of words- deep learning for NLP- Applications of deep learning to NLP.

CONVOLUTIONAL NEURAL NETWORKS	12 Hours

Classification tasks in NLP-Window-based Approach for language modelling -Window-based Approach for NER, POS tagging, and Chunking- Convolutional Neural Net for NLP- Max-margin Training- Scaling Softmax - Adaptive input and output.

RECURRENT NEURAL NETWORK ARCHITECTURES	10 Hours

Basic RNN structures- Language modeling with RNNs- Backpropagation through time- Text generation with RNN LM- Issues with Vanilla RNNs- Exploding gradient- Gated Recurrent Units (GRUs) and LSTMs- Bidirectional RNNs- Multi-layer RNNs- Sequence labeling with RNNs- Sequence classification with RNNs- Attention, Variants

GANS, ADVERSARIAL NLP AND DEEP GENERATIVE MODELS	13 Hours

Generative adversarial nets (GANs)- Domain adversarial nets (DANs)- Adversarial attacks in NLP- Defense: Training with adversarial examples- Consistency regularization- Cross-view consistency, Variational inference, Autoencoders, Variational autoencoders, Conditional VAEs, Vector Quantized VAEs, Variational Generative adversarial nets- Multi-task Learning for NLP

Theory: 45 Hrs	Tutorial: 0	Total Hours: 45 Hrs

Text Books:

1. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, “Deep Learning”, First Edition, MIT Press, 2016.
2. Sunil Patel, “Deep Learning for Natural Language Processing”, BPB Publications, 2021.

Reference Books:

1. Goldberg Yoav, “Neural Network Methods in Natural Language Processing”, Morgan and Claypool publishers.
2. Karthiek Reddy Bokka; Shubhangi Hora; Tanuj Jain; Monicah Wambugu, " Deep Learning for Natural Language Processing", Packt Publishing.

U18AIEX002	INTRODUCTION TO SPATIAL COMPUTING	L	T	P	J	C
		3	0	0	0	3

Course Objectives:

· To distinguish traditional relational data and spatial data.
· To understand spatial design issues and data models.
· To make use of technologies to build applications combined with geographical data.
· To understand spatial information services and XR.

Pre-requisite courses: U18AII4202 Neural Networks and Deep Learning

Course Outcomes:

After successful completion of this course, the students should able to

CO1 :	Understand the foundations of spatial data and its storage.
CO2 :	Identify the spatial design issues and data models for real world problems
CO3 :	Use advanced technologies to build applications combined with geographical data
CO4 :	Extend knowledge on spatial information services and XR

CO/PO Mapping
(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S										M
CO2	S	S		M								M
CO3	S	S	S	S	M							M
CO4	S	S	S	S	S							M

Course Assessment methods:
a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation,Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. End Semester Examination (Theory component)

b) Indirect

1. Course-end survey

Topics covered:

INTRODUCTION	**10 Hours**

Geo-spatial science, systems and services, spatial concepts and data models: field vs object based, spatial query languages. Fundamental spatial algorithms: space filling curves, voronoi diagrams. Spatial storage and indexing: Grid files, Quadtrees and R-trees, query processing, join strategies, and optimization.

SPATIAL MODELING	**12 Hours**

Conceptual, logical and physical level design issues, spatial data models, Sequenced semantics, Spatial databases, Query processing in spatial network databases, spatial data mining: classification, association and clustering.

SPATIAL STATISTICS	**13 Hours**

Hot-spot and distributions using Arc. Conceptualization of spatial relationships: spatial autocorrelation by distance, autocorrelation, nearest neighbor, hot-spot analysis. Exploratory regression, OLS, Geographically weighted regression, Spatial computing systems: Geographic Information Systems: Open Source GRASS GIS, ESRI ArcGIS family

APPLICATION SERVICES AND XR	**10 Hours**

Virtual globes, location-based services, enterprise consulting. Application programming interfaces: HTML5 - Geolocation API, Google Maps API, Bing Maps API, Flickr location API, Twitter location API, Extending reality with spatial computing- audio visual technology, interaction technology, virtual prototypes.

Theory: 45 Hrs	**Tutorial: 0**	**Total Hours: 45 Hrs**

Text Books:

1. Paul Longley and Michael Batty, “Spatial Analysis: Modeling in a GIS Environment”, Wiley, 1994
2. Shashi Shekhar and Sanjay Chawla, “Spatial Databases: A Tour”, Pearson, 2002

Reference Books:

1. Shaowen Wang, Michael F. Goodchild, “Cyber GIS for Geospatial Discovery and Innovation”, Springer, 2019.
2. Shashi Shekhar, Pamela Vold, “Spatial Computing”, The MIT press, 2020

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U18AIEX003	COMPUTER VISION TECHNIQUES	L	T	P	J	C
		3	0	0	0	3

Course Objectives:

· To teach basics concepts of computer vision

· To provides a pathway for students to gain the knowledge and skills to apply machine learning to students work

· To teach the capabilities, challenges, and consequences of deep learning

Pre-requisite courses: Nil

Course Outcomes:

After successful completion of this course, the students should able to

CO1 :	Understand how computer vision has evolved and become familiar with its exciting applications
CO2 :	Build a convolutional neural network, including recent variations such as residual networks
CO3 :	Apply convolutional networks to visual detection and recognition tasks and use neural style transfer to generate art
CO4 :	Apply these techniques to a variety of image, video, and other 2D or 3D data

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	**Programme Outcomes (POs)**											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S		M								S
CO2	S	S		M								S
CO3	S	S	S	M					W	M		S
CO4	S	S	S								M	S

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. End Semester Examination (Theory component)

b) Indirect

1. Course-end survey

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Topics covered:

INTRODUCTION AND OVERVIEW	**10 Hours**

Introduction to Image Formation- Capture and Representation- Linear Filtering- Correlation Edge- Blobs- Corner Detection- Scale Space and Scale Selection

FOUNDATIONS OF CONVOLUTIONAL NEURAL NETWORKS	**12 Hours**

Computer Vision- Edge Detection- Padding- Strided Convolutions- Convolutions Over Volume- One Layer of a Convolutional Network- Simple Convolutional Network- Pooling Layers

OBJECT DETECTION	**10 Hours**

Object Localization- Landmark Detection- Object Detection- Convolutional Implementation of Sliding Windows- Bounding Box Predictions- Intersection Over Union- Non-max Suppression- Anchor Boxes- YOLO Algorithm- Semantic Segmentation with U-Net- U-Net Architecture Intuition

SPECIAL APPLICATIONS: FACE RECOGNITION & NEURAL STYLE TRANSFER	**13 Hours**

Face Recognition- One Shot Learning- Siamese Network- Triplet Loss- Face Verification and Binary Classification- Neural Style Transformation- Cost Function- Content Cost Function- Style Cost Function- 1D and 3D Generalizations

Theory: 45 Hrs	**Tutorial: 0**	**Total Hours: 45 Hrs**

Text Books:

1. Vaibhav Verdhan, "Computer Vision Using Deep Learning: Neural Network Architectures with Python, Keras, and TensorFlow: Neural Network Architectures with Python and Keras", Apress; 1st ed. edition, 2021.
2. Salman Khan, Hossein Rahmani, Syed Afaq Ali Shah, Mohammed Bennamoun, “A Guide to Convolutional Neural Networks for Computer Vision”, Morgan & Claypool Publishers, 2018.

Reference Books:

1. Benjamin Planche, Eliot Andres, "Hands-On Computer Vision with TensorFlow 2: Leverage deep learning to create powerful image processing apps with TensorFlow 2.0 and Keras", Packt Publishing Limited, 2019.
2. Rajalingappaa Shanmugamani, "Deep Learning for Computer Vision: Expert techniques to train advanced neural networks using TensorFlow and Keras", Packt Publishing Limited, 2018.

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U18AIEX004	RECOMMENDATION SYSTEM FOR e-COMMERCE	L	T	P	J	C
		3	0	0	0	3

Course Objectives:

- To understand the basic concepts of recommender systems.
- To categorize the types of recommender systems.
- To evaluate the recommender systems based on various metrics.
- To inspect advanced e-commerce applications of recommender systems.

Pre-requisite courses: U18AII2205 Introduction to AI & ML

Course Outcomes:

After successful completion of this course, the students should able to

CO1 :	Understand the basic concepts of recommender systems
CO2 :	Categorize types of recommender systems
CO3 :	Evaluate recommender systems based on various metrics
CO4 :	Analyze advanced e-commerce applications of recommender systems

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M										M
CO2	M	S	S	M								M
CO3	M	S	S	M								M
CO4	M	S	S	S								M

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. End Semester Examination (Theory component)

b) Indirect

1. Course-end survey

Topics covered:

INTRODUCTION	**8 Hours**

Introduction: Evolution and Basic taxonomy of recommender systems, Recommender system functions, Recommendation Techniques, Recommender Systems and Human Computer Interaction, Applications of recommendation systems, merits and demerits of recommendation systems in e-commerce.

CONTENT-BASED RECOMMENDATION	**13 Hours**

High level architecture of content-based systems, Advantages and drawbacks of content-based filtering, Item representation, methods for learning user profiles. Knowledge based recommendation: Knowledge representation and reasoning, Constraint based recommenders, Case based recommenders.

COLLABORATIVE FILTERING AND MODEL EVALUATION	**14 Hours**

User-based nearest neighbor recommendation, Item-based nearest neighbor recommendation, Model based and pre-processing-based approaches, Matrix factorization models, Neighborhood models. Evaluating Recommender System: Introduction, General properties of evaluation research, Evaluation designs, Evaluation on historical datasets, Error metrics, Decision-Support metrics, User-Centered metrics.

RECOMMENDER SYSTEMS AND COMMUNITIES	**10 Hours**

Communities, collaboration and recommender systems in personalized web search, social tagging recommender systems, Trust and recommendations, Group recommender systems, Context-Aware Recommender Systems, Hybrid approaches, Active learning in recommender systems.
Case study - amazon, Netflix, YouTube.

Theory: 45 Hrs	**Tutorial: 0**	**Total Hours: 45 Hrs**

Text Books:

1. Francesco Ricci, Lior Rokach, Bracha Shapira, Paul B. Kantor, Recommender Systems Handbook, Springer
2. C.C. Aggarwal, Recommender Systems: The Textbook, Springer, 2016.

Reference Books:

1. Jannach D., Zanker M. and FelFering A., Recommender Systems: An Introduction, Cambridge University Press.
2. Manouselis N., Drachsler H., Verbert K., Duval E., Recommender Systems For Learning, Springer.

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U18AIEX005	MINING BIGDATA	L	T	P	J	C
		3	0	0	0	3

Course Objective

- To develop skills to both design and critique visualizations
- To make students understand and work on Hadoop Framework and Eco systems
- To teach basic concept of mining data streams
- To teach fundamentals of Link Analysis & Mining Social Network Graphs

Pre-requisites: U18AII4203 Data Mining and Modeling

Course Outcomes:

After successful completion of this course, the students should be able to

CO1:	Choose b tools to carry out exploratory data analysis and produce effective visualization of given data.
CO2:	Perform parallel data processing and duplication with Hadoop and Map-Reduce.
CO3:	Identify suitable data model and algorithms for mining mass data set.
CO4:	Apply link analysis & mining social network graphs in real time problem

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S								M			M
CO2	S	S		M							S	S
CO3	S	S	S	M	S		M		M		S	S
CO4	S	S	S		S						S	S

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product Demonstration etc (as applicable)Pre/Post -
3. End Semester Examination

b)Indirect

1. Course-end survey

Topics covered:

INTRODUCTION TO EDA	**10 Hours**

Mathematics foundations, Statistical inference – Statistical modeling, Probability distributions, Fitting a model, Exploratory Data Analysis(EDA) and data visualization - Basic tools (Plots, Graphs and Summary statistics) of EDA, Data science process, Data visualization – Basic principles, ideas and tools for visualization, Analytic processes and tools - Analysis Vs Reporting

BIG DATA	**12 Hours**

Big data platform – Challenges of conventional systems - Intelligent data analysis - Transition to big data databases- Map reduce - Map Tasks- Grouping by Key - Reduce Tasks- Combiners

MINING DATA STREAMS	**10 Hours**

Stream data model and architecture – Stream computing, sampling data in a stream – Filtering streams – Counting distinct elements in a stream – Estimating moments –Counting oneness in window – Decaying window – Real-time analytics platform (RTAP) applications.

LINK ANALYSIS & MINING SOCIAL NETWORK GRAPHS	**13 Hours**

PageRank- Representing Transition Matrices- PageRank Iteration Using MapReduce- Use of Combiners to Consolidate the Result Vector - Topic-Sensitive PageRank- Biased Random Walk- Inferring Topics from Words - Link Spam - Architecture of a Spam Farm - Analysis of a Spam Farm - Combating Link Spam - TrustRank - Spam Mass

Theory : 45 Hrs	**Tutorial : 0**	**Total Hours: 45 Hrs**

Textbooks:

1. Jure Leskovec, Anand Rajaraman, and Jeffrey David Ullman, "Mining of Massive Datasets", 2nd edition, Cambridge University Press, 2014
2. Scott E, "The Model Thinker- What You Need to Know to Make Data Work for You" First Edition New York: Basic Books, 2018

Reference Books:

1. Cathy O'Neil and Rachel Schutt, “Doing Data Science, Straight Talk From The Frontlin”, O'Reilly. 2014.
2. Foster Provost and Tom Fawcett, “Data Science for Business: What You Need to Know about Data Mining and Data-analytic Thinking”, ISBN 1449361323, 2013.
3. Kevin P. Murphy,” Machine Learning: A Probabilistic Perspective”, ISBN 0262018020, EMC Education Services, Wiley, 2015

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U18AIEX006	NEURAL COMPUTATION	L	T	P	J	C
		3	0	0	0	3

Course Objectives:

· To enable students to formalize biological facts into mathematical models.
· To provide an introduction to theories of neural computation.
· To enable students to investigate computations by neurons.
· To make students familiar with neural network models.

Course Outcomes:

After successful completion of this course, the students should able to

CO 1:	Understand the basics of neurology and computational neuroscience.
CO 2:	Apply information theory and coding principles to model neurons.
CO 3:	Analyze the working of neurons in various neural network architectures.
CO 4:	Compare and contrast the working of neurons through different types of learning.

Pre-requisite courses: U18AII4202 Neural Network and Deep Learning

CO/PO Mapping
(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	M									S
CO2	S	M	M									S
CO3	S	S	M	M								S
CO4	S	S	M	M								S

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation,Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. End Semester Examination (Theory component)

b) Indirect

1. Course-end survey

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Topics covered:

INTRODUCTION & BASIC NEUROLOGY	**8 Hours**

Overview – Neurons and Membranes – Spikes and Cables – Synapses and Dendrites – Synaptic Plasticity – Computational Neuroscience – Descriptive and Interpretive Models - Hebbian Learning – Neural Code – Neural Encoding & Decoding.

INFORMATION THEORY & NEURAL CODING	**13 Hours**

Information and Entropy – Calculating Information in Spike Trains – Coding Principles - Computation and Logical Units – Biological Visual Systems – Sparse Coding and Predictive Coding – Dynamical Systems Theory: Fixed Points, Nullclines – Computational Maps – Markov Network – Neural Correlations and Synchrony.

NEURAL NETWORK MODELS	**13 Hours**

Attractor Network and Memory - Deep Belief Net – Causal Inference – Neural Network: Perceptron - Deep Network and Brain – Convolutional Neural Networks – Recurrent Neural Networks.

LEARNING FROM SUPERVISION AND REWARDS	**11 Hours**

Biological Plausible Learning – Hierarchical Inference - Attention and Self-Attention – Prediction – Probabilistic Inference – Inference Mechanisms – Reinforcement Learning – Curiosity and Imagination – Emotion and Consciousness.

Theory: 45 Hrs	**Tutorial: 0**	**Total Hours: 45 Hrs**

Text Books:

1. Trappenberg T.P. (TTP), "Fundamentals of computational neuroscience", 2nd edition, Oxford University Press 2009.
2. Dayan, P and Abbott, L (DP), "Theoretical Neuroscience", MIT Press. 2001.
3. Sterling, P. and Laughlin, S., "Principles of Neural Design", MIT Press, 2015.
4. W. Gerstner, W.M. Kistler, R. Naud and L. Paninski, "Neuronal Dynamics - from single neurons to networks and models of cognition", Cambridge Univ. Press. 2014.

Reference Books:

1. Michael. A. Arbib, "The Handbook of Brain Theory and Neural Network", MIT Press, 1995.
2. Hertz J, Krogh A, Palmer RG (HKP), "Introduction to the theory of neural computation", Addison Wesley 1991.
3. Gordon M. Shepherd M.D., "The Synaptic Organization of the Brain", 5th Edition, Oxford University Press, 2004

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U18AIEX007	HUMAN-CENTERED SYSTEMS	L	T	P	J	C
		3	0	0	0	3

Course Objectives:

· To teach basics concepts of human centered systems
· To provides a pathway for students to gain the knowledge and skills to apply human centered systems in students work
· To teach the capabilities, challenges, and consequences of human centered systems
·

Course Outcomes:

After successful completion of this course, the students should able to

CO1:	Understand basic concepts in Human Centered Systems
CO2:	Build user centered system to solve real time problems
CO3:	Demonstrate a broad knowledge of contemporary issues and challenges in HCS
CO4:	Design user interfaces and experiences grounded in known principles of usability and HCS

Pre-requisite courses: Nil

CO/PO Mapping
(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S		M							M	S
CO2	S	S		M								S
CO3	S	S	S	M				M		M		S
CO4	S	S	S					M				S

Course Assessment methods:

a) Direct

a. Continuous Assessment Test I, II (Theory component)
b. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
c. Demonstration etc (as applicable) (Theory component)
d. End Semester Examination (Theory component)

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b) Indirect

a. Course-end survey

Topics covered:

INTRODUCTION TO HUMAN-CENTERED SYSTEMS	**13 Hours**

Introduction- logistics- overview- matrix operations- probability- Different flavors of mathematical models- importance and evolution of Human centered system- software quality and usability- software design and interaction design

MODELS IN HUMAN-CENTERED DESIGN	**10 Hours**

Mentals models- conceptual model and system image- gulf of execution and gulf of evaluation- metaphors- principles- guidelines and rules

UCD	**10 Hours**

Basic elements of User Center Design- models for interaction design- steps for UCD- user and need identification- requirements specifications

PROTOTYPING	**13 Hours**

Characteristics of a prototype- Lo-fi and Hi-fi prototypes- prototyping techniques- prototyping tools- evaluation paradigms and techniques- user observation- interviews and surveys- user modeling- experience designing- affective computing- perceptual systems and ambience intelligence

Theory: 45 Hrs	**Tutorial: 0**	**Total Hours: 45 Hrs**

Text Books:

1. Ideo, "Human Centered Design Toolkit", Authorhouse publisher, 2nd edition, 2011
2. Guy Boy, "Orchestrating Human-Centered Design", Springer, 2012

Reference Books:

1. Ideo, "The Field Guide to Human-Centered Design", IDEO.ORG, 2015.
2. Ethan Beute, "Human-Centered Communication: A Business Case Against Digital Pollution", Fast Company Press, 2021

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U18AIEX008	SPEECH PROCESSING	L	T	P	J	C
		3	0	0	0	3

Course Objectives:

· To teach basics of speech processing and dialog systems

· To make students understand the language modeling

· To make students understand the concepts of Automated Speech Recognition and Speech Conversion

· To make students extract social meaning in the context provided.

Pre-requisite courses: U18AII4202 Neural Networks and Deep Learning

Course Outcomes:

After successful completion of this course, the students should able to

CO1 :	Understand speech production and perception process
CO2 :	Categorize and analyze speech signals in time and frequency domain.
CO3 :	Interpret the idea for building neural chatbots and personal voice assistants.
CO4 :	Explain the process of speech conversions and voice conversions.

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	M	M							S
CO2	S	S		S	W							S
CO3	S	S	S	S	M							S
CO4	S	S	S		M							S

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation, Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. End Semester Examination (Theory component)

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b) Indirect

1. Course-end survey

Topics covered:

INTRODUCTION & DIALOG SYSTEMS	**12 Hours**

Acoustics and its types – Phonetics – Audio File Analysis – Digitization and Recording of Speech – Human-Speech Production - Task-oriented Dialogs – Dialog System Design – GUS & Frame based Dialog System – Neural Chatbots – Encoder-Decoder Model – End-to-End Neural Approach.Case Study: GoButler, Alexa Skills Kit

AUTOMATED SPEECH RECOGNITION	**10 Hours**

Audio Signals & its Types – Signal Sampling and Theorem – Acoustic Modeling – Language Modeling – Building a Natural Language Model – Hidden Markov Model in ASR – HMM-DNN Systems – Spectrum Analysis - Case Study: Speech-Brain ASR Toolkit

SPEECH-TO-TEXT & TEXT-TO-SPEECH	**13 Hours**

Speech-to-Text: Modeling – Data Exploration and Data Visualization – Transcription Model using Deep Speech ,Text-to-Speech: Text Analysis and its methods – Stemming and Lemmatization – Stop Words – Phonetic Analysis – Prosodic Analysis – Waveform Synthesis – Wave Analysis of Heart Beat Sound – Voice Builder - Case Study: Voice Building using Text Personal Voice Assistant.

MULTILINGUAL SPEECH PROCESSING & VOICE CONVERSION	**10 Hours**

Multilingual Speech Processing: Understanding Multilingual – Issues in Multilingual – Encoding Characters – Multilingual Speech Models. Voice Conversion: Introduction – Phonetic SID Systems – Speaker Identification & De-Identification
Case Study: Social Meaning Extraction: Interpersonal stance. Flirtation. Intoxication.

Theory: 45 Hrs	**Tutorial: 0**	**Total Hours: 45 Hrs**

Text Books:

1. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, “Deep Learning”, First Edition, MIT Press, 2016.
2. Sunil Patel, “Deep Learning for Natural Language Processing”, BPB Publications, 2021.

Reference Books:

1. Goldberg Yoav, “Neural Network Methods in Natural Language Processing”, Morgan and Claypool publishers.
2. Karthiek Reddy Bokka; Shubhangi Hora; Tanuj Jain; Monicah Wambugu, " Deep Learning for Natural Language Processing", Packt Publishing

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U18AIEX009	STARTUP FUNDAMENTALS	L	T	P	J	C
		3	0	0	0	3

Course Objectives:

- To develop an entrepreneurial mindset that will help them identify, assess, shape & act on opportunities in a variety of contexts & organization.
- To demonstrate the potential of an innovative idea to create economic value, as a startup.
- To understand the scientific process to explore a viable business model to build a scale business.
- To acquire knowledge on the fundamental concepts of Intellectual Property to Draft the Patent for a product.

Course Outcomes:

After successful completion of this course, the students should able to

CO1:	Identify, assess, shape & act on opportunities in a variety of contexts & organization.
CO2:	Demonstrate the potential of an innovative idea to create economic value, as a startup.
CO3:	Understand the scientific process to explore a viable business model to build a scale business.
CO4:	Acquire knowledge on the fundamental concepts of Intellectual Property to Draft the Patent for a product.

Pre-requisite courses: Nil

CO/PO Mapping

(S/M/W indicates the strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcome (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M			S								W
CO2		S	S	S								W
CO3	S	S		S					W			W
CO4			S	S					W			W

Course Assessment methods:

a) Direct

1. Continuous Assessment Test I, II (Theory component)
2. Open Book Test; Cooperative Learning Report, Assignment; Journal Paper Review, Group Presentation,Project Report, Poster Preparation, Prototype or Product
3. Demonstration etc (as applicable) (Theory component)
4. End Semester Examination (Theory component)

b) Indirect

1. Course-end survey

Topics covered:

ENTREPRENEURIAL MINDSET & METHOD	**11 Hours**

Introduction to Innovation-led, tech-powered entrepreneurship - Understand from research the attributes of an expert entrepreneur - Effectuation principles - Dealing with the unknowns - Case studies of startup failures.

IDEA TO ENTERPRISE	**12 Hours**

Design and Planning of Product Concept - Business Model - Business Planning - Building Proof of Product and Value Testing - Target Market and Revenue Planning

MINIMUM VIABLE BUSINESS	**12 Hours**

Framework for Minimum Viable Business - Disruptive Innovation - Theory of Disruption - Competitive advantage - Building proof of viable business model - Demystifying Scalability - Pitch Clinic

IPR AND PATENT DRAFTING	**10 Hours**

Intellectual Property 101- Introduction and the need for Intellectual Property Rights, Prior Art Search & Case studies of IPR. Fundamentals of Patent Drafting - Invention as a concept - Keywords formation - Structure of patent - Key attributes in patent drafting - Drafting provisional specifications - Drafting complete specifications - Draft claims - Case studies on patent drafting

Theory: 30 Hrs	**Tutorial: 0**	**Total Hours: 30 Hrs**

Text Books:

1. Steven Blank and Bob Dorf, “The Startup Owner’s Manual: The Step-by-Step Guide for Building a Great Company”, K&S Ranch, 2012.

Reference Books:

1. Dr.Saras Sarasvathy, “Effectuation: Elements of Entrepreneurial Expertise”, New Horizons in Entrepreneurship series, 2008.
2. WIPO Intellectual Property Handbook - https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub_489.pdf