AMRITA VISHWA VIDYAPEETHAM
DEEMED TO BE UNIVERSITY
School of Engineering

(AMRITAPURI, BANGALORE, COIMBATORE, CHENNAI)

B.Tech. in COMPUTER SCIENCE AND ENGINEERING (ARTIFICIAL INTELLIGENCE)

(BTC-AIE)

CURRICULUM AND SYLLABI 2019

GENERAL INFORMATION

ABBREVIATIONS USED IN THE CURRICULUM

Cat	-	Category
L	-	Lecture
T	-	Tutorial
P	-	Practical
Cr	-	Credits
ENGG	-	Engineering Sciences (including General, Core and Electives)
HUM	-	Humanities (includingLanguages and others)
SCI	-	Basic Sciences (includingMathematics)
PRJ	-	Project Work (includingSeminars)
AES	-	Aerospace Engineering
AIE	-	Computer Science and Engineering - Artificial Intelligence
BIO	-	Biology
CCE	-	Computer and Communication Engineering
CHE	-	Chemical Engineering
CHY	-	Chemistry
CSE	-	Computer Science and Engineering
CVL	-	Civil Engineering
CUL	-	Cultural Education
EAC	-	Electronics and Computer Engineering
ECE	-	Electronics and Communication Engineering
EEE	-	Electrical and Electronics Engineering
ELC	-	Electrical and Computer Engineering
HUM	-	Humanities
MAT	-	Mathematics
MEE	-	Mechanical Engineering
PHY	-	Physics

Course Outcome (CO) – Statements that describe what students are expected to know, and are able to do at the end of each course. These relate to the skills, knowledge and behaviour that students acquire in their progress through the course.

Program Outcomes (POs) – Program Outcomes are statements that describe what students are expected to know and be able to do upon graduating from the Program. These relate to the skills, knowledge, attitude and behaviour that students acquire through the program. NBA has defined the Program Outcomes for each discipline.

PROGRAM OUTCOMES FOR ENGINEERING

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **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.
4. **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.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **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.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **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.
11. **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.
12. **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.

Program Specific Outcomes (PSO's)

1. Integrate the foundations of mathematics, programming and domain knowledge to build AI enabled systems.

2. Acquire Skills in computational thinking required for the AI assisted engineering systems.

3. Acquire Skills to model the AI assisted decision making systems and to analyse the data from these systems to arrive at appropriate decisions.

SYLLABUS

SEMESTER I

19MAT105	MATHEMATICS FOR INTELLIGENT SYSTEMS 1	L-T-P-C: 2- 0- 3- 3

Course Objectives

- The course will lay down the basic concepts and techniques of linear algebra, calculus and basic probability theory needed for subsequent study
- It will explore the concepts initially through computational experiments and then try to understand the concepts/theory behind it.
- At the same time, it will provide an appreciation of the wide application of these disciplines within the scientific field
- Another goal of the course is to provide connection between the concepts of linear algebra, differential equation and probability theory.

Course Outcomes

CO1: To develop an understanding of the basic concepts and techniques of linear algebra, calculus and basic probability theory needed for AI.
CO2: To provide an appreciation of the wide application of these disciplines within the scientific field.
CO3: To provide connection between the concepts of linear algebra, differential equation and probability theory.
CO4: To develop an insight into the applicability of linear algebra in business and scientific domains.
CO5: To enable the students to understand the use of calculus and Linear algebra in modelling electrical and mechanical elements**.**
CO6: To equip the students to understand the role of probability theory in providing data sets for computational experiments in data science.

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3				3	2	3	3
CO2	3	3	3	3	3	2			3	2	3	3
CO3	3	2	3	3	3				3	2	3	3
CO4	3	3	3	2	3				3	2	3	3
	3	2	3	3	3				3	2	3	3
	3	3	3	3	3	2			3	2	3	3

Syllabus

Basics of Linear Algebra - Linear Dependence and independence of vectors - Gaussian Elimination - Rank of set of vectors forming a matrix - Vector space and Basis set for a Vector space - Dot product and Orthogonality - Rotation matrices - Eigenvalues and Eigenvectors and its interpretation - Projection matrix and Regression – Singular Value Decomposition.

Convolution sum, Convolution Integral, Ordinary Linear differential equations, formulation, analytical and Numerical solutions, Impulse Response Computations, formulating state space models of Physical systems.

Examples of ODE modelling in falling objects, satellite and planetary motion, Electrical and mechanical systems. Multivariate calculus, Taylor series, Introduction to Optimization.

Introduction to Probability Distributions and Monte Carlo Simulations.

Text Books / References

Gilbert Strang, Linear Algebra and Learning from Data, Wellesley, Cambridge press, 2019.
William Flannery, Mathematical Modelling and Computational Calculus, Vol-1, Berkeley Science Books, 2013.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19PHY104	COMPUTATIONAL ENGINEERING MECHANICS 1	L-T-P-C: 2- 0 - 3 -3

Course Objectives

- The course will lay down the basic concepts and techniques of engineering mechanics needed for verticals such as robotics.
- It will explore the concepts initially through computational experiments and then try to understand the concepts/theory behind it.
- It will help the students to perceive the engineering problems using the fundamental concepts in mechanics.
- Another goal of the course is to provide connection between the concepts of mechanics, mathematics and computational thinking

Course Outcomes

CO1: To develop a basic understanding of the principles in statics and dynamics.
CO2: To introduce the state of the art computational techniques that can be employed to analyse the structured problems in mechanics.
CO3: To enable the students to model engineering problems in the perspective of mechanics.
CO4: To facilitate the students to understand the intricate connection between mathematics, mechanics and computational thinking.

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3				3	2	3	3
CO2	3	3	3	3	3	2			3	2	3	3
CO3	3	2	3	3	3				3	2	3	3
CO4	3	3	3	2	3				3	2	3	3

Syllabus

Equilibrium of rigid bodies, free body diagram, Analysis of beams and trusses – Friction - Lumped mass models in Dynamics – Particle motion in Cartesian, cylindrical and spherical coordinates – 2D translation – 2D rotation – basics of coordinate transformation – Rotation matrix – 3D translation – 3D rotation- Quaternion representation of rotation - Kinematics of rigid bodies - angular momentum of rigid bodies - relative motion with translating and rotating axes and Coriolis acceleration – Analysis of a simple robotic joint – Analysing 2-joint robotic arm.

Text Books / References

Beer F.P. and Johnston E.R., Vector Mechanics for Engineers - Volume I - Statics, Volume II - Dynamics, McGraw Hill, New York, 2004.

Merlam J.L and Kraige L.G., Engineering Mechanics, Volume I - statics, Volume 11- dynamics, John Wiley & Sons, New York, 2018.

Elementary Mechanics Using Matlab – Malthe&Sorenssen – Undetrgraduate Lecture Notes in Physics, Springer International Publishing, 2015.

Elementary Mechanics Using Python – Malthe&Sorenssen – Undetrgraduate Lecture Notes in Physics, Springer International Publishing, 2015.

Statics with Matlab – Marghitu, Dupac& Madsen, Springer – Verlag London 2013.

Advanced Dynamics - Marghitu, Dupac& Madsen, Springer – Verlag London 2013.

Shames L.H., Engineering Mechanics, Prentice HaII, New Delhi, 1996.

Hibbeler R. C., Engineering Mechanics: Statics and Dynamics, 11th edition, Pearson Education India, 2017.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE105	OBJECT ORIENTED PROGRAMMING	L-T-P-C: 2- 1 -3- 4

Course Objectives

- The course will provide an introduction to object oriented programming.
- It will expose the students to the paradigm of object oriented programming.
- Students will also be motivated to solve the problems in engineering using the concepts of object oriented programming.

Course Outcomes

CO1: Understand Abstraction in all forms and in a holistic way.
CO2: Observe and Analyse object-oriented Software to effectively utilise its features.
CO3: To enable the students to design and implement programs using standard design patterns to solve general problems.

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3				3	2	3	3
CO2	3	3	3	3	3	2			3	2	3	3
CO3	3	2	3	3	3				3	2	3	3

Syllabus

Introduction to Scratch/Blockly Visual programming and program constructs. Introduction to Java Language and Runtime Environment- Basic program syntax, Hello world, Data types, variables and Functions - Value types and Reference types, Implicit Pointers and the Null Pointer exceptions - Objects in Java, Class file, constructor functions, Class members and method, Class Instance variables, the Object class, new Operators, Heap allocation and Garbage collector – Basic Java API, Stream classes and objects for Data IO, hierarchy of data streams in Java, Throwable type hierarchy and exception handling syntax, the Thread class. Object-Oriented Concepts-Abstraction, Encapsulation, Inheritance and Polymorphism- Abstract Class, partially abstract and purely abstract, purely abstract class called Interface. Inheritance a way of extending classes, multiple inheritances and implements relation with Interfaces, The Base class and Derived class. Revisiting Instance and Class variables-Static and Dynamic Polymorphisms, Overloading and Overriding, Idea of a virtual function. Revisiting Thread API, the Runnable Interface, Other major Interfaces, Cloneable, Serializable and Observable. Interface as a mode of Type Polymorphism. UML Diagrams, Object relations and interactions, Containment and cardinality, Cohesion and Coupling. Object-Oriented Design Patterns: Creational: Factory, Singleton, Pool and Prototype - Behavioural: Command, Iterator, Memento, Observer, State, Visitor – Structural: Adapter, Bridge, Decorator, Flyweight and Proxy.

Textbooks / References

Blaha, Michael. Object-Oriented Modelling and Design with UML: For VTU, 2/e. Pearson Education India, 2005.

Robert Lafore, Object-Oriented Programming in C++ , Pearson Education India, 2017.

Bert Bates, Kathy Sierra, Head First Java, O Reilly, second edition, 2009.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE101	ELEMENTS OF COMPUTING SYSTEMS -1	L-T-P-C: 2-0- 3- 3

Course Objectives

- The course will expose the students to basics of Boolean algebra and it will further help them to understand the workings of a modern computer.
- Students will be trained to build a computing system using elementary logic gates such as NAND, AND, OR etc. through simulation software.

Course Outcomes

CO1: To develop an understanding on Boolean Algebra and Digital Logic
CO2: To introduce the implementation of digital logic systems
CO3: To develop an understanding on the working of a modern computing system

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3				3	2	3	3
CO2	3	3	3	3	3	2			3	2	3	3
CO3	3	2	3	3	3				3	2	3	3

Syllabus

Machine level language Vs. High Level Language, Decimal to Binary Conversion, Boolean Logic, Logic Gates, Boolean Algebra, Combinational logic, ALU , Introduction to Hardware simulator platforms, Sequential logic, Flip Flops, Registers, RAM, ROM, Memory Elements Computer Architecture: Von-Neumann architecture, Machine language, Basic experiments using machine language, Assembler.

Text Books/ References

Noam Nisan and Shimon Schocken, "Elements of Computing Systems", MIT Press, 2012.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE104	INTRODUCTION TO ELECTRICAL ENGINEERING	L-T-P-C: 2- 0- 3- 3

Course Objectives

- The course will lay down the basic concepts and techniques of electrical engineering needed for advanced topics in AI.
- It will explore the concepts initially through computational experiments and then try to understand the concepts/theory behind it.
- It will help the students to perceive the engineering problems using the fundamental concepts in electrical engineering.
- Another goal of the course is to provide connection between the concepts of electrical engineering, mathematics and computational thinking..

Course outcomes

CO1: To develop a basic understanding of the principles in electrical engineering.
CO2: To introduce the state of the art computational techniques that can be employed to analyse the structured problems in electrical engineering.
CO3: To enable the students to model engineering problems in the perspective of electrical engineering.
CO4: To facilitate the students to understand the intricate connection between mathematics, electrical engineering and computational thinking.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3				3	2	3	3
CO2	3	3	3	3	3	2			3	2	3	3
CO3	3	2	3	3	3				3	2	3	3
CO4	3	3	3	2	3				3	2	3	3

Syllabus

Fundamentals of solid-state physics- Fundamental electrical laws – Fundamental circuit elements: Charge, Voltage, and Current Resistance -Ohm's Law - Kirchoff's Voltage Law - Kirchoff's Current Law - Thevenin Equivalent Circuit - Norton Equivalent Circuit - Inductors and Capacitors - Impedance and AC Sinusoidal Signals - Operational Amplifiers - Semiconductor Devices - Transistors Circuits - Analog-to-Digital and Digital-to-Analog Conversion.

Textbooks/References:

John. O. Attia, "Electronics and Circuit Analysis using MATLAB", CRC Press, 1999.

Felix Huning, "Fundamentals of Electrical Engineering for Mechatronics", De Gruyter, 2014.

William Flannery, "Mathematical Modeling and Computational Calculus", Vol-1, Berkeley Science Books, 2013.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19BIO103	INTELLIGENCE OF BIOLOGICAL SYSTEMS 1	L-T-P-C: 1-0-3-2

Course Objectives

- This course will introduce the basics of cell biology.
- This will pave way for advanced courses in computational biology.
- It will help the students understand the basic cellular processes and it will provide a very basic introduction about intelligence of the cell.

Course Outcomes

CO1: To introduce the basic concepts in cell biology.
CO2: To develop an understanding about the basic cellular process.
CO3: To introduce the basic concepts about the cell intelligence.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	3		2		3	2		3
CO2	1	1	1	1	3		2		3	2		3
CO3	1	3	2	2	3		2		3	2		3

Syllabus

Classification of biological macromolecules, Cellular Structures, Cellular Energy Production and Utilization, The Cell Cycle and Cell Division, Meiosis and Formation of Gametes, Protein Synthesis, Gene Expression and Mutation, Evolution Patterns and Processes.

Textbooks/ References

Ryan Rogers, Cell and Molecular Biology for Environmental Engineers, Momentum Press Engineering, 2018.

Gabi Nindl Waite, Lee R. Waite, Applied Cell and Molecular Biology for Engineers, McGraw Hill Publishers, 2007.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE102	INTRODUCTION TO DIGITAL MANUFACTURING	L-T-P-C: 1- 0-3- 2

Course Objective

- This course will at imparting the knowledge of basics of digital manufacturing and its importance in current era.
- It will also equip the students to understand about the basics of Additive manufacturing used in various industry applications.
- Further it will expose the students to additive manufacturing technology using 3-D printing.

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Course Outcomes

CO1: To impart the knowledge of basic working principle of a 3D printer, how to use a 3D printer and how to assemble a 3D printer.
CO2: To impart basic drawing skills to design simple 3D design using open source 3D drawing software (FreeCAD).
CO3: To enable the students to design small robots and DIY projects where they can accommodate simple electronics to printed parts and make it live

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CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	3	2	3	2	2		3	2	3	3
CO2	2	2	3	2	3	2	2		3	2	3	3
CO3	2	3	3	2	3	2	2		3	2	3	3

Syllabus

History of Manufacturing: From classical to Additive manufacturing, 3D Printers and Printable Materials, 3D Printer Workflow and Software, Selecting a Printer: Comparing Technologies, Working with a 3D Printer, 3D Models, Applications, Building Projects.

Textbook/References:

Joan Horvath, Rich Cameron, Mastering 3D Printing in the Classroom, Library and Lab, Apress, 2018.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	30
Quiz(5 Quizzes with equal credit)	20
Project	50

19AIE103	INTRODUCTION TO DRONES	L-T-P-C: 1-0-3-2

Course Objective

- The main aim of this course is to understand the basics of Unmanned Arial Vehicles (Drones) and its various applications.
- The course will also impart the knowledge of how to fly a drone by considering the rules and regulations to the specific country.
- Further the students will be introduced to the safety measures to be taken during flight.

Course Outcomes

CO1: To introduce the various types of frame design used for the UAV and to accommodate the electronics over the frame to fly UAV.
CO2 : To make the students understand the basic working principal behind the electronic components used and its specification to build a drone from scratch.
CO3: To enable the students to identify and understand various functional modules of the controller using a pre-programmed controller used in the UAV.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	3	2	3	2	2		3	2	3	3
CO2	2	2	3	2	3	2	2		3	2	3	3
CO 3	2	3	3	2	3	2	2		3	2	3	3

Syllabus

Intro to Drones I (Sensor-Processor-Actuator), Intro to Drones II (How to Build a Drone),
Intro to Drones III (Communication Links), Intro to Drones IV (How to Fly a Drone)
Drone part design using 3D Printer, Flying Projects.

Textbook/References:

Syed Omar FarukTowaha, Building Smart Drones with ESP8266 and Arduino: Build exciting drones by leveraging the capabilities of Arduino and ESP8266, Packt Publishing, 2018.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	30
Quiz(5 Quizzes with equal credit)	20
Project	50

19CUL101	CULTURAL EDUCATION I	L-T-P-C: 2-0-0-2

Course Objective

- The course is designed as an introductory guide to the variegated dimensions of Indian cultural and intellectual heritage, to enable students to obtain a synoptic view of the grandiose achievements of India in diverse fields.
- It will equip students with concrete knowledge of their country and the mind of its people and instil in them some of the great values of Indian culture.

Course Outcomes

CO1: Be introduced to the cultural ethos of Amrita Vishwa Vidyapeetham, and Amma's life and vision of holistic education**.**
CO2: Understand the foundational concepts of Indian civilization like *puruśārtha*-s, law of karma and *varṇāśrama*.
CO3: Gain a positive appreciation of Indian culture, traditions, customs and practices**.**
CO4: Imbibe spirit of living in harmony with nature, and principles and practices of Yoga.
CO5: Get guidelines for healthy and happy living from the great spiritual masters

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1						3	2	3				2		
CO2						3	1	3				2		
CO3						3	1	3				2		
CO4						3	3	3				2		
CO5						3	1	3				2		

Syllabus

Unit 1
Introduction to Indian culture; Understanding the cultural ethos of Amrita Vishwa Vidyapeetham; Amma's life and vision of holistic education.
Unit 2
Goals of Life – Purusharthas; Introduction to Varnasrama Dharma; Law of Karma; Practices for Happiness.
Unit 3
Symbols of Indian Culture; Festivals of India; Living in Harmony with Nature; Relevance of Epics in Modern Era; Lessons from Ramayana; Life and Work of Great Seers of India.

Text Book
Cultural Education Resource Material Semester-1

Reference Book(s)
The Eternal Truth (A compilation of Amma's teachings on Indian Culture)
Eternal Values for a Changing Society. Swami Ranganathananda. BharatiyaVidyaBhavan.
Awaken Children (Dialogues with Mata Amritanandamayi) Volumes 1 to 9

My India, India Eternal. Swami Vivekananda. Ramakrishna Mission.

Evaluation Pattern:

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

SEMESTER II

19MAT117	MATHEMATICS FOR INTELLIGENT SYSTEM 2	L-T-P-C:2- 0-3 -3

Course Objective

- The course will lay down the basic concepts and techniques of linear algebras applied to signal processing.
- It will explore the concepts initially through computational experiments and then try to understand the concepts/theory behind it.
- At the same time, it will provide an appreciation of the wide application of these disciplines within the scientific field.
- Another goal of the course is to provide connection between the concepts of linear algebra, differential equation and probability theory.

Course Outcomes

CO1: To develop an understanding of the basic concepts and techniques of linear algebra as applied to signal processing.
CO2: To provide an appreciation of these disciplines within the scientific field.
CO3: To provide connection between the concepts of linear algebra, differential equation and probability theory.
CO4: To develop an insight into the applicability of linear algebra in business and scientific domains.
CO5: To enable the students to understand the use of calculus and Linear algebra in modelling electrical and mechanical elements.
CO6: To equip the students to understand the role of probability theory in providing data sets for computational experiments in data science.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3				3	2	3	3
CO2	3	3	3	3	3	2			3	2	3	3
CO3	3	2	3	3	3				3	2	3	3
CO4	3	3	3	2	3				3	2	3	3
CO5	3	2	3	3	3				3	2	3	3
CO6	3	3	3	3	3	2			3	2	3	3

Syllabus

Gaussian elimination, LU decomposition. Vector Spaces , Bases, Orthogonal bases Infinite dimensional vector spaces Fourier Series and Fourier Transform and its properties Convolution Vector spaces associated with Matrices Projection matrices and its properties Cayley Hamilton theorem Diagonalizability of matrices Eigenvalues and Eigenvectors of Symmetric matrices Eigenvalues and Eigen vectors of A^TA, AA^T Relationship between vector spaces associated with A, A^TA, AA^T. Formulation of ordinary differential equation with

constant coefficients in various engineering domains, Converting higher order into first order equations Numerical solution with Rungekutta method. Taylor series expansion of multivariate functions, conditions for maxima , minima and saddle points, Concept of gradient and hessian matrices Multivariate regression and regularized regression , Newton methods for optimization, Signal processing with regularized regression. Random variables and distributions, Expectation, variance , moments cumulants, Sampling from univariate distribution- various methods, Concept of Jacobian and its use in finding pdf of functions of Random variables(RVs), box-muller formula for sampling normal distribution, Concept of correlation and Covariance of two linearly related RVs, Multivariate Gaussian distribution, Bayes theorem, Introduction to Bayesian estimation process, Markov chain, Markov decision process.

Text Books / References

Gilbert Strang, Linear Algebra and Learning from Data, Wellesley, Cambridge press, 2019.

William Flannery, "Mathematical Modeling and Computational Calculus", Vol-1, Berkeley Science Books, 2013.

Evaluation Pattern

Assessment	Weightage (%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19PHY113	COMPUTATIONAL ENGINEERING MECHANICS 2	L-T-P-C: 2-0-3-3

Course Objective

- The course will lay down the basic concepts and techniques of kinetics and kinematics needed for verticals such as robotics.
- It will explore the concepts initially through computational experiments and then try to understand the concepts/theory behind it.
- It will help the students to perceive the engineering problems using the fundamental concepts in kinetics and kinematics.
- Another goal of the course is to provide connection between the concepts of mechanics, mathematics and computational thinking.

Course Outcomes

CO1: To develop a basic understanding of the principles in kinematics and kinetics.
CO2: To introduce the state of the art computational techniques that can be employed to analyze the structured problems in kinematics and kinetics as applied to robotics.
CO3: To enable the students to model engineering problems in the perspective of mechanics.
CO4: To facilitate the students to understand the intricate connection between mathematics, mechanics and computational thinking.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3				3	2	3	3
CO2	3	3	3	3	3				3	2	3	3
CO3	3	2	3	3	3				3	2	3	3
CO4	3	3	3	2	3				3	2	3	3

Syllabus

Review of 2D & 3D translation and rotation - Kinetics of rigid bodies-translation and rotation motion of a rigid body. Kinematics & Dynamics definition – Definition of a linkage, mechanism and a machine – planar mechanisms- Kinematic pairs – Kinematic chains – Velocity analysis of planar and spatial mechanisms – Acceleration analysis of planar and spatial mechanisms – Analytical and Graphical methods for acceleration and velocity analysis – Kinetics and Kinematics of Robots.

Text Books/References

Beer F.P. and Johnston E.R., Vector Mechanics for Engineers - Volume I - Statics, Volume II - Dynamics, McGraw Hill, New York, 2004.

Merlam J.L and Kraige L.G., Engineering Mechanics, Volume I - statics, Volume 11- dynamics, John Wiley & Sons, New York, 2018.

Elementary Mechanics Using Matlab – Malthe&Sorenssen – Undetrgraduate Lecture Notes in Physics, Springer International Publishing, 2015.

Elementary Mechanics Using Python – Malthe&Sorenssen – Undetrgraduate Lecture Notes in Physics, Springer International Publishing, 2015.

Statics with Matlab – Marghitu, Dupac& Madsen, Springer – Verlag London 2013.

Advanced Dynamics - Marghitu, Dupac& Madsen, Springer – Verlag London 2013.

Shames L.H., Engineering Mechanics, Prentice HaII, New Delhi, 1996.

Hibbeler R. C., Engineering Mechanics: Statics and Dynamics, 11th edition, Pearson Education India, 2017.

Evaluation Pattern

Assessment	Weightage (%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE114	PRINCIPLES OF MEASUREMENTS & SENSORS	L-T-P-C: 1-1-3- 3

Course Objectives

- The main objective of this course is to familiarise the students with various sensing technologies and various sensors used in engineering.
- Students will be inspired to collect data using sensors and analyse& interpret the collected data.
- Further, the course will focus on equipping the students to interface various sensors with computing platforms

Course Outcomes

CO 1: To develop a basic understanding of the principles involved in measurements
CO 2: To introduce the state of the art sensors for various engineering applications.
CO 3: To enable the students to interface the sensors with computing platforms.
CO 4: To facilitate the students to understand the engineering applications of various sensors.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	3				3	2	3	3		
CO2	3	3	3	3	3				3	2	3	3		
CO3	3	2	3	3	3				3	2	3	3		
CO4	3	3	3	2	3				3	2	3	3		

Syllabus

Introduction to measurement systems and sensors, Overview of Introduction to Arduino and Raspberry-PI, Static and Dynamic Characteristics of measurement systems: Systematic Characteristics, Generalized model, Calibration errors , Review of Op-Amp Circuit, passive-and active-filters, Accuracy of measurement systems in steady state: Measurement error, Error probability function, Error reduction techniques, Physics -Principles and Applications of sensing elements, Thermal sensors, Mechanical sensors, Optical Sensors Intelligent measurement systems, Introduction to scalar and vector data type sensors, Analog to digital Converters, analog and Digital processing of sensor values.

Textbooks / References

E.O. Doebelin, D.N. Manik, Measurement systems, 6/E, Tata McGraw Hill, New Delhi, 2011.

J.P.Bentley, Principles of Measurement systems, 4/E, Pearson education ltd, UK, 2005.

G.C.M. Meijer, Smart Sensor Systems, Vol 10, John Wiley and Sons, UK, 2008.

Alan S. Morris, R. Langari, Measurement and Instrumentation; Theory and Application, Academic Press, USA, 2012.

Evaluation Pattern

Assessment	Weightage (%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE111	DATA STRUCTURES & ALGORITHMS 1	L-T-P-C: 2-1-3-4

Course Objectives

- This course aims at introducing the concept of data structure hierarchy.
- It will also expose the students to the basic and higher order data structures.
- Further the students will be motivated to apply the concept of data structures to various engineering problems.

Course Outcomes

CO1: To choose an appropriate data structure as applied to a specified problem
CO2: To introduce various techniques for representation of the data in the real world
CO3: To develop application using data structures.
CO4: To improve the logical ability

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	3				3	2	3	3		
CO2	3	3	3	3	3				3	2	3	3		
CO3	3	2	3	3	3				3	2	3	3		
CO4	3	3	3	2	3				3	2	3	3		

Syllabus

Data Structure Hierarchy – Primitive – datatypes and their representations, Interger, 2;s complement, IEEE756 Floating point-single and double precision – String and character representation types-Unicode and UTF-8 encodings- Predefined – Arrays and Structures- Records types-Class and Objects as Types- User Defined-Linear structures-, Array subscripting and indexing- Concept of pointers- pointers as array names, self-referential structure, List, Linked implementation- array implementation. Variations on basic List, Doubly linked list, indexed List, Skip lists, Vectors, Sets, Maps and Dictionaries as application of basic list. Higher order Concept Data Structures. Stacks- stack invariants-push and pop- invariant variables, stack array, stack list, applications of stack- nested bracket validation, postfix expression evaluation. Stack uses in Computers-recursion-some recursion examples-factorial and Fibonacci- Queue- invariants-enqueue and queue- invariant variables- circular queue array, queue list- applications of queue- job scheduling- variations on basic queue-Double ended Queue and Priority queue – Nonlinear structures – Binary tree- Binary search Tree (BST) and lexicographic ordering- array and list implementations -Complete binary tree array - Set using a BST list-applications of Binary Trees – Binary Heap Data structure-Heap order and Heapsort- heap as a priority queue-balanced binary trees and AVL self-balancing trees. some more tree based structures. Traversals of Binary trees Depth traversals- in-order, pre-order and post-order Breadth traversal. Reconstructions of Binary trees from traversals.

Textbooks/References

Alfred V Aho, John E Hopcroft, Jeffrey D Ullman. Data Structures & Algorithms, Pearson Publishers, 2002.

'Maria Rukadikar S. Data Structures & Algorithms, SPD Publishers, 2011.

Evaluation Pattern

Assessment	Weightage (%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE112	ELEMENTS OF COMPUTING SYSTEMS - 2	L-T-P-C: 2-0-3-3

Course Objectives

- This course is an integrative, project-oriented systems building course.
- The course exposes students to a significant body of computer science knowledge, gained through a series of hardware and software construction tasks.
- These tasks demonstrate how theoretical and applied techniques taught in other higher courses in AI are used in practice

Course Outcomes

CO1: To develop an understanding on basic computer architecture
CO2: To introduce the implementation of operating systems
CO3: To develop an understanding on the working of a modern computing system

CO-PO MAPPING

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	3				3	2	3	3		
CO2	3	3	3	3	3				3	2	3	3		
CO3	3	2	3	3	3				3	2	3	3		

Syllabus

Basic Computer Architecture-Instruction set and Machine language-MIPS instructions- add, subtract, bitwise operators, branches- CPI metric- Data path design for single clock. Data path for multi clock instructions-pipelining and pipeline faults-Control unit design-state based control – microprogramed control-Revising Assemblers. Virtual Machine I: Stack Arithmetic, Background VM Specification Part-1, Implementation and Perspective. Virtual Machine II: Program Control Background, VM Specification Part-2, Implementation, Perspective. High-Level Language: Background, The Jack Language Specification. Writing Jack Applications. Perspective. Compiler I - Syntax Analysis: Background, Specification, Implementation, Perspective. Compiler II - Code Generation: Background, Specification, Implementation, Perspective. Operating System: Background, the Jack OS Specification, Implementation, Perspective.

Textbooks/References

Hennessy, John L., and David A. Patterson. Computer architecture: a quantitative approach. Elsevier, 5th Edition, 2011.

Nisan, Noam, and Shimon Schocken. The elements of computing systems: building a modern computer from first principles. MIT press, 2005.

Evaluation Pattern

Assessment	Weightage (%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE113	INTRODUCTION TO ELECTRONICS	L-T-P-C:2-0-3-3

Course Objective

- The course will lay down the basic concepts and techniques of electronics needed for advanced topics in AI.
- It will explore the concepts initially through computational/hardware experiments and then try to understand the concepts/theory behind it.
- It will help the students to perceive the engineering problems using the fundamental concepts in electronics.

Course Outcome

CO 1: To introduce the basic concepts of analog and digital electronics.

CO 2: To enable the students to understand the application of electronics in communication engineering.

CO 3: To enable the students to model engineering problems in the perspective of electronics.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	3				3	2	3	3		
CO2	3	3	3	3	3				3	2	3	3		
CO3	3	2	3	3	3				3	2	3	3		

Syllabus

Semiconductor Devices : Diode - Zener circuits - BJT : simple biasing methods – MOSFET - DC Power supply – Flip-Flops- Counters - Adders - OPAMP based circuits including Schmitt trigger and astablemultivibrator - Feedback amplifiers - Oscillators - Boolean logic - basic gates - truth tables - logic minimization using K maps - combinatorial and sequential circuits - DAC and ADC - Introduction to Communication Engineering.

Textbooks/References

Jacob Millman and A. Grabel, `Microelectronics', Tata McGraw-Hill Publishers, Second Edition, New Delhi, 1999

RamakantGayakwad, `Op-amps and Linear Integrated circuits', Prentice Hall, New Delhi, 1988.

Evaluation Pattern

Assessment	Weightage (%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19BIO112	INTELLIGENCE OF BIOLOGICAL SYSTEMS 2	L-T-P-C: 1-0-3-2

Course Objective

- The course will aim at introducing the concepts pertaining to DNA replication and will equip the students to explore the question where in the genome does the DNA replication will begin.
- Further it will motivate the students to investigate the origin of various rhythms observed in human body such as circadian rhythm and how they are encoded in the DNA

Course Outcome

CO1: To investigate DNA replication.
CO2: To investigate the encodings in DNA to maintain various rhythms associated with the body.
CO3: To introduce state of the art computational algorithms to understand DNA encodings.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2	2	3	2	2		3	2	3	3		
CO2	1	3	3	2	3	2	2		3	2	3	3		
CO3	1	2	3	3	3	2	2		3	2	3	3		

Syllabus

DNA replication – genome - hidden messages in the genome - Python Programming and packages for Bioinformatics - Finding Replication Origins - DnaA boxes - Counting words - The Frequent Words Problem - Frequent words in Vibrio cholera – encodings in DNA to maintain circadian rhythm – Hunting for Regulatory Motifs - Motif Finding - Scoring Motifs - Greedy Motif Search - Randomized Motif Search - Gibbs Sampling.

Textbooks/References

1. Philip Compeau and PavelPevzener, Finding Hidden Messages in DNA, Active Learning Publishers 2015.

Evaluation Pattern

Assessment	Weightage (%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19CUL111	CULTURAL EDUCATION II	L-T-P-C: 2-0-0-2

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Course Objective

- To deepen students' understanding and further their knowledge about the different aspects of Indian culture and heritage.
- To in still into students a dynamic awareness and understanding of their country's achievements and civilizing influences in various fields and at various epochs.

Course Outcome

CO1: Get an overview of Indian contribution to the world in the field of science and literature.
CO2: Understand the foundational concepts of ancient Indian education system.
CO3: Learn the important concepts of Vedas and *Yogasutra*-s and their relevance to daily life.
CO4: Familiarize themselves with the inspirational characters and anecdotes from the *Mahābhārata* and *Bhagavad-Gītā* and Indian history.
CO5: Gain an understanding of Amma's role in the empowerment of women

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1						3	3					2		
CO2						1		3				2		
CO3						3	3	3				2		
CO4						3	3	3				2		
CO5						1		1						

Syllabus

Unit 1
To the World from India; Education System in India; Insights from Mahabharata; Human Personality. India's Scientific System for Personality Refinement.

Unit 2
The Vedas: An Overview; One God, Many Forms; Bhagavad Gita – The Handbook for Human Life; Examples of Karma Yoga in Modern India.

Unit 3
Chanakya's Guidelines for Successful Life; Role of Women; Conservations with Amma.

Text Book
Cultural Education Resource Material Semester-2

Reference Book(s)

Cultural Heritage of India. R.C.Majumdar. Ramakrishna Mission Institute of Culture.
The Vedas. Swami ChandrashekharaBharati. BharatiyaVidyaBhavan.
Indian Culture and India's Future. Michel Danino. DK Publications.
The Beautiful Tree. Dharmapal. DK Publications.
India's Rebirth. Sri Aurobindo. Auroville Publications.

Evaluation Pattern:

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

SEMESTER III

19MAT204 MATHEMATICS FOR INTELLIGENT SYSTEMS 3 L-T-P-C: 2- 0 -3- 3

Course Objectives

- The course will lay down the basic concepts and techniques of linear algebra, calculus and basic probability theory needed for subsequent study.
- It will explore the concepts initially through computational experiments and then try to understand the concepts/theory behind it.
- At the same time, it will provide an appreciation of the wide application of these disciplines within the scientific field.
- Another goal of the course is to provide connection between the concepts of linear algebra, differential equation and probability theory.

Course Outcomes

CO1: To develop an understanding of the basic concepts and techniques of linear algebra, calculus and basic probability theory needed for AI
CO2: To provide an appreciation of the wide application of these disciplines within the scientific field.
CO3: To provide connection between the concepts of linear algebra, differential equation and probability theory.
CO4: To develop an insight into the applicability of linear algebra in business and scientific domains.
CO5: To enable the students to understand the use of calculus and Linear algebra in modelling electrical and mechanical elements
CO6: To equip the students to understand the role of probability theory in providing data sets for computational experiments in data science

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3	---	---	---	3	2	3	3
CO2	3	3	3	3	3	2	---	---	3	2	3	3
CO3	3	2	3	3	3	---	---	---	3	2	3	3
CO4	3	3	3	2	3	---	---	---	3	2	3	3
CO5	3	2	3	3	3	---	---	---	3	2	3	3
CO6	3	3	3	3	3	2	---	---	3	2	3	3

Syllabus

Linear Algebra -3 - Highlights of Linear Algebra: Four Fundamental Spaces, Eigenvalues and Eigenvectors, SVD, PCA and best low rank matrix. Raleigh Quotients and Generalized Eigenvalues, Norms of vectors and

matrices, Factoring matrices and tensors. Computation with Large matrices: Krylov subspaces and Arnoldi iteration, Linear System solution by Arnoldi and GMRES, Conjugate gradient method. Calculus -3 - Theory of Optimization: (Convex and Non-convex basics) - Unconstrained optimization methods, Direct methods for convex functions, sparsity inducing penalty functions, Newton methods for non-convex functions. Constrained Convex Optimization problems, Formulating problems as LP and QP, support vector machines, solving by packages (CVXOPT) , Lagrangian multiplier method, KKT conditions, Introduction to Alternating direction method of multipliers- the algorithm. Applications in signal processing and pattern classification. Introduction to PDEs arising in Physics and Engineering (problem formulations and simple numerical methods for solutions). Probability and statistics-3 - Moments, cumulants, and inequalities of statistics, Covariance matrices and joint probabilities, Multivariate Gaussian and weighted least squares, Markov chains, Markov decision process - advanced aspects.

Text Book / Reference Books

'Differential Equations and Linear Algebra', Gilbert Strang, Wellesley, Cambridge press, 2018.
'Linear Algebra and learning from data', Gilbert Strang, Wellesley, Cambridge press, 2019.
'Convex Optimization', Stephen Boyd and LievenVandenberghe, Cambridge University Press, 2018
'Introduction to Applied Linear Algebra – Vectors, Matrices, and Least Squares', Stephen Boyd and LievenVandenberghe, Cambridge University Press, 2018

Evaluation Pattern

Assessment	Weightage (%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE201	INTRODUCTION TO ROBOTICS	L-T-P-C: 1- 2- 0- 3

Course Objectives

- To provide an introductory understanding of robotics.
- To introduce the mathematical concepts needed for understanding robotic operation.
- To introduce the various components of a robotic system such as vision, control and navigation.

Course Outcomes

CO 1: To explain the fundamentals of robotics and its components
CO 2: To understand the mathematical concepts needed for robotics
CO 3: To understand the various sub-systems in a robotic system

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	3	3	---	---	3	3	3	3		
CO2	3	3	2	2	3	1	---	---	3	3	3	3		
CO3	3	2	3	2	3	2	---	---	3	3	3	3		

Syllabus

Introduction to robots – History – Types of robots – Technology and basic principles of robots – Mathematical representation of robots – Position and orientation of rigid bodies – Rotation and Orientation - Quaternions – Transformation Matrix – D-H parameters – Introduction to sensors in robotics – Introduction to Navigation – Introduction to robotic vision.

Text Book / Reference Books

'Robotics, Vision & Control'P. Corke, 2nd edition, Springer, 2011
'Robot Modeling and Control', M.W. Spong, S. Hutchinson and M. Vidyasagar, , Wiley, 2006
'Robotics: Fundamental Concepts & Analysis', A. Ghosal, Oxford University Press, Ninth Edition, 2006
'Introduction to Robotics', T. Bajd, M. Mihelj and M. Munih, Springer Briefs in Applied Sciences and Technology, 2013
'Introduction to AI Robotics', Robin Murphy, MIT Press, 2000

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE202	OPERATING SYSTEMS	L-T-P-C: 2- 1- 3- 4

Course Objectives

- This course examines the important problems in operating system design and implementation.
- The operating system provides an established, convenient, and efficient interface between user programs and the bare hardware of the computer on which they run.
- Understanding the operating system responsibilities like sharing resources (e.g., disks, networks, and processors), providing common services needed by many different programs (e.g., file service, the ability to start or stop processes, and access to the printer), and protecting individual programs from interfering with one another.
- The course will start with a brief historical perspective of the evolution of operating systems over the last fifty years and then cover the major components of most operating systems.
- This discussion will cover the trade-offs that can be made between performance and functionality during the design and implementation of an operating system.
- Particular emphasis will be given to three major OS subsystems: process management (processes, threads, CPU scheduling, synchronization, and deadlock), memory management (segmentation, paging, swapping), and file systems; and on operating system support for distributed systems

Course outcomes

CO1: Understanding the fundamentals of operating system design and implementation.
CO2: Understanding various operating system functionalities by programming.
CO3: This knowledge will help you to more effectively use and manipulate computers and computer programs.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	---	---	3	2	3	3
CO2	3	3	3	3	3	2	---	---	3	2	3	3
CO3	3	3	3	3	3	2	---	---	3	2	3	3

Syllabus

Introduction and history of Operating systems, structure and operations; processes and files; Processor management: inter process communication, process scheduling and algorithms, critical sections, threads, multithreading; Memory management: contiguous memory allocation, virtual memory, paging, page table structure, demand paging, page replacement policies, thrashing, segmentation, case study; Deadlock: Shared resources, resource allocation and scheduling, resource graph models, deadlock detection, deadlock avoidance, deadlock prevention algorithms, mutual exclusion, semaphores, wait and signal procedures; Device management: devices and their characteristics, device drivers, device handling, disk scheduling algorithms and policies, File management: file concept, types and structures, directory structure, cases studies, access methods and matrices, file security, user authentication; UNIX operating system as a case study.

Text Books / Reference Books

'Operating System concepts and principles', Silberschatzand P.B. Galvin, Wiley India, 8th ed., 2009
'Modern Operating Systems', Tanenbaum, PrenticeHall India, 2003
'Operating Systems: Internals and designPrinciples', W. Stallings, Pearson Ed., LPE, 6th Ed., 2009
'Design of Unix Operating system', M.J. Bach, PrenticeHall, 1986

Evaluation Pattern

Assessment	Weightage (%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE203	DATA STRUCTURES & ALGORITHMS 2	L-T-P-C: 2- 1- 3- 4

Course Objectives

- To provide an in-depth understanding of Abstract Data types
- To implement and understand space and time optimizing structures and learn their behaviours
- To comprehend multidimensionality in memory structures
- To understand geometric organization of data
- To comprehend concepts of space-building and immutability in functional data structure
- Understand graphical structures and use them in solving problems

Course Outcomes

CO1: Use and design data structures in problem solving**.**
CO2: Understand interoperability of advanced data structures.
CO3: Visualize multidimensional geometry of data structure and concurrency.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	---	---	3	3	1	3
CO2	3	3	3	3	2	1	---	---	2	3	2	3
CO3	3	2	2	3	3	1	---	---	3	3	2	3

Syllabus

Revisiting BSTs, Heaps and AVL trees- Stacks and Queue implementations under constraints, Stack with queue and Queue with stack, union and intersections of tree structures- Complexity comparisons - Sparse Matrices- Key Value and Structural implementations, Scalability and data driven parallelism, Block and band matrices. Generalized Matrix and Vector interface. Standard implementations in Numpy (Python) and NDArray (Java) - Temporal manipulation and persistence - Functional data structures, ConsList, immutable Set, Immutable Maps, Sorting immutable linear structures (functional sort). Map and Reduce Operations on Sequences, Retroactive structures and operations – Geometric structures- Point location and sweeping, Orthogonal Range searches and fractional cascading in 2D and 3D. -Higher data structures - Tries and inverted Tries-Hashing and Hash Tables – Hash functions, Radix Sort, Higher Hash functions, SHA256, Hash Tables, Chaining of Hash Lists (Blockchain) and change detection, Merkel trees- Distributed bitwise representations and Fusion trees - Large string structures(Google and DNA problems) – Graphs- Representations of graphs, Adjacency and Incidence matrices, Adjacency List, Dynamic Graphs and persistence.

Text Books / Reference Books

'Advanced Data Structures Hardcover', – 8 Sep 2008
'Data Structures and Algorithms with Scala: A Practitioner's Approach with Emphasis on Functional Programming', Bhim P Upadhyaya
'Introduction to Algorithms', Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein, Third edition, The MIT Press, 2009

Evaluation Pattern

Assessment	Weightage (%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE204	INTRODUCTION TO COMMUNICATION SYSTEMS	L-T-P-C: 1- 2- 0- 3

Course Objective

- Starting from the basic understanding of analog communications systems, the objective of the course is to focus more on the digital modulation and demodulation techniques used extensively in modern day communication systems.
- Students will also be trained to develop an understanding on various software defined radio systems .

Course Outcomes

CO1: Develop an understanding on the basic analog Communication Engineering.
CO2: Develop an understanding on the digital communication techniques (ASK, PSK, FSK, OFDM).
CO3: Develop an understanding on software defined radios (USRP), GNU Radio, GRC (GNU Radio Companion).

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	3	---	---	2	2	1	1
CO2	3	3	3	3	3	3	---	---	3	3	3	3
CO3	3	3	3	3	3	3	---	---	3	3	3	3

Syllabus

Signal types, Spectral domain representation of periodic signals, characteristics of noise and interference in wireless channels, filters,(low-pass, bandpass and matched (correlation) and understand their impact on the performance of a communication system. Analog modulation schemes, FM and AM, and specify the effect of system parameters (such as carrier frequency, bandwidth, rate) on performance. Specifying Quantifying the effect of ADC and DAC on wireless system performance, digital modulation schemes (PSK, DPSK, GMSK, QPSK and QAM) , effects system parameters and synchronization errors on digital modulation schemes, multipath effects of wireless channels and demonstrate their compensation with equalization. multicarrier (OFDM) modulation and its performance. Performance predictions of wireless communications with software-defined radios. Prospects for AI in communication systems.

Text Books / Reference Books

'Software-Defined Radio for Engineers', Collins, Travis F, Getz, Robin, Pu, Di, Wyglinski and Alexander M, ArtechHosue, 2018
'Wireless Communications from the Ground Up: An SDR Perspective', QasimChaudhari, 2018
'Software Defined Radio: for Amateur Radio Operators and Shortwave Listeners', Andrew Barron, 2019
'Software Receiver Design: Build Your Own Digital Communication System in Five Easy Steps', C.R. Johnson and W.A. Sethares, Cambridge University Press, 2011
'Contemporary Communication Systems Using Matlab', J. Proakis and Salehi, PWS, 1998
'Digital Communication Receivers', H. Meyr, M. Moeneclaey and S. A. Fechtel, Wiley, 1997
'Digital Communication Systems Engineering with Software-Defined Radio', Di Pu, Alexander M. Wyglinski, ArtechHosue, 2013

Evaluation Pattern

Assessment	Weightage (%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19BIO201	INTELLIGENCE OF BIOLOGICAL SYSTEMS 3	L-T-P-C: 1- 2 - 0 -3

Course Objectives

- To introduce the basic concepts of bioinformatics using computational methods
- To introduce the programming for bioinformatics.
- To explore the challenges and the potential of Artificial Intelligence in bioinformatics.

Course Outcomes

CO1: To understand the basics of assembling genomes using computational methods.
CO2: To learn the python programming for bioinformatics.
CO3: To explore the potential challenges and applications of computational bioinformatics.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	3	3	---	3	3	3	3		
CO2	3	3	3	3	3	3	3	---	3	3	3	3		
CO3	3	3	3	3	3	3	3	---	3	3	3	3		

Syllabus

Assembling Genomes using Graph algorithms: the string reconstruction problem – string reconstruction as a walk in the overlap graph – gluing nodes – de Bruijn graphs – the seven bridges of Konigsberg Euler's theorem – from Euler's theorem to an algorithm for finding Eulerian Cycle – assembling genomes from read-pairs – Python programming for bioinformatics.

Text Book / Reference

'Bioinformatics algorithm, An active learning Approach', Phillip Compeauand Pavel PevznerVol.1. and Vol. 2 , 2015.
'Essential Bioinformatics', JinXiong, Cambridge University Press, 2006

Evaluation pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE205	PYTHON FOR MACHINE LEARNING	L-T-P-C: 0- 0- 3- 1

Course Objective

- This course dives into the basics of Machine Learning using Python - an approachable and well-known programming language.
- The students will learn about Supervised Vs Unsupervised Learning, look into how Statistical Modeling relates to Machine Learning, and do a comparison of each
- The students will enrich with the hands on experience in python to implement various machine learning algorithms
- It will also enable the student to work with various types of data and its pre-processing techniques required to apply machine learning algorithms

.

Course Outcomes

CO1: To develop an understanding on python programming for machine learning.
CO2: Implementation of machine learning algorithms in python.
CO3: Data preprocessing and implementation of machine learning algorithms in python for different data

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	3	2	3	2	2	---	3	2	3	3
CO2	2	2	3	2	3	2	2	---	3	2	3	3
CO3	2	3	3	2	3	2	2	---	3	2	3	3

Syllabus

Introduction to python programming – Variables, data structures, control statements and library management, Introduction to python scientific computing packages and management, introduction to data preprocessing in python, implementation of machine learning algorithms and package management, visualization of data and results obtained by machine learning algorithms, implementation of metrics for validating machine learning results for various data using python.

Text Books / Reference Books

'Introduction to machine learning with Python: a guide for data scientists', Müller, A. C., and Guido, S, O'Reilly Media, Inc, 2016

'Python Machine Learning From Scratch: The Ultimate Step By Step Beginner's Guides To Deep Learning, Machine Learning, and Neural Networks', Dark, S, Independently published, 2018

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19LAW300	INDIAN CONSTITUTION	L-T-P-C: P/F

Course Objective

- To know about Indian constitution.
- To know about central and state government functionalities in India
- To know about Indian society

Course Outcomes

CO1: Understand the functions of the Indian government
CO2: Understand and abide the rules of the Indian constitution
CO3: Understand and appreciate different culture among the people

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	3	2	3	-	-	-	-	-	-
CO2	-	-	-	-	-	3	2	3	-	-	-	-	-	-
CO3	-	-	-	-	-	3	2	3	-	-	-	-	-	-

Syllabus

Unit 1
Historical Background – Constituent Assembly Of India – Philosophical Foundations Of The Indian Constitution – Preamble – Fundamental Rights – Directive Principles Of State Policy – Fundamental Duties – Citizenship – Constitutional Remedies For Citizens.

Unit 2
Union Government – Structures of the Union Government and Functions – President – Vice President – Prime Minister – Cabinet – Parliament – Supreme Court of India – Judicial Review.

Unit 3
State Government – Structure and Functions – Governor – Chief Minister – Cabinet – State Legislature – Judicial System in States – High Courts and other Subordinate Courts.

Text Book(s)
Durga Das Basu, "Introduction to the Constitution of India ", Prentice Hall of India, New Delhi.
R.C.Agarwal, (1997) "Indian Political System", S.Chand and Company, New Delhi.

Reference(s)
Sharma, Brij Kishore, "Introduction to the Constitution of India", Prentice Hall of India, New Delhi.

Evaluation Pattern

Assessment	Internal	External
Online Test	-	100
		P/F

19AVP201	AMRITA VALUES PROGRAM I	L-T-P-C: 1-0-0 -1

Amrita University's Amrita Values Programme (AVP) is a new initiative to give exposure to students about richness and beauty of Indian way of life. India is a country where history, culture, art, aesthetics, cuisine and nature exhibit more diversity than nearly anywhere else in the world.

Amrita Values Programmes emphasize on making students familiar with the rich tapestry of Indian life, culture, arts, science and heritage which has historically drawn people from all over the world.

Students shall have to register for any two of the following courses, one each in the third and the fourth semesters, which may be offered by the respective school during the concerned semester.

Course Outcome

CO1: Understanding the impact of *itihasas* on Indian civilization with a special reference to the *Adiparva* of Mahabharata

CO2: Enabling students to importance offighting*adharma* for the welfare of the society through Sabha and Vanaparva.

CO3: Understanding the nuances of dharma through the contrast between noble and ignoble characters of the epic as depicted in the Vana, Virata, Udyoga and Bhishmaparvas.

CO4: Getting the deeper understanding of the Yuddha Dharma through the subsequent Parvas viz., Drona, Karna,
Shalya, SauptikaParvas.

CO5: Making the students appreciative of spiritual instruction on the ultimate triumph of dharma through the presentations of the important episodes of the MB with special light on Shanti, Anushasana, Ashwamedhika, Ashramavasika, Mausala, Mahaprasthanika and SwargarohanaParvas.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	2	2	3	3	3	-	3	-	-
CO2	-	-	-	-	-	3	3	3	3	2	-	3	-	-
CO3	-	-	-	-	-	3	2	3	3	3	-	3	-	-
CO4	-	-	-	-	-	3	-	3	3	3	-	3	-	-
CO5	-	-	-	-	-	3	-	3	3	2	-	3	-	-

Courses offered under the framework of Amrita Values Programmes I and II

Message from Amma's Life for the Modern World

Amma's messages can be put to action in our life through pragmatism and attuning of our thought process in a positive and creative manner. Every single word Amma speaks and the guidance received in on matters which we consider as trivial are rich in content and touches the very inner being of our personality. Life gets enriched by Amma's guidance and She teaches us the art of exemplary life skills where we become witness to all the happenings around us still keeping the balance of the mind.

Lessons from the Ramayana

Introduction to Ramayana, the first Epic in the world – Influence of Ramayana on Indian values and culture – Storyline of Ramayana – Study of leading characters in Ramayana – Influence of Ramayana outside India – Relevance of Ramayana for modern times.

Lessons from the Mahabharata
Introduction to Mahabharata, the largest Epic in the world – Influence of Mahabharata on Indian values and culture – Storyline of Mahabharata – Study of leading characters in Mahabharata – Kurukshetra War and its significance - Relevance of Mahabharata for modern times.

Lessons from the Upanishads
Introduction to the Upanishads: Sruti versus Smrti - Overview of the four Vedas and the ten Principal Upanishads - The central problems of the Upanishads – The Upanishads and Indian Culture – Relevance of Upanishads for modern times – A few Upanishad Personalities: Nachiketas, SatyakamaJabala, Aruni, Shvetaketu.

Message of the Bhagavad Gita
Introduction to Bhagavad Gita – Brief storyline of Mahabharata - Context of Kurukshetra War – The anguish of Arjuna – Counsel by Sri. Krishna – Key teachings of the Bhagavad Gita – Karma Yoga, Jnana Yoga and Bhakti Yoga - Theory of Karma and Reincarnation – Concept of Dharma – Concept of Avatar - Relevance of Mahabharata for modern times.

Life and Message of Swami Vivekananda
Brief Sketch of Swami Vivekananda's Life – Meeting with Guru – Disciplining of Narendra - Travel across India - Inspiring Life incidents – Address at the Parliament of Religions – Travel in United States and Europe – Return and reception India – Message from Swamiji's life.

Life and Teachings of Spiritual Masters India
Sri Rama, Sri Krishna, Sri Buddha, AdiShankaracharya, Sri Ramakrishna Paramahamsa, Swami Vivekananda, Sri RamanaMaharshi, Mata Amritanandamayi Devi.

Insights into Indian Arts and Literature
The aim of this course is to present the rich literature and culture of Ancient India and help students appreciate their deep influence on Indian Life - Vedic culture, primary source of Indian Culture – Brief introduction and appreciation of a few of the art forms of India - Arts, Music, Dance, Theatre.

Yoga and Meditation
The objective of the course is to provide practical training in YOGA ASANAS with a sound theoretical base and theory classes on selected verses of Patanjali's Yoga Sutra and Ashtanga Yoga. The coverage also includes the effect of yoga on integrated personality development.

Kerala Mural Art and Painting
Mural painting is an offshoot of the devotional tradition of Kerala. A mural is any piece of artwork painted or applied directly on a wall, ceiling or other large permanent surface. In the contemporary scenario Mural painting is not restricted to the permanent structures and are being done even on canvas. Kerala mural paintings are the frescos depicting mythology and legends, which are drawn on the walls of temples and churches in South India, principally in Kerala. Ancient temples, churches and places in Kerala, South India, display an abounding tradition of mural paintings mostly dating back between the 9th to 12th centuries when this form of art enjoyed Royal patronage. Learning Mural painting through the theory and practice workshop is the objective of this course.

Course on Organic Farming and Sustainability
Organic farming is emerging as an important segment of human sustainability and healthy life. Haritamritam' is an attempt to empower the youth with basic skills in tradition of organic farming and to revive the culture of growing vegetables that one consumes, without using chemicals and pesticides. Growth of Agriculture through such positive initiatives will go a long way in nation development. In Amma'swords "it is a big step in restoring the lost harmony of nature".

Benefits of Indian Medicinal Systems
Indian medicinal systems are one of the most ancient in the world. Even today society continues to derive enormous benefits from the wealth of knowledge in Ayurveda of which is recognised as a viable and sustainable

medicinal tradition. This course will expose students to the fundamental principles and philosophy of Ayurveda and other Indian medicinal traditions.

Traditional Fine Arts of India

India is home to one of the most diverse Art forms world over. The underlying philosophy of Indian life is 'Únity in Diversity" and it has led to the most diverse expressions of culture in India. Most art forms of India are an expression of devotion by the devotee towards the Lord and its influence in Indian life is very pervasive. This course will introduce students to the deeper philosophical basis of Indian Art forms and attempt to provide a practical demonstration of the continuing relevance of the Art.

Science of Worship in India

Indian mode of worship is unique among the world civilisations. Nowhere in the world has the philosophical idea of reverence and worshipfulness for everything in this universe found universal acceptance as it in India. Indian religious life even today is a practical demonstration of the potential for realisation of this profound truth. To see the all-pervading consciousness in everything, including animate and inanimate, and constituting society to realise this truth can be seen as the epitome of civilizational excellence. This course will discuss the principles and rationale behind different modes of worship prevalent in India.

TEXT BOOKS/REFERENCES:

1. Rajagopalachari. C, *The Ramayana*

2. Valmiki, *The Ramayana*, Gita Press

SEMESTER IV

19MAT212	MATHEMATICS FOR INTELLIGENT SYSTEMS 4	L-T-P-C:2-0-3-3

Course Objectives

- The course will lay down the basic concepts and techniques of linear algebra, calculus and basic probability theory needed for subsequent study.
- It will explore the concepts initially through computational experiments and then try to understand the concepts/theory behind it.
- At the same time, it will provide an appreciation of the wide application of these disciplines within the scientific field.
- Another goal of the course is to provide connection between the concepts of linear algebra, differential equation and probability theory

Course Outcomes

CO1: To develop an understanding of the basic concepts and techniques of linear algebra, calculus and basic probability theory needed for AI.
CO2: To provide an appreciation of the wide application of these disciplines within the scientific field.
CO3: To provide connection between the concepts of linear algebra, differential equation and probability theory.
CO4: To develop an insight into the applicability of linear algebra in business and scientific domains.
CO5: To enable the students to understand the use of calculus and Linear algebra in modelling electrical and mechanical elements.
CO6: To equip the students to understand the role of probability theory in providing data sets for computational experiments in data science

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3	---	---	---	3	2	3	3
CO2	3	3	3	3	3	2	---	---	3	2	3	3
CO3	3	2	3	3	3	---	---	---	3	2	3	3
CO4	3	3	3	2	3	---	---	---	3	2	3	3
CO5	3	2	3	3	3	---	---	---	3	2	3	3
CO6	3	3	3	3	3	2	---	---	3	2	3	3

Syllabus

Linear Algebra-4 - Special Matrices: Fourier Transform, discrete and Continuous, Shift matrices and Circulant matrices, The Kronecker product, Toeplitz matrices and shift invariant filters, Graphs and Laplacians and Kirchhoff's laws, Clustering by spectral methods and K-means, Completing rank one matrices, The Orthogonal Procrustes Problem, Distance matrices. Calculus-4 - Optimization methods for sparsity: Split algorithm for L2+ L1, Split algorithm for L1 optimization, Augmented Lagrangian, ADMM, ADMM for LP and QP, Matrix splitting and Proximal algorithms, Compressed sensing and Matrix Completion. Optimization methods for Neural Networks: Gradient Descent, Stochastic gradient descent and ADAM (adaptive methods), Loss function

and learning function. Probability and statistics – 4 - Basics of statistical estimation theory and testing of hypothesis.

Text Books / Reference Books

'Linear Algebra and learning from data', Gilbert Strang, Wellesley, Cambridge press, 2019.
'Computer Age Statistical Inference, Algorithms, Evidence and Data Science', Bradley Efronand Trevor Hastie
'Convex Optimization', Stephen Boyd andLievenVandenberghe, Cambridge University Press, 2018
'Introduction to Applied Linear Algebra – Vectors, Matrices, and Least Squares', Stephen Boyd andLievenVandenberghe, Cambridge University Press, 2018

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE211	INTRODUCTION TO COMPUTER NETWORKS	L-T-P-C:2-0-3-3

Course Objectives

- The primary course objective is to provide the importance of computer networks in the era of Artificial intelligence.
- Enable the student to understand the fundamental networking principles, standards, protocols and technologies.
- The course also provide insights into concepts of the internet of things and its various applications.
- The course will enrich the students with hands on experience in creating physical networks and developing network applications using Raspberry-PI.
- The course also provides an introduction to the modern software defined networks and its applications.

Course Outcomes

CO1: To develop an understanding of computer networking and its applications.
CO2: Developing and managing computer networks using Raspberry- pi.
CO3: Lay down the networking concepts to develop network applications and internet of things.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	3	2	3	2	2	---	3	2	3	3
CO2	2	2	3	2	3	2	2	---	3	2	3	3
CO3	2	3	3	2	3	2	2	---	3	2	3	3

Syllabus

Introduction to wired/wireless network principles, organization, topologies, hardware, applications, and protocols in the context of the Internet protocol stack. Configuration and implementation of local area networks and intranets. Internet protocols, packet forwarding, and routing. Network software development using raspberry-PI, Basic Network implementation using raspberry –PI, Network administration using raspberry –PI, Introduction to IOT and Software Defined networking.

Text Books / Reference Books

'Computer Networks Title: Computer Networking: A Top-Down Approach', Tanenbaum, A., Wetherall, D., Kurose, J., and Ross, K, Wellesley, Instructor, 2019.
'Raspberry Pi networking Cook Book – Second Edition', Rick Golden, 2017

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE212	DESIGN AND ANALYSIS OF ALGORITHMS	L-T-P-C:2-0-3-3

Course Objectives

- To impart various design techniques for formulation of algorithm.
- To understand basic categories of algorithms.
- To understand and apply analysis of space and time complexity of algorithms and understand concept of growth rate.
- To deliver standard notations and representations of algorithmic complexity and known complexities.
- To comprehend basic complexity classes.
- To acquaint with will know tractable and intractable problems and map solutions to it.

Course Outcomes

CO1: To develop an understanding of computer networking and its applications.
CO2: Map problems to know class of tractable or intractable problems.
CO3: Analyze and compare various algorithms for the same problem.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	1	1	3	3	2	3
CO2	3	3	3	3	2	1	---	---	3	3	3	3
CO3	3	3	3	3	2	1	---	---	3	3	3	3

Syllabus

Notion of an Algorithm – Fundamentals of Algorithmic Problem Solving – Important Problem Types – Fundamentals of the Analysis of Algorithmic Efficiency –Asymptotic Notations and growth rate- Empirical analysis – Recursive and non-Recursive Templates. Brute Force: Exhaustive Search and String Matching, – Travelling Salesman Problem – Knapsack Problem – Assignment problem. Divide and Conquer Methodology: Binary Search – Merge sort – Quick sort – Heap Sort – Multiplication of Large Integers.: Dynamic programming: Principle of optimality – Coin changing problem, Computing a Binomial Coefficient – Floyd‘s algorithm – Multi stage graph – Optimal Binary Search Trees – Knapsack Problem and Memory functions. Greedy Technique: Container loading problem – Huffman Trees. Iterative methods: The Simplex Method – The Maximum-Flow Problem – Maximum Matching in Bipartite Graphs, Stable marriage Problem. Measuring Limitations: Lower – Bound Arguments – P, NP NP- Complete and NP Hard Problems. Backtracking – n-Queen problem – Hamiltonian Circuit Problem – Subset Sum Problem. Branch and Bound – LIFO Search and FIFO search – Assignment problem – Knapsack Problem – Travelling Salesman Problem – Approximation Algorithms for NP-Hard Problems – Travelling Salesman problem – Knapsack problem revisited.

Text Books / Reference Books

‘Analysis of Algorithms’, Jeffrey J McConnel,Jones and Bartlett Publishers,Inc; 2nd Revised edition edition, 2 November 2007
‘Introduction to the Design and Analysis of Algorithms’, Anany Levitin, Third Edition, Pearson Education, 2012
‘Algorithms Design and Analysis’, Harsh Bhasin, Oxford university press, 2016

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE213	ROBOTIC OPERATING SYSTEMS & ROBOT SIMULATION	L-T-P-C:2-0-3-3

Course Objectives

- The course will provide an introduction to Robotic Operating System platform.
- The course will enrich the students with various module developments in ROS for Robot control, Navigation and environment mapping.
- The course will also deliver the multiple robot communication and control using ROS.
- The final goal of the course will be designing a ROS module for the robotic system designed by the student.

Course Outcomes

CO1: To develop simple applications to control robot motion.
CO2: To master the basics of ROS module development for robots.
CO3: To program the robots to perform simple and specific tasks.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	3	3	---	---	3	3	3	3
CO2	3	2	3	2	3	2	---	---	3	3	3	3
CO3	3	2	3	2	3	3	---	---	3	3	3	3

Syllabus

ROS concepts - Preliminaries – Publishing a topic – Subscribing to a topic – Latched topics – Defining message types – Mixing Publishers and subscribers – Services – Defining a service – Implementing a service – Using a service – Actions – Definition of an Action – Implementing a basic action server – Robots and Simulators – Sub systems – Actuation: Mobile platform – Actuation manipulator arm – Cameras and Scanners.

Text Books / Reference Books

'Programing Robots with ROS', M. Quigley, B. Gerkey, and W. D. Smart, Oreilly Publishers, 2015.
'ROS Robotics by example', Fairchild & Harman, PACKT Publishing, 2016
'Introduction to Robotics', T. Bajd, M. Mihelj and M. Munih, Springer Briefs in Applied Sciences and Technology, 2013
'Introduction to AI Robotics', Robin Murphy, MIT Press, 2000

Evaluation Pattern

Assessment	Weightage (%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE214	BIG DATA ANALYTICS	L-T-P-C:2-0-3-3

Course Objectives

- To understand how to use Big data frameworks and APIs.
- To conceptualize data analysis.
- To learn about various data processing and pipelining strategies.
- To understand and visualize map-reduce computing paradigm.
- To learn the intricate and distributed working of Big Data clusters
- To train and impart the skills required for managing and balancing large data clusters

Course Outcomes

CO1: Understand the basic data abstraction and imbibe the map-reduce skillset.
CO2: Will know about general data pipelining and use to design data analytics solutions.
CO3: Will comprehend and visualize data as tuples and key-value pairs and solve problems using active analytics.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	---	---	2	2	3	2
CO2	3	3	3	3	3	2	---	---	3	3	3	3
CO3	3	3	3	3	3	1	---	---	2	3	3	2

Syllabus

Hadoop ecosystem in Brief – Basic Paradigm and system architecture, MapRed and HDFS, Making a small Hadoop cluster – Iterative and non-Iterative batch processing, Data stores, HBASE, HIVE, PIG- New generation Big data using Functional Programming in Scala: Basic Syntax- type inference and static types-function types and value types, closures. Immutability and immutable types-generic type Parameters-Recursive arbitrary collections – ConsList - Iterative arbitrary collections-Arrays-Tail recursion- factorial example-functional abstractions with examples-square root, fixed point, sequence summations. Higher order functions-MapReduce Template-Pattern Matching syntax. Similar higher order (Cons) List operations on arbitrary Collections-filter, fold, partition, span. Basic entity classes and objects in Scala. Apache Spark: - Resilient Distributed Datasets - Creating RDDs, Lineage and Fault tolerance, DAGs, Immutability, task division and partitions, transformations and actions, lazy evolutions and optimization - Formatting and housing data from spark RDDs--Persistence. Setting up a standalone Spark cluster-: spark-shell, basic API, Modules-Core, Key/Value pairs and other RDD features, MLlib-examples for bi-class SVM and logistic regression..

Text Books / Reference Books

'Learning Spark: Lightning-Fast Big Data Analysis', Holden Karau , Andy Konwinski, Patrick Wendell andMateiZaharia, 1st Edition

'Programming in Scala: A Comprehensive Step-by-Step Guide', Martin Odersky, Lex Spoon and Bill Venners,Third Edition

'High Performance Spark: Best Practices for Scaling and Optimizing Apache Spark', Holden Karau, Rachel Warren, 1st Edition

'Scala for the Impatient', Cay S. Horstmann, 2nd Edition
'Spark: The Definitive Guide: Big Data Processing Made Simple', Bill Chambers and MateiZaharia, 1st Edition

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19BIO211	INTELLIGENCE OF BIOLOGICAL SYSTEMS 4	L-T-P-C:1-2-0-3

Course Objectives

- To introduce the basic concepts of biological sequences using computational methods.
- To introduce the programming for bioinformatics.
- To explore the challenges and the potential applications of bioinformatics databases.

Course Outcomes

CO1: To understand the basics of biological sequences using computational methods.
CO2: To learn the python programming for bioinformatics.
CO3: To explore the potential challenges and applications of bioinformatics databases.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	3	---	3	3	3	3
CO2	3	3	3	3	3	3	3	---	3	3	3	3
CO3	3	3	3	3	3	3	3	---	3	3	3	3

Syllabus

Antibiotics Sequencing – Shattering into pieces – Brute force algorithm for Cyclopeptide Sequencing – Mass Spectrometry- From 20 to more than 100 Amino Acids – Comparison of biological sequences – Cracking the Non-Ribosomal Code – Introduction to Sequence Alignment – Introduction to Dynamic Programming, Sequence alignment as building a Manhattan-like graph - Bioinformatics databases - Python programming for bioinformatics - Introduction to Deep learning in Bioinformatics.

Text Books / Reference Books

'Bioinformatics algorithm, An active learning Approach', Phillip Compeauand Pavel Pevzner, Vol.1. and Vol. 2, 2015.
'Essential Bioinformatics', JinXiong, Cambridge University Press, 2006

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AVP211	AMRITA VALUES PROGRAM II	L-T-P-C: 1- 0-0 -1

Amrita University's Amrita Values Programme (AVP) is a new initiative to give exposure to students about richness and beauty of Indian way of life. India is a country where history, culture, art, aesthetics, cuisine and nature exhibit more diversity than nearly anywhere else in the world.

Amrita Values Programmes emphasize on making students familiar with the rich tapestry of Indian life, culture, arts, science and heritage which has historically drawn people from all over the world.

Students shall have to register for any two of the following courses, one each in the third and the fourth semesters, which may be offered by the respective school during the concerned semester.

Course Outcome

CO1: Understanding the impact of *itihasas* on Indian civilization with a special reference to the *Adiparva* of Mahabharata

CO2: Enabling students to importance offighting*adharma* for the welfare of the society through Sabha and Vanaparva.

CO3: Understanding the nuances of dharma through the contrast between noble and ignoble characters of the epic as depicted in the Vana, Virata, Udyoga and Bhishmaparvas.

CO4: Getting the deeper understanding of the Yuddha Dharma through the subsequent Parvas viz., Drona, Karna,
Shalya, SauptikaParvas.

CO5: Making the students appreciative of spiritual instruction on the ultimate triumph of dharma through the presentations of the important episodes of the MB with special light on Shanti, Anushasana, Ashwamedhika, Ashramavasika, Mausala, Mahaprasthanika and SwargarohanaParvas.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	2	2	3	3	3	-	3	-	-
CO2	-	-	-	-	-	3	3	3	3	2	-	3	-	-
CO3	-	-	-	-	-	3	2	3	3	3	-	3	-	-
CO4	-	-	-	-	-	3	-	3	3	3	-	3	-	-
CO5	-	-	-	-	-	3	-	3	3	2	-	3	-	-

Courses offered under the framework of Amrita Values Programmes I and II

Message from Amma's Life for the Modern World

Amma's messages can be put to action in our life through pragmatism and attuning of our thought process in a positive and creative manner. Every single word Amma speaks and the guidance received in on matters which we consider as trivial are rich in content and touches the very inner being of our personality. Life gets enriched by Amma's guidance and She teaches us the art of exemplary life skills where we become witness to all the happenings around us still keeping the balance of the mind.

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Introduction to Ramayana, the first Epic in the world – Influence of Ramayana on Indian values and culture – Storyline of Ramayana – Study of leading characters in Ramayana – Influence of Ramayana outside India – Relevance of Ramayana for modern times.

Lessons from the Mahabharata
Introduction to Mahabharata, the largest Epic in the world – Influence of Mahabharata on Indian values and culture – Storyline of Mahabharata – Study of leading characters in Mahabharata – Kurukshetra War and its significance - Relevance of Mahabharata for modern times.

Lessons from the Upanishads
Introduction to the Upanishads: Sruti versus Smrti - Overview of the four Vedas and the ten Principal Upanishads - The central problems of the Upanishads – The Upanishads and Indian Culture – Relevance of Upanishads for modern times – A few Upanishad Personalities: Nachiketas, SatyakamaJabala, Aruni, Shvetaketu.

Message of the Bhagavad Gita
Introduction to Bhagavad Gita – Brief storyline of Mahabharata - Context of Kurukshetra War – The anguish of Arjuna – Counsel by Sri. Krishna – Key teachings of the Bhagavad Gita – Karma Yoga, Jnana Yoga and Bhakti Yoga - Theory of Karma and Reincarnation – Concept of Dharma – Concept of Avatar - Relevance of Mahabharata for modern times.

Life and Message of Swami Vivekananda
Brief Sketch of Swami Vivekananda's Life – Meeting with Guru – Disciplining of Narendra - Travel across India - Inspiring Life incidents – Address at the Parliament of Religions – Travel in United States and Europe – Return and reception India – Message from Swamiji's life.

Life and Teachings of Spiritual Masters India
Sri Rama, Sri Krishna, Sri Buddha, AdiShankaracharya, Sri Ramakrishna Paramahamsa, Swami Vivekananda, Sri RamanaMaharshi, Mata Amritanandamayi Devi.

Insights into Indian Arts and Literature
The aim of this course is to present the rich literature and culture of Ancient India and help students appreciate their deep influence on Indian Life - Vedic culture, primary source of Indian Culture – Brief introduction and appreciation of a few of the art forms of India - Arts, Music, Dance, Theatre.

Yoga and Meditation
The objective of the course is to provide practical training in YOGA ASANAS with a sound theoretical base and theory classes on selected verses of Patanjali's Yoga Sutra and Ashtanga Yoga. The coverage also includes the effect of yoga on integrated personality development.

Kerala Mural Art and Painting
Mural painting is an offshoot of the devotional tradition of Kerala. A mural is any piece of artwork painted or applied directly on a wall, ceiling or other large permanent surface. In the contemporary scenario Mural painting is not restricted to the permanent structures and are being done even on canvas. Kerala mural paintings are the frescos depicting mythology and legends, which are drawn on the walls of temples and churches in South India, principally in Kerala. Ancient temples, churches and places in Kerala, South India, display an abounding tradition of mural paintings mostly dating back between the 9th to 12th centuries when this form of art enjoyed Royal patronage. Learning Mural painting through the theory and practice workshop is the objective of this course.

Course on Organic Farming and Sustainability
Organic farming is emerging as an important segment of human sustainability and healthy life. Haritamritam' is an attempt to empower the youth with basic skills in tradition of organic farming and to revive the culture of growing vegetables that one consumes, without using chemicals and pesticides. Growth of Agriculture through such positive initiatives will go a long way in nation development. In Amma'swords "it is a big step in restoring the lost harmony of nature".

Benefits of Indian Medicinal Systems
Indian medicinal systems are one of the most ancient in the world. Even today society continues to derive enormous benefits from the wealth of knowledge in Ayurveda of which is recognised as a viable and sustainable

medicinal tradition. This course will expose students to the fundamental principles and philosophy of Ayurveda and other Indian medicinal traditions.

Traditional Fine Arts of India

India is home to one of the most diverse Art forms world over. The underlying philosophy of Indian life is 'Únity in Diversity" and it has led to the most diverse expressions of culture in India. Most art forms of India are an expression of devotion by the devotee towards the Lord and its influence in Indian life is very pervasive. This course will introduce students to the deeper philosophical basis of Indian Art forms and attempt to provide a practical demonstration of the continuing relevance of the Art.

Science of Worship in India

Indian mode of worship is unique among the world civilisations. Nowhere in the world has the philosophical idea of reverence and worshipfulness for everything in this universe found universal acceptance as it in India. Indian religious life even today is a practical demonstration of the potential for realisation of this profound truth. To see the all-pervading consciousness in everything, including animate and inanimate, and constituting society to realise this truth can be seen as the epitome of civilizational excellence. This course will discuss the principles and rationale behind different modes of worship prevalent in India.

TEXT BOOKS/REFERENCES:

1. Rajagopalachari. C, *The Ramayana*

2. Valmiki, *The Ramayana*, Gita Press

19ENV300	ENVIRONMENTAL SCIENCE	P/F

Course Objectives

- To study the nature and facts about environment
- To appreciate the importance of environment by assessing its impact on the human world
- To study the integrated themes and biodiversity, pollution control and waste management

Course Outcomes

CO1: Ability to understand aspects of nature and environment
CO2: Ability to analyse impact of environment on human world
CO3: Ability to comprehend pollution control and waste management

CO – PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	3	2	3	-	-	-	-	-	-
CO2	-	-	-	-	-	3	2	3	-	-	-	-	-	-
CO3	-	-	-	-	-	3	2	3	-	-	-	-	-	-

Syllabus
Unit 1

Over view of the global environment crisis – Biogeochemical cycles – Climate change and related international conventions and treaties and regulations – Ozone hole and related International conventions and treaties and regulations – Overpopulation – energy crisis – Water crisis – ground water hydrogeology – surface water resource development.

Unit 2
Ecology, biodiversity loss and related international conventions – treaties and regulations – Deforestation and land degradation – food crisis – water pollution and related International and local conventions – treaties and regulations – Sewage domestic and industrial and effluent treatment – air pollution and related international and local conventions – treaties and regulations – Other pollution (land, thermal, noise).

Unit 3
Solid waste management (municipal, medical, e-waste, nuclear, household hazardous wastes) – environmental management – environmental accounting – green business – eco-labelling – environmental impact assessment – Constitutional – legal and regulatory provisions – sustainable development.

Text Book(s)
R. Rajagopalan,"Environmental Studies – From Crisis to Cure", Oxford University Press, 2005, ISBN 0-19-567393-X.

Reference(s)
G.T.Miller Jr., "Environmental Science", 11th Edition, Cenage Learning Pvt. Ltd., 2008.
Benny Joseph, "Environmental Studies", Tata McGraw-Hill Publishing company Limited, 2008.

Evaluation Pattern

Assessment	Internal	External
Online Test	-	100
		P/F

19SSK211	SOFT SKILLS I	L-T-P-C: 1-0-2-2

Course Outcome

CO 1 - Soft Skills: At the end of the course, the students would have developed self-confidence and positive attitude necessary to compete and challenge themselves. They would also be able to analyse and manage their emotions to face real life situations.

CO 2 - Soft Skills: Soft Skills: At the end of the course, the students would hone their presentation skills by understanding the nuances of content creation, effective delivery, use of appropriate body language and the art of overcoming nervousness to create an impact in the minds of a target audience.

CO 3 - Aptitude: At the end of the course, the student will have acquired the ability to analyze, understand and classify questions under arithmetic, algebra and logical reasoning and solve them employing the most suitable methods. They will be able to analyze, compare and arrive at conclusions for data analysis questions.

CO 4 – Verbal: At the end of the course, the students will have the ability to dissect polysyllabic words, infer the meaning, inspect, classify, contextualise and use them effectively.

CO 5 - Verbal: At the end of the course, the students will have the ability to understand the nuances of English grammar and apply them effectively.

CO 6 – Verbal: At the end of the course, the students will have the ability to identify, analyse and interpret relationship between words and use the process of elimination to arrive at the answer. They will also have the ability to judge, evaluate, summarise, criticise, present and defend their perceptions convincingly.

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1								2	3	3		3
CO2									2	3		3
CO3		3		2								
CO4										3		3
CO5										3		3
CO6									3	3		3

Soft skills and its importance: Pleasure and pains of transition from an academic environment to work - environment. Need for change. Fears, stress and competition in the professional world. Importance of positive attitude, Self motivation and continuous knowledge upgradation.

Self-confidence: Characteristics of the person perceived, characteristics of the situation, characteristics of the perceiver. Attitude, values, motivation, emotion management, steps to like yourself, positive mental attitude, assertiveness.

Presentations: Preparations, outlining, hints for efficient practice, last minute tasks, means of effective presentation, language, gestures, posture, facial expressions, professional attire.

Vocabulary building: A brief introduction into the methods and practices of learning vocabulary. Learning how to face questions on antonyms, synonyms, spelling error, analogy, etc. Faulty comparison, wrong form of words

and confused words like understanding the nuances of spelling changes and wrong use of words. Listening skills: The importance of listening in communication and how to listen actively.

Prepositions, articles and punctuation: A experiential method of learning the uses of articles and prepositions in sentences is provided.

Problem solving level I: Number system; LCM &HCF; Divisibility test; Surds and indices; Logarithms; Ratio, proportions and variations; Partnership;

Problem solving level II: Time speed and distance; work time problems;

Data interpretation: Numerical data tables; Line graphs; Bar charts and Pie charts; Caselet forms; Mix diagrams; Geometrical diagrams and other forms of data representation.

Logical reasoning: Family tree; Deductions; Logical connectives; Binary logic; Linear arrangements; Circular and complex arrangement; Conditionalities and grouping; Sequencing and scheduling; Selections; Networks; Codes; Cubes; Venn diagram in logical reasoning; Quant based reasoning; Flaw detection; Puzzles; Cryptogrithms.

TEXTBOOKS

A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.
Adair. J., (1986), "Effective Team Building: How to make a winning team", London, U.K: Pan Books.
Gulati. S., (2006) "Corporate Soft Skills", New Delhi, India: Rupa& Co.
The Hard Truth about Soft Skills, by Amazone Publication.
Quantitative Aptitude by R. S. Aggarwal,S. Chand
Quantitative Aptitude – AbijithGuha, TMH.
Quantitative Aptitude for Cat - Arun Sharma. TMH.

REFERENCES:

Books on GRE by publishers like R. S. Aggrawal, Barrons, Kaplan, The Big Book, and Nova.
More Games Teams Play, by Leslie Bendaly, McGraw Hill Ryerson.
The BBC and British Council online resources
Owl Purdue University online teaching resources
www.the grammarbook.com - online teaching resources www.englishpage.com- online teaching resources and other useful websites.

SEMESTER V

19MAT301	MATHEMATICS FOR INTELLIGENT SYSTEMS 5	L-T-P-C:2-0-3-3

Course Objectives

- The course will lay down the basic concepts and techniques of linear algebra, calculus and basic probability theory needed for subsequent study.
- It will explore the concepts initially through computational experiments and then try to understand the concepts/theory behind it.
- At the same time, it will provide an appreciation of the wide application of these disciplines within the scientific field.
- Another goal of the course is to provide connection between the concepts of linear algebra, differential equation and probability theory.

Course Outcomes

CO1: To develop an understanding of the basic concepts and techniques of linear algebra, calculus and basic probability theory needed for AI
CO2: To provide an appreciation of the wide application of these disciplines within the scientific field.
CO3: To provide connection between the concepts of linear algebra, differential equation and probability Theory
CO4: To develop an insight into the applicability of linear algebra in business and scientific domains
CO5: To enable the students to understand the use of calculus and Linear algebra in modelling electrical and mechanical elements
CO6: To equip the students to understand the role of probability theory in providing data sets for computational experiments in data science

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3	---	---	---	3	2	3	3
CO2	3	3	3	3	3	2	---	---	3	2	3	3
CO3	3	2	3	3	3	---	---	---	3	2	3	3
CO4	3	3	3	2	3	---	---	---	3	2	3	3
CO5	3	2	3	3	3	---	---	---	3	2	3	3
CO6	3	3	3	3	3	2	---	---	3	2	3	3

Syllabus

Linear Algebra -5- Data Driven Dynamical Systems: Motivation and Challenges, Dynamic Mode decomposition, Sparse identification of Non-linear Dynamics. Statistics and Probability -5- Probability theory, Bayesian Networks (BNs), Representation Learning in Bayesian Networks, Markov Random Fields- MRF, Inference, Message Passing, Learning in Markov Networks, Numerical Optimization, MRFs and BNs Monte

Carlo Method. Calculus -5- Linear Control Theory: Closed loop Feedback Control, LTI, Controllability and Observability, Optimal Full State Control, Optimal Full-State Estimation, The Kalman Filter.

Text Books / Reference Books

'Machine Learning: a Probabilistic Perspective', Kevin Murphy and Francis Bach, Penguin Publishers, 2012
'Data Driven Science and Engineering', Steve Brunton and Nathan Kutz, Cambridge University Press, 2018

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE301	FORMAL LANGUAGE AND AUTOMATA	L-T-P-C:2-0-3-3

Course Objectives

- To understand discrete mathematical structures and formalism.
- To formalize and to formulate discrete concepts and algorithms.
- To understand the standard hierarchy of formal grammars and their corresponding automata.
- To visualize symbolic computation with automata.
- To understand decidable and undecidable problems in computer science, and appreciate the Turing thesis
- To build automata and Turing Machines to solve computing problems

Course Outcomes

CO1: Learn to analyze formalisms and write formal proofs for properties
CO2: Use grammatical notations to represent sequence manipulation problems.
CO3: Understand various formal grammars and apply them to other problem solving avenues

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	3	3	2	---	---	3	2	3	2
CO2	3	3	3	3	3	3	---	---	2	3	3	3
CO3	3	3	3	3	3	3	---	---	2	2	3	3

Syllabus

Formal grammars: Formalism, Chomsky hierarchies- Regular, Context Free, Context sensitive and Unrestricted grammars, Alphabets, strings and Production rule and Formal languages. Automata for each grammar type, Regular Grammars and Finite state automata: Pumping Lemma for Regular Grammars. Deterministic and non-deterministic automata. Regular Expressions, Applications of Regular Expressions, Algebraic Laws for Regular Expressions, Properties of Regular Languages, Closure Properties of Regular, Minimization and NFA-DFA equivalence. Context-Free Grammars and Pushdown Automata: Definition of Context-Free Grammars, Normal forms -CNF and GNF, Derivations Using a Grammar, Leftmost and Rightmost Derivations, the Language of a Grammar, Sentential Forms, Parse Tress, Applications of Context-Free Grammars, Ambiguity in Grammars and Languages, Pumping lemma for CFGs. Push Down Automata, Definition of the Pushdown Automaton, the Languages of a PDA, Deterministic Pushdown Automata. Non Chomsky Grammars: Tree adjoining Grammars and application, Type Categorical grammars. Turing Machines TM -Formal definition and behavior, Transition diagrams, Language of a TM, TM as accepters and deciders. TM as a computer of integer functions. Variants of Turing machines. Grammars and grammatically computable functions. Recursive languages, Some properties of recursive and recursively enumerable languages, Codes for TMs. A language that is not recursively enumerable (the diagonalization language). The universal language, Undecidability of the universal language, The Halting problem, Undecidable problems about TMs.

Text Books / Reference Books

'Formal Language and Automata', Peter Linz, Fifth edition, 2012.
'Introduction to Automata Theory, Languages and Computation', J.E.Hopcroft, R.Motwaniand andJ.D.Ullman, Pearson, 2001
'Elements of the Theory of Computation', H.R.Lewis and C.H.Papadimitriou, Prentice Hall, 1997/Pearson 1998

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE302	ADVANCED COMPUTER NETWORKS	L-T-P-C:2-0-3-3

Course Objectives

- This course enables the students to work on advanced concepts in networking.
- The course delivers the basic introduction to the networking concepts and terminologies.
- It will also lead to software defined networking and the fundamental changes from conventional networking
- Implementation of various network communication and management using software defined networks
- The students will be enabled with hands on experience in working with openVswicth and Mininet to implement the various functional modules of networking using SDN
- Significant emphasis will be put on security and network management issues related to computer networks and solutions using AI and ML algorithms, as these are becoming increasingly important given the growing number attacks and complexity of networks.
- The students will get the hands on experience to design and develop IOT networks using SDN and to study the security issues in IOT networks.

Course Outcomes

CO1: Introducing the fundamentals of conventional networking and software defined networking
CO2: Implementation of software defined networks using Mininet and raspberry pi.
CO3: Understanding network management and security in software defined networks and network data analysis using AI and ML algorithms

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	3	2	3	2	2	---	3	2	1	3
CO2	2	2	3	2	3	2	2	---	3	2	1	3
CO3	2	3	3	2	3	2	2	---	3	2	1	3

Syllabus

Introduction to network protocols, network measurement, Internet routing, peer to peer networks, network security, wireless and sensor networks. Introduction to software defined networking and architectures, Implementation of software defined networking using Mininet, Routing , protocol management in software defined networks, Network topologies and implementation in SDN, Network security in software defined networks, implementation of IOT networks using SDN.

Text Books / Reference Books

'Foundations of modern networking: SDN, NFV, QoE, IoT, and Cloud', Stallings, W, Addison-Wesley Professional, 2015
'Software defined Networking with OpenFlow', SiamakAzodolmolky, PACKT publishers, 2017

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE303	SIGNAL & IMAGE PROCESSING	L-T-P-C:2-0-3-3

Course Objectives

- The students will be to process the signals sensed by the electronic systems.
- Able to understand the signals, interpret, filter and develop systems to process them automatically.
- To extend the processes of applications from 1D signals to 2D images

Course Outcomes

CO1: Apply signal processing techniques to understand and analyze 1-dimensional and 2-dimensional signals
CO2: To use basic techniques to process 1-dimensional signals and be able to implement standard approaches to process 2-dimensional images.
CO3: Apply signal and image processing in research and industrial environments

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	3	---	---	3	3	---	3
CO2	3	3	3	2	3	3	---	---	3	3	---	3
CO3	3	3	3	2	3	3	---	---	3	3	---	3

Syllabus

Introduction to Signal Processing - Linear Algebra for Signal Processing – Complex Bases for Real Signals – Convolution – From DFT to FFT- Z Domain Representation of Signals – Digital Filter Design- Elements of digital image processing - Image model - Sampling and quantization - Relationships between pixels - Image Transforms - Discrete Fourier Transform, Discrete Cosine Transform, Discrete Wavelet Transform –Image Enhancement: Enhancement by point processing - Spatial filtering - Enhancement in the frequency domain - Color Image Processing - Image Segmentation - Representation and Description - Morphological Image Processing: Dilation and Erosion - Opening and Closing - Some basic morphological algorithms.

Text Books / Reference Books

'Digital Image Processing using MATLAB', Rafael C. Gonzalez, Richard E. Woods and Steven Eddins, Pearson Education Inc., 2011
'Digital Image Processing', William K. Pratt, John Wiley, New York, 2002
'Digital Signal and Image Processing The Sparse Way', K.P.Soman and R. Ramanathan,Cengage Learning Pvt. Ltd, 2016

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE304	BIG DATA AND DATABASE MANAGEMENT	L-T-P-C:2-0-3-3

Course Objectives

- To understand how traditional DBMS works.
- To impart the concepts of normalization and indexing in RDBMS as why they were required.
- To understand how NoSQL data bases works and various ACID and Graph data base structures
- To introduce SQL for query writing and database management
- To convert query processing to function calls using SparkSQL API and understand their equivalence
- To understand topic based streaming and multi-source data acquisition.

Course Outcomes

CO1: Understand RDBMS AND basic entity relations, normalization and Functional Dependencies as well as time series and sequence data.
CO2: To comprehend and design NoSQL databases and Manipulate them using SQL and API functions.
CO3: Will understand indexing and its shortcomings in large and fast datasets, key-value aggregation and graph databases

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	1	---	---	3	3	3	2
CO2	3	3	3	3	3	3	---	---	3	3	3	3
CO3	3	2	3	3	3	1	---	---	3	3	3	3

Syllabus

Data Frames and Datasets revisited. NoSQL data bases and ACID concept. Data Frames and Datasets. Creating data frames from RDDs. Introduction to Spark SQL to query data frames. Streaming data and Spark Streaming- Big Time series data representations- Traditional Database systems and Indexing issues: The NoSQL advantage, Index vs Computation. Dealing with timeseries data: Skewing techniques, creating overlapping and non-overlap windows using joins and group by, creating Henkel matrices from univariate time series. Streaming data and Stream API, Dealing with Topic data using Apache Kafka. Distributed Matrix operations – Row Matrix and its APIs. Introduction to Apache Flink – Graph processing- Introduction to GraphX library. Graph problem examples, PageRank and other graph based examples. Process methods on multivariate time series using map reduce. Interfacing Spark with sensor devices for data accusations (PMU, Arduino, Raspberry PI). Pushing data to DataFrames and NoSQL/ ACID databases (Cassandra/MongoDB), Some popular file formats for large data sets, Some real case study projects on large scale multi source data warehousing.

Text Books / Reference Books

Text books

'Learning Spark: Lightning-Fast Big Data Analysis 1st Edition by Holden Karau , Andy Konwinski, Patrick Wendell, Matei Zaharia

'Programming in Scala: A Comprehensive Step-by-Step Guide Third Edition by Martin Odersky, Lex Spoon, Bill Venners.

References

'High Performance Spark: Best Practices for Scaling and Optimizing Apache Spark 1st Edition, by Holden Karau, Rachel Warren

'Scala for the Impatient 2nd Edition, by Cay S. Horstmann

'Spark: The Definitive Guide: Big Data Processing Made Simple 1st Edition, Kindle Edition by Bill Chambers, Matei Zaharia

Evaluation Pattern

Assessment	Weightage (%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19LIV390	LIVE-IN-LAB I	L-T-P-C: 0-0-0-3

Course Objectives

- Identify and analyse the various challenge indicators present in the village by applying concepts of Human Centered Design and Participatory Rural Appraisal.
- User Need Assessment through Quantitative and Qualitative Measurements
- Designing a solution by integrating Human Centered Design concepts
- Devising proposed intervention strategies for Sustainable Social Change Management

Course Outcome

CO1: Learn ethnographic research and utilise the methodologies to enhance participatory engagement.
CO2: Prioritize challenges and derive constraints using Participatory Rural Appraisal.
CO3: Identify and formulate the research challenges in rural communities.
CO4: Design solutions using human centered approach.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		3		3		1	1		3	3		3
CO2		3						3	3	3		
CO3		3					1		3	3		3
CO4	3		3				3	3	3	3		3

Syllabus

This initiative is to provide opportunities for students to get involved in coming up with technology solutions for societal problems. The students shall visit villages or rural sites during the vacations (after 4th semester) and if they identify a worthwhile project, they shall register for a 3-credit Live-in-Lab project, in the fifth semester.
Thematic Areas

- Agriculture & Risk Management
- Education & Gender Equality
- Energy & Environment
- Livelihood & Skill Development
- Water & Sanitation
- Health & Hygiene
- Waste Management & Infrastructure

The objectives and the projected outcome of the project will be reviewed and approved by the department chairperson and a faculty assigned as the project guide.

Evaluation Pattern

Assessment	Marks

Internal (Continuous Evaluation) [75 marks]	
Workshop (Group Participation)	15
Village Visit Assignments & Reports	15
Problem Identification and Assessment	15
Ideation: Defining the Needs, Proposed Designs & Review	20
Poster Presentation	10
External [25 marks]	
Research Paper Submission	25
Total	**100**
Attendance (To be added separately)	5
Grand Total	**105**

19SSK301	SOFT SKILLS II	L-T-P-C: 1-0-2-2

Course Outcomes

CO # 1 - Soft Skills: At the end of the course, the students will have the ability to communicate convincingly and negotiate diplomatically while working in a team to arrive at a win-win situation. They would further develop their inter-personal and leadership skills.

CO # 2 - Soft Skills: At the end of the course, the students shall learn to examine the context of a Group Discussion topic and develop new perspectives and ideas through brainstorming and arrive at a consensus.

CO # 3 - Aptitude: At the end of the course, students will be able to identify, recall and arrive at appropriate strategies to solve questions on geometry. They will be able to investigate, interpret and select suitable methods to solve questions on arithmetic, probability and combinatorics.

CO # 4 – Verbal: At the end of the course, the students will have the ability to relate, choose, conclude and determine the usage of right vocabulary.

CO # 5 - Verbal: At the end of the course, the students will have the ability to utilise prior knowledge of grammar to recognise structural instabilities and modify them.

CO # 6 – Verbal At the end of the course, the students will have the ability to comprehend, interpret, deduce and logically categorise words, phrases and sentences. They will also have the ability to theorise, discuss, elaborate, criticise and defend their ideas.

Syllabus

Professional grooming and practices: Basics of corporate culture, key pillars of business etiquette. Basics of etiquette: Etiquette – socially acceptable ways of behaviour, personal hygiene, professional attire, cultural adaptability. Introductions and greetings: Rules of the handshake, earning respect, business manners. Telephone etiquette: activities during the conversation, conclude the call, to take a message. Body Language: Components, undesirable body language, desirable body language. Adapting to corporate life: Dealing with people.

Group discussions: Advantages of group discussions, structured GD – roles, negative roles to be avoided, personality traits to do well in a GD, initiation techniques, how to perform in a group discussion, summarization techniques.

Listening comprehension advanced: Exercise on improving listening skills, grammar basics: Topics like clauses, punctuation, capitalization, number agreement, pronouns, tenses etc.

Reading comprehension advanced: A course on how to approach middle level reading comprehension passages.

Problem solving level III: Money related problems; Mixtures; Symbol based problems; Clocks and calendars; Simple, linear, quadratic and polynomial equations; special equations; Inequalities; Functions and graphs; Sequence and series; Set theory; Permutations and combinations; Probability; Statistics.

Data sufficiency: Concepts and problem solving.

Non-verbal reasoning and simple engineering aptitude: Mirror image; Water image; Paper folding; Paper cutting; Grouping of figures; Figure formation and analysis; Completion of incomplete pattern; Figure matrix; Miscellaneous.

Spacial aptitude: Cloth, leather, 2D and 3D objects, coin, match sticks, stubs, chalk, chess board, land and geodesic problems etc., related problems.

TEXTBOOK(S)

A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.
Adair. J., (1986), "Effective Team Building: How to make a winning team", London, U.K: Pan Books.
Gulati. S., (2006) "Corporate Soft Skills", New Delhi, India: Rupa& Co.
The Hard Truth about Soft Skills, by Amazone Publication.
Quick Maths – Tyra.

Quicker Arithmetic – Ashish Aggarwal
Test of reasoning for competitive examinations by Thorpe.E. TMH
Non-verbal reasoning by R. S. Aggarwal, S. Chand

REFERENCE(S)

Books on GRE by publishers like R. S. Aggrawal, Barrons, Kaplan, The Big Book, and Nova
More Games Teams Play, by Leslie Bendaly, McGraw Hill Ryerson.
The BBC and British Council online resources
Owl Purdue University online teaching resources
www.the grammarbook.com - online teaching resources www.englishpage.com- online teaching resources and other useful websites.

19MNG300	DISASTER MANAGEMENT	P/F

Course Objectives

To provide an awareness on the types and impacts of disasters and concepts of disaster management

Course Outcome

CO 1: Analyze relationship between Development and Disasters.
CO 2: Understand impact of Disasters and realization of societal responsibilities
CO 3: ApplyDisaster management principles

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3				2	3	2		3		2			3
CO2	2	3				2	3	2	2	2		2			3
CO3	2	3				2		2				2			3

Syllabus

Unit 1
Introduction - Concepts and definitions. Disasters - Disasters classification; natural disasters (floods, draught, cyclones, volcanoes, earthquakes, tsunami, landslides, coastal erosion, soil erosion, forest fires etc.); man-made disasters (industrial pollution, artificial flooding in urban areas, nuclear radiation, chemical spills, transportation accidents, terrorist strikes, etc.)

Unit 2
Hazard and vulnerability profile of India, mountain and coastal areas, ecological fragility. Factors affecting vulnerability such as impact of developmental projects and environmental modifications (including of dams, land use changes, urbanization etc.)
Disaster Impacts - Disaster impacts (environmental, physical, social, ecological, economic, political, etc.); health, psycho-social issues; demographic aspects (gender, age, special needs); hazard locations; global and national disaster trends; climate change and urban disasters.

Unit 3
Disaster Risk Reduction (DRR) - Disaster management cycle – its phases; prevention, mitigation, preparedness, relief and recovery; structural and non-structural measures; risk analysis, vulnerability and capacity assessment; early warning systems, Post disaster environmental response (water, sanitation, food safety, waste management, disease control, security, communications); Roles and responsibilities of government, community, local institutions, NGOs and other stakeholders; Policies and legislation for disaster risk reduction, DRR programmes in India and the activities of National Disaster Management Authority.

Text Book(s)
R. Subramanian, Disaster Management, Vikas Publishing House (2018)

Reference(s)
Bhandari and Rajendra Kumar, Disaster Education and Management, Springer, 2016.
NIDM publications, https://nidm.gov.in/books.asp
http://ndma.gov.in/ (Home page of National Disaster Management Authority)
http://www.ndmindia.nic.in/ (National Disaster management in India, Ministry of Home Affairs).

Pradeep Sahni, 2004, Disaster Risk Reduction in South Asia, Prentice Hall.
Singh B.K., 2008, Handbook of Disaster Management: Techniques & Guidelines, Rajat Publication.
Ghosh G.K., 2006, Disaster Management, APH Publishing Corporation
Inter Agency Standing Committee (IASC) (Feb. 2007). IASC Guidelines on Mental Health and Psychosocial Support in Emergency Settings. Geneva: IASC

Evaluation Pattern

Assessment	Internal	External
*Continuous Assessment (CA)	80	
**End Semester		20

•CA – Can be Discussions/Debates/Quiz/ Case study presentation
****** - Term project

SEMESTER VI

19MAT311	MATHEMATICS FOR INTELLIGENT SYSTEMS 6	L-T-P-C:2-0-3-3

Course Objectives

- The course will lay down the basic concepts and techniques of linear algebra, calculus and basic probability theory needed for subsequent study.
- It will explore the concepts initially through computational experiments and then try to understand the concepts/theory behind it.
- At the same time, it will provide an appreciation of the wide application of these disciplines within the scientific field.
- Another goal of the course is to provide connection between the concepts of linear algebra, differential equation and probability theory.

Course Outcomes

CO1: To develop an understanding of the basic concepts and techniques of linear algebra, calculus and basic probability theory needed for AI
CO2: To provide an appreciation of the wide application of these disciplines within the scientific field.
CO3: To provide connection between the concepts of linear algebra, differential equation and probability theory
CO4: To develop an insight into the applicability of linear algebra in business and scientific domains.
CO5: To enable the students to understand the use of calculus and Linear algebra in modelling electrical and mechanical elements.
CO6: To equip the students to understand the role of probability theory in providing data sets for computational experiments in data science

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3	---	---	---	3	2	3	3
CO2	3	3	3	3	3	2	---	---	3	2	3	3
CO3	3	2	3	3	3	---	---	---	3	2	3	3
CO4	3	3	3	2	3	---	---	---	3	2	3	3
CO5	3	2	3	3	3	---	---	---	3	2	3	3
CO6	3	3	3	3	3	2	---	---	3	2	3	3

Syllabus

Linear Algebra with Calculs-6- Learning from Data: The Construction of Deep Neural Networks, CNNs, Backpropagation and Chain Rule, Hyper Parameters, The world of Machine learning. Calculus -6- Kalman Filter, Optimal Sensor based Control, , Full state Feedback of Cartpole Pendulum, Robust Control and Frequency domain Techniques. Statistics and Probability -6- Expectation-Maximization, Variational Inference, Variational Learning, Support Vector Machines, Neural Networks, Bayesian Modelling.

Text Books / Reference Books

'Linear Algebra and learning from data', Gilbert Strang, Wellesley, Cambridge press, 2019
'Data Driven Science and Engineering', Steve Brunton and Nathan Kutz, Cambridge University Press, 2018
'Machine Learning: A Probabilistic Perspective', Kevin Murphy and Francis Bach, 2012

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE311	REINFORCEMENT LEARNING	L-T-P-C:2-0-3-3

Course Objectives

- This course will provide a solid introduction to the field of reinforcement learning.
- It will also make the students learn about the core challenges and approaches, including exploration and exploitation.
- The course will make the students well versed in the key ideas and techniques for reinforcement learning.

Course Outcomes

CO1: To understand the basics of reinforcement learning
CO2: To implement in code reinforcement learning algorithms.
CO3: To explore the core challenges and opportunities in the field of reinforcement learning

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	2	---	3	3	3	3
CO2	3	3	3	3	3	2	2	---	3	3	3	3
CO3	3	3	3	3	3	2	2	---	3	3	3	3

Syllabus

Introduction to Reinforcement Learning – Elements of Reinforcement Learning – Multi-armed Bandits – Finite Markov Decision Processes – Dynamic Programming – Monte Carlo Methods – Temporal-Difference Learning – n-step Bootstrapping - Planning and Learning with Tabular Methods.

Text Books / Reference Books

'Reinforcement Learning', Richard.S.Sutton and Andrew G.Barto, Second edition, MIT Press, 2018

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE312	DEEP LEARNING FOR SIGNAL & IMAGE PROCESSING	L-T-P-C:2-0-3-3

Course Objectives

- The main objective of the course is to introduce the fundamental concepts of deep learning for signal and image analysis.
- To explore the applications of deep learning algorithms in signal and image analysis and to develop the skillset of problem solving pertaining to real-time signal and image data.

Course Outcomes

CO1: Thorough Understanding of the fundamentals of Deep Learning
CO2: Practical Engineering tricks for training and fine-tuning the networks by developing the skill to use multiplepackages required to build AI systems for signal and image analysis
CO3: Gaining Knowledge of standard deep convolutional architectures and use the pre-trained model for transfer learning for signal and image analysis

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	3	---	---	3	3	---	3
CO2	3	3	3	2	3	3	---	---	3	3	---	3
CO3	3	3	3	2	3	3	---	---	3	3	---	3

Syllabus

Introduction to deep learning – Strategies of deep learning: learning via gradient descent; recursive chain rule (back propagation); time: bias-variance tradeoff, regularization; output units: linear, softmax; hidden units: tanh, RELU, dropouts. Convolutional Neural Networks – Deep Belief Nets – Recurrent Neural Nets – Transfer Learning - Applications of deep learning algorithms in signal and image analysis.

Text Books / Reference Books

'Deep Learning', Ian Goodfellow, YoshuaBengio and Aaron Courville, Second edition, MIT Press, 2016
'Matlab Deep Learning with Machine Learning, Neural Networks and Artificial Intelligence', Phil Kim, Apress, 2017

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE313	INTRODUCTION TO MODERN COMPILER DESIGN	L-T-P-C:2-0-0-2

Course Objectives

- Understand intricacies of Compilers and their working.
- Learn hands on the working of modern compiler modules.
- Imbibe the skill on LEX and YACC tools specifications
- Implement various parsers and get a feel of their working and design
- Understand and imbibe the concept of Abstract Syntax and higher constructs in PLs

Course Outcomes

CO1: Design lexical and parser specifications using LEX and YACC scripts
CO2: Design Abstract syntax for higher language structures and help create programmable interfaces
CO3: Design and implement LL and LR type grammar for script interfaces for programmability

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	---	---	3	3	1	3
CO2	3	3	3	3	3	1	---	---	3	3	1	3
CO3	3	3	3	3	3	1	---	---	3	3	1	3

Syllabus

Structure of computer programs, Token and Lexical analysis, Lexical categories, making lexical analysers with FSA(JAVA). The 'lex' script and lex specification using 'JLEX' to create a lexical analyser. Syntax using CFG. Syntax Analysis-Parsing and Parse tree. Top down 'derivation 'parser, Implementing a top down Recursive descend Parser, LL(1) type Grammars, left recursion and left factoring, The LL(1) parsing algorithm and tabular parsing. Bottom up 'reduction' parsing, implementing The Shift reduce parser. LR(1) type grammars and LR(1) parsing algorithm. Semantic actions while parsing, Abstract syntax. The YACC Parser specification, using YACC spec with 'JCUPS' parser generator. Sematic actions in 'JCUPS'. Abstract Syntax and Abstract Syntax tree. Intermediate Language generation and Optimization.

Text Books / Reference Books

'Modern Compiler Implementation in Java', Andrew W Appel, 2002
'Compilers: Principles, Techniques, and Tools', Aho, Sethi and Ullman, Addison-Wesley, 1986

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19LIV490	LIVE-IN-LAB II	L-T-P-C: 0-0-0-3

Course Objectives

- Proposal writing in order to bring in a detailed project planning, enlist the materials required and propose budget requirement.
- Use the concept of CoDesign to ensure User Participation in the Design Process in order to rightly capture user needs/requirements.
- Building and testing a prototype to ensure that the final design implementation is satisfies the user needs, feasible, affordable, sustainable and efficient.
- Real time project implementation in the village followed by awareness generation and skill training of the users (villagers)

Course Outcome

CO1: Learn co-design methodologies and engage participatorily to finalise a solution
CO2: Understand sustainable social change models and identify change agents in a community.
CO3: Learn Project Management to effectively manage the resources
CO4: Lab scale implementation and validation
CO5. Prototype implementation of the solution

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	3	3			1	3	3	3		3
CO2									3	3		
CO3									3	3	3	
CO4	3		3			3	1	3	3	3		3
CO5			1						3	3		

Syllabus

The students shall visit villages or rural sites during the vacations (after 6th semester) and if they identify a worthwhile project, they shall register for a 3-credit Live-in-Lab project, in the fifth semester.
Thematic Areas

- Agriculture & Risk Management
- Education & Gender Equality
- Energy & Environment
- Livelihood & Skill Development
- Water & Sanitation
- Health & Hygiene
- Waste Management & Infrastructure

Evaluation Pattern

Assessment	Marks
Internal (Continuous Evaluation) [63 marks]	

1. Proposed Implementation	**2**
Presentation Round 1	
2. Proposal Submission + Review	**6**
3. Co-design	**6**
i. Village Visit I (Co-Design Field Work Assignments)	4
ii. Presentation of Co-design Assessment	2
4. Prototype Design	**14**
i. Prototype Design	4
ii. Prototype Submission	8
iii. Sustenance Plan	2
5. Implementation	**35**
i. Implementation Plan Review	3
ii. Implementation	24
iii. Testing & Evaluation	4
iv. Sustenance Model Implementation	4
External [37 marks]	
6. Research Paper	**18**
7. Final Report	**15**
8. Poster Presentation	**4**
Total	**100**
Attendance	5
Grand Total	**10**

19AIE314	AI IN NATURAL LANGUAGE PROCESSING	L-T-P-C:2-0-3-3

Course Objectives

- To imbibe the domain of Computational Linguistics and entailing standard problems.
- To understand representations of words for AI and Machine learning algorithms.
- To understand and implement various algorithms generating word representations
- Understand the concept of semantics and quantify it using word representations
- To generate word vectors and learn the associated popular algorithms.
- To relate semantics to feature representations of words, such that machine learning and deep learning can be applied onto such problems.

Course Outcomes

CO1: Understand word representation
CO2: Generate and manipulate word representation and syntax representations, to solve NLP problems
CO3: Apply contemporary Machine/ Deep Learning on to NLP and Text data for problem solving

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	3	3	---	---	1	3	3	3
CO2	3	3	3	3	3	3	---	---	3	3	3	3
CO3	3	3	3	3	3	3	---	---	3	3	3	3

Syllabus

Computational linguistics- Introduction, syntax, semantics, morphology, co-location and other NLP problems. Word representation: One-hot encoding, Bag-of-Words (BoW) Dictionary: Term Frequency – Inverse Document Frequency (TF-IDF), N-gram,Embedding: Word2vec, Glove and Fasttext. Sequences and sequential data: NLP applications, Topic classification, Part-of-Speech tagging, Named Entity recognition, Morphological analysis, Sentiment analysis, Dependency parsing, Machine translation, Question answering, Text summarization, Machine learning and deep learning for NLP, Sequence to sequence modelling (Encoder decoder), Attention mechanism, A brief introduction to Reinforcement learning for NLP.

Text Books / Reference Books

'Foundations of Statistical Natural Language Processing', Christopher Manning and HinrichSchütze
'Natural Language Processing with Python', Steven Bird, Ewan Klein and Edward Loper
'Deep Learning for Natural Language Processing: Develop Deep Learning Models for your Natural Language Problems (Ebook)', Jason Browlee

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE315	AI IN SPEECH PROCESSING	L-T-P-C:2-0-3-3

Course Objectives

- The objective of the course is to understand acoustic theory behind the human speech production and speech perception systems.
- As a part of this course students will be able to analyze and estimate the acoustic features from a speech signal.
- Understanding the AI based algorithms used for speech modeling enable the students to develop various speech systems.

Course Outcomes

CO1: Understanding the acoustics of speech production and perception
CO2: Analyzing efficient speech features used for modeling
CO3: Understanding various algorithms on AI based Speech modeling

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	2	---	---	2	2	1	3
CO2	3	3	3	3	3	3	---	---	3	3	2	3
CO3	3	3	3	3	3	3	---	---	3	3	3	3

Syllabus

Overview of Speech Processing Systems, Speech Production, Speech Perception, Speech Signal Characteristics, Sounds (Syllables, Phonemes, etc.), Properties of speech sounds. Speech signal processing, Short time processing of speech- Time Domain parameters, Frequency domain parameters, Tie-Frequency representation (Spectrograms), Cepstral Analysis, MFCC, Linear Prediction Analysis - Speech modeling, Basic speech models, Gaussian mixture modeling of speech, Hidden markov models, model adaptations, DNN models (DBN, TDNN, LSTM, etc.) used for speech modeling - Development of speech systems, Speech synthesis (diphones and syllable based unit selection systems, parametric synthesis systems), Speaker recognition/Verification systems, Development of speaker verification/recognition systems.

Text Books / Reference Books

'Fundamentals of Speech Recognition', L. Rabiner, Biing-Hwang Juang and B. Yegnanarayana, Pearson Education Inc.2009
'Speech Communication', Douglas O'Shaughnessy, University Press, 2001
'Discrete Time Speech Signal Processing', Thomas F Quatieri, Pearson Education Inc., 2004

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19SSK311	SOFT SKILLS III	L-T-P-C: 1-0-3-2

Course Outcomes:

CO # 1 - Soft Skills: At the end of the course, the students will have the ability to prepare a suitable resume (including video resume). They would also have acquired the necessary skills, abilities and knowledge to present themselves confidently. They would be sure-footed in introducing themselves and facing interviews.

CO # 2 - Soft Skills: At the end of the course, the students will have the ability to analyse every question asked by the interviewer, compose correct responses and respond in the right manner to justify and convince the interviewer of one's right candidature through displaying etiquette, positive attitude and courteous communication.

CO # 3 - Aptitude: At the end of the course, students will be able to interpret, critically analyze and solve logical reasoning questions. They will have acquired the skills to manage time while applying methods to solve questions on arithmetic, algebra, logical reasoning, and statistics and data analysis and arrive at appropriate conclusions.

CO # 4 – Verbal: At the end of the course, the students will have the ability to understand and use words, idioms and phrases, interpret the meaning of standard expressions and compose sentences using the same.

CO # 5 - Verbal: At the end of the course, the students will have the ability to decide, conclude, identify and choose the right grammatical construction.

CO # 6 – Verbal: At the end of the course, the students will have the ability to examine, interpret and investigate arguments, use inductive and deductive reasoning to support, defend, prove or disprove them. They will also have the ability to create, generate and relate facts / ideas / opinions and share / express the same convincingly to the audience / recipient using their communication skills in English.

Team work: Value of team work in organisations, definition of a team, why team, elements of leadership, disadvantages of a team, stages of team formation. Group development activities: Orientation, internal problem solving, growth and productivity, evaluation and control. Effective team building: Basics of team building, teamwork parameters, roles, empowerment, communication, effective team working, team effectiveness criteria, common characteristics of effective teams, factors affecting team effectiveness, personal characteristics of members, team structure, team process, team outcomes.

Facing an interview: Foundation in core subject, industry orientation / knowledge about the company, professional personality, communication skills, activities before interview, upon entering interview room, during the interview and at the end. Mock interviews.

Advanced grammar: Topics like parallel construction, dangling modifiers, active and passive voices, etc.

Syllogisms, critical reasoning: A course on verbal reasoning. Listening comprehension advanced: An exercise on improving listening skills.

Reading comprehension advanced: A course on how to approach advanced level of reading, comprehension passages. Exercises on competitive exam questions.

Problem solving level IV: Geometry; Trigonometry; Heights and distances; Co-ordinate geometry; Mensuration.

Specific training: Solving campus recruitment papers, national level and state level competitive examination papers; Speed mathematics; Tackling aptitude problems asked in interview; Techniques to remember (In mathematics). Lateral thinking problems. Quick checking of answers techniques; Techniques on elimination of options, estimating and predicting correct answer; Time management in aptitude tests; Test taking strategies.

TEXTBOOK(S)

A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.
Adair. J., (1986), "Effective Team Building: How to make a winning team", London, U.K: Pan Books.
Gulati. S., (2006) "Corporate Soft Skills", New Delhi, India: Rupa& Co.
The Hard Truth about Soft Skills, by Amazone Publication.
Data Interpretation by R. S. Aggarwal, S. Chand
Logical Reasoning and Data Interpretation – Niskit K Sinkha
Puzzles – Shakuntala Devi
Puzzles – George J. Summers.

REFERENCE(S)

Books on GRE by publishers like R. S. Aggrawal, Barrons, Kaplan, The Big Book, and Nova.
More Games Teams Play, by Leslie Bendaly, McGraw-Hill Ryerson.
The BBC and British Council online resources
Owl Purdue University online teaching resources

www.the grammarbook.com - online teaching resources www.englishpage.com- online teaching resources and other useful websites.

SEMESTER VII

19AIE401	DEEP REINFORCEMENT LEARNING	L-T-P-C: 1-2-0-3

Course Objectives

- This course aims to provide the cutting edge concepts in deep reinforcement learning.
- It also helps the students to train an agent which can perform a variety of complex tasks.
- It will also help students to learn about the core challenges and approaches, including generalization and exploration and also make the students well versed in the key ideas and techniques for deep reinforcement learning

Course Outcome

CO1: To understand the basics of deep reinforcement learning.
CO2: To implement in code deep reinforcement learning algorithms.
CO3: To explore the core challenges and opportunities in the field of deep reinforcement learning.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	2	2		3	3	3	3		
CO2	3	3	3	3	3	2	2		3	3	3	3		
CO3	3	3	3	3	3	2	2		3	3	3	3		

Syllabus

Introduction to Deep Reinforcement Learning – Approximate Solution Methods: On-policy Prediction with Approximation – On-policy Control with Approximation – Off-policy Methods with Approximation – Eligibility Traces – Policy Gradient Methods – Applications and Case studies.

Textbooks / References

Richard.S.Sutton and Andrew G.Barto, Reinforcement Learning, second edition, MIT Press, 2018.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

PROFESSIONAL ELECTIVES

Pool 1: AI in Cyber Secuity

19AIE431	APPLIED CRYPTOGRAPHY	L-T-P-C: 1-2-0-3

Course Objectives

- A strong grasp of the basic concepts underlying classical and modern cryptography, and the fundamentals.
- Understand how security is defined and proven at the cryptographic level.
- Understand common attacks and how to prevent them.
- Gain the ability to apply appropriate cryptographic techniques to a security engineering (and management) problem at hand.

Course Outcome

CO1: Understanding the classical and modern cryptography.
CO2: To equip the student to understand common attacks and the preventive systems..
CO3: To equip the student to apply appropriate cryptographic techniques to a security engineering problem.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	3	2	3	2	2	2	3	2	1	3
CO2	2	2	3	2	3	2	2	2	3	2	1	3
CO3	2	3	3	2	3	2	2	3	3	2	1	3

Syllabus

Overview of cryptography-What is a cipher, Basic symmetric-key encryption- One time pad and stream ciphers, Block ciphers, Block cipher abstractions: PRPs and PRFs, Attacks on block ciphers, Message integrity- Message integrity: definition and applications, Collision resistant hashing, Authenticated encryption: security against active attacks, Public key cryptography- Arithmetic modulo primes, Cryptography using arithmetic modulo primes, Public key encryption, Arithmetic modulo composites, Digital signatures- Digital signatures: definitions and applications, More signature schemes and applications, Identification protocols, Authenticated key exchange and SSL/TLS session setup, Zero knowledge protocols

Textbooks / References

D. Bonesh and V Shoup, A Graduate Course in Applied Cryptography , Standford university Press, Volume-0.4

Katz, Jonathan, and Yehuda Lindell. Introduction to modern cryptography. Chapman and Hall/CRC, 2014.

Katz, Jonathan, Alfred J. Menezes, Paul C. Van Oorschot, and Scott A. Vanstone. Handbook of applied cryptography. CRC press, 1996.

Stallings, William. Cryptography and network security: principles and practice. Upper Saddle River: Pearson, 2017.

Evaluation Pattern

Assessment	Weightage(%)

Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE432	NETWORK & WIRELESS SECURITY	L-T-P-C: 1-2-0-3

Course Objectives

- This subject covers security and privacy issues in wireless networks and systems, such as cellular networks, wireless LANs, wireless PANs, mobile ad hoc networks, vehicular networks, satellite networks, wireless mesh networks, sensor networks and RFID systems.
- The course will lay down the Functions, protocols and configurations for realizing authentication, key distribution, integrity, confidentiality and anonymity in wireless access networks for mobile users.
- The course presents security techniques employed in existing systems, such as WPAN, WLAN, UMTS and IMS.
- Proposed solutions for new network technology, such as various types of ad-hoc networks. Digital forensics in wireless systems.

Course Outcome

CO1: The course will provide knowledge of information security technology and methods for communication systems that provide services for mobile users by wireless access networks.
CO2: Knowledge and understanding of security mechanisms and protocols in wireless communication systems, such as the topical technologies of WLAN IEEE 802.11, WAN 802.16, GSM/UMTS/LTE, Ad-hoc and sensor networks.
CO3: Knowledge about some of the models, design principles, mechanisms and solutions used in wireless network security to obtain authentication and key transport protocols.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	3	2	3	2	2	1	3	2	1	3			
CO2	2	2	3	2	3	2	2	2	3	2	1	3			
CO3	2	3	3	2	3	2	2	3	3	2	1	3			

Syllabus

Introduction to network security and wireless network, Wireless network technologies and application, Security and Cryptography ,Network Security Protocols ,Security and Layered Architecture ,Voice-Oriented Wireless Networks ,Data-Oriented Wireless Networks ,Security in Traditional Wireless Networks ,Security in Wireless LAN ,Security in Wireless Ad Hoc Network

Textbooks / References

Xiao, Yang, Hui Chen, Shuhui Yang, Yi-Bing Lin, and Ding-Zhu Du. "Wireless network security." (2009),Springer

Vacca, J. R, Guide to wireless network security. Springer Science & Business Media ,2006.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE433	INTRUSION DETECTION & PREVENTION SYSTEMS	L-T-P-C: 1-2-0-3

Course Objectives

- Understand when, where, how, and why to apply Intrusion Detection tools and techniques in order to improve the security posture of an enterprise.
- Apply knowledge of the fundamentals and history of Intrusion Detection in order to avoid common pitfalls in the creation and evaluation of new Intrusion Detection Systems.
- Analyze intrusion detection alerts and logs to distinguish attack types from false alarms.

Course Outcome

CO1: Understanding of basic issues, concepts, principles, and techniques in intrusion detection
CO2: Be able to evaluate intrusion detection systems for particular security requirements**.**
CO3: Design and implementation of preventive systems for various engineering applications.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	3	2	3	2	2	2	3	2	1	3		
CO2	2	2	3	2	3	2	2	2	3	2	1	3		
CO3	2	3	3	2	3	2	2	3	3	2	1	3		

Syllabus

Introduction-Understanding Intrusion Detection – Intrusion detection and prevention basics – IDS and IPS analysis schemes, Attacks, Detection approaches –Misuse detection – anamoly detection – specification based detection – hybrid detection , Theoretical foundations of detection-Taxonomy of anomaly detection system – fuzzy logic – Bayes theory – Artificial Neural networks – Support vector machine – Evolutionary computation – Association rules – Clustering, Architecture and implementation-Centralized – Distributed – Cooperative Intrusion Detection – Tiered architecture, Justifying intrusion detection-Intrusion detection in security – Threat Briefing –Quantifying risk – Return on Investment (ROI), Applications and tools -Tool Selection and Acquisition Process – Bro Intrusion Detection – Prelude Intrusion Detection – Cisco Security IDS – Snorts Intrusion Detection – NFR security, Legal issues and Organizations standards-Law Enforcement / Criminal Prosecutions – Standard of Due Care – Evidentiary Issues, Organizations and Standardizations.

Textbooks / References

Ali A. Ghorbani, Wei Lu, "Network Intrusion Detection and Prevention: Concepts and Techniques", Springer, 2010.
Carl Enrolf, Eugene Schultz, Jim Mellander, "Intrusion detection and Prevention", McGraw Hill, 2004
Paul E. Proctor, "The Practical Intrusion Detection Handbook ",Prentice Hall , 2001.
Ankit Fadia and Mnu Zacharia, "Intrusiion Alert", Vikas Publishing house Pvt., Ltd, 2007.
Earl Carter, Jonathan Hogue, "Intrusion Prevention Fundamentals", Pearson Education, 2006.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE434	SOFTWARE VULNERABILITY ANALYSIS	L-T-P-C: 1-2-0-3

Course Objectives

- This course teaches software engineering techniques for building security into software as it is developed.
- Introduces students to the discipline of designing, developing, and testing secure and dependable software-based systems.
- The course will lay down to expose the techniques needed for the practice of effective software security techniques.
- Providing hands on experience in software security analysis and development using Fortify, Threat Modeling, and Rational AppScan software.

Course Outcome

CO1: Students will be able to assess the security risk of a system under development. Risk management will include the development of formal and informal misuse case and threat models.
CO2: Students will understand secure coding practices to prevent common vulnerabilities from being injected into software.
CO3: Students will be able to write security requirements (which include privacy requirements). They will be able to validate these requirements and to perform additional verification practices of static analysis and security inspection.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	3	2	3	2		1		2		3		
CO2	2	2	3	2	3	2		2		2		3		
CO3	2	3	3	2	3	2	3	3	3	2	2	3		

Syllabus

Introduction to software and system security principles-Confidentiality, Integrity, and Availability, Isolation, Least Privilege, Compartmentalization, Threat Model, Bug versus Vulnerability,Secure Software Life Cycle-Software Design, Software Implementation, Software Testing, Continuous Updates and Patches, Modern Software Engineering, Memory and Type Safety - Pointer Capabilities, Memory Safety, Spatial Memory Safety, Temporal Memory Safety, a Definition of Memory Safety, Practical Memory Safety, Type Safety, Defense Strategies – Software verification, Software testing, Language based security, Mitigations – data execution prevention, Address space layout randomization, Stack integrity, Safe exception handling, Fortify source, Control flow integrity, Code pointer integrity, sandboxing and software based fault isolation, Attack vectors – Denial of service, information Leakage, Privilege escalation, Web security- Browser security, Command injection, Sql injection , Cross site scripting, Mobile security- Android system security, application specific security measures.

Textbooks / References

Mathias Payer, "Software Security: Principles, Policies, and Protection",HexHive Books ,edition 0.35, 2019
Anderson, Ross. Security engineering. John Wiley & Sons, 2008.
Dowd, Mark, John McDonald, and Justin Schuh. The art of software security assessment: Identifying and preventing software vulnerabilities. Pearson Education, 2006.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE435	CYBERCRIME INVESTIGATIONS & DIGITAL FORENSICS	L-T-P-C: 1-2-0-3

Course Objectives

- To provide overview of global reach of the Internet and various cybercrimes in various domains.
- This course provides an overview of cybercrime and the digital law enforcement practices put in place to respond to them.
- The course will focus on the types and extent of current cyber-crimes, how the justice system responds to these crimes, the various constitutional protections afforded to computer users, the law and policies that govern cybercrime detection and prosecution, and related technologies.

Course Outcome

CO1: Enable the student to define and describe the nature and scope of cybercrime.
CO2: Develop knowledge of major incidents of cybercrime and their resulting impact.
CO3: Facilitate the student to analyze and discuss national and global digital law enforcement efforts and evaluate the specific technology that facilitates cybercrime and digital law enforcement

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2	2	3	3		3		1		3		
CO2	2	2	3	2	3	3		3		2		3		
CO3	2	3	3	2	3	3	2	3	3	2	2	3		

Syllabus

Introduction to cybercrime, criminal law, courts, and lawmaking, Types of computer-related crimes, Sources of cybercrime law (substantive and procedural), Technology, cybercrime, and police investigations, Technology and crime, Cyber deviance, cybercrime, and cyber terror, Computer misuse crimes, Malware and automated computer attacks, Malware, DDoS attacks, and Botnets, Digital piracy and Intellectual property theft, Digital piracy, Copyright, trademark, and trade secrets, Pornography, prostitution, and sex crime, The Fourth Amendment, computers, and computer networks, Digital/Computer Forensics -Introduction to digital and computer forensics, Legal issues related to digital investigations, National security and international

Textbooks / References

Thomas J. Holt, Adam M. Bossler, and Kathryn C. Seigfried-Spellar. 2015. Cybercrime and Digital Forensics: An Introduction. New York: Routledge. ISBN: 978-1138021303.
Nate Anderson. 2014. The Internet Police: How Crime Went Online, and the Cops Followed. New York: W.W. Norton & Company, Inc. ISBN: 978-0393349450.
Peter Grabosky. 2016. Cybercrime. Oxford/New York: Oxford University Press. ISBN: 978-0190211554.
Kevin F. Steinmetz. 2016. Hacked: A Radical Approach to Hacker Culture and Crime.New York: New York University Press. ISBN: 978-1479869718.
Orin S. Kerr. 2013. Computer Crime Law (3ded.). St. Paul: Thomsen Reuters. ISBN: 978-0314281364.
Susan W. Brenner. 2012. Cybercrime and the Law: Challenges, Issues, and Outcomes. Lebanon, NH: Northeastern University Press. ISBN: 978-1555537999.
Ralph D. Clifford. 2011. Cybercrime: The Investigation, Prosecution and Defense of a Computer-related Crime. Durham: Carolina Academic Press. ISBN: 978-1594608537.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE436	DISTRIBUTED SYSTEMS SECURITY	L-T-P-C: 1-2-0-3

Course Objectives

- The emphasis will be on the techniques for creating functional, usable, and high-performance distributed systems.
- The course focuses on security in networks and distributed systems, and gives a short introduction to cryptography.
- The course covers threats against distributed systems, as well as applicable methods, technologies and standards to protect against these threats.

Course Outcome

CO1: Understand the distributed systems and threats against distributed systems and how to protect against them
CO2: To have a foundation for designing and developing secure distributed systems, and for evaluating the security of existing solutions.
CO3: To have knowledge of standards, security protocols, technologies, principles, methods and cryptographic mechanisms applicable for securing modern distributed systems.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	3	2	3	2	2		3	2	1	3		
CO2	2	2	3	2	3	2	2	1	3	2	1	3		
CO3	2	3	3	2	3	2	2	1	3	2	1	3		

Syllabus

Understanding the Core Concepts of Distributed Systems -distributed systems designs, system constraints, trade-offs and techniques in distributed systems, distributed system for different data and applications, Distributed system security-Access and location transparency,Processes and Communication, naming, Parallelization of tasks - Concurrency and Synchronization, Consistency and Replication, Distributed system Security and network protocols – types of attacks, encryption algorithms, authentication, public key cryptosystems, data verification.

Textbooks / References

Andrew S. Tannenbaum and Maarten Van Steen, "Distributed Systems: Principles and Paradigms", Second Edition, Pearson, 2007.
Belapurkar, Abhijit, Anirban Chakrabarti, HarigopalPonnapalli, Niranjan Varadarajan, Srinivas Padmanabhuni, and Srikanth Sundarrajan. Distributed systems security: issues, processes and solutions. John Wiley & Sons, 2009.
George Coulouris, Jean Dollimore, Tim Kindberg, and Gordon Blair, "Distributed Systems: Concepts and Design", Fifth Edition,Addison Wesley, 2011.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

Pool 2: AI in Healthcare

19AIE451	COMPUTATIONAL HEALTHCARE	L-T-P-C: 1-2-0-3

Course Objectives

- The goal of this course is to introduce the underlying concepts, methods, and the potential of intelligent systems in healthcare.
- This course will explore foundational methods in artificial intelligence (AI) with greater emphasis on machine learning and knowledge representation and reasoning, and apply them to specific areas in healthcare including, but not limited to, time series analysis of physiological data, disease progression modeling, and patient outcome prediction.
- As a research and project-based course, student(s) will have opportunities to identify and specialize in particular AI methods, clinical/healthcare applications, and relevant tools.

Course Outcome

CO1: Understand models of human and artificial intelligence, specifically computational models of intelligence.
CO2: Comprehend a collection of machine learning models and their applications in healthcare.
CO3: Identify and apply appropriate intelligent system models and computational tools to specific problems in healthcare.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	3	3	2		3	3		3		
CO2	3	3	3	2	3	3	2		3	3		3		
CO3	3	3	3	2	3	3	2		3	3		3		

Pre Requisite(s): A basic foundation in linear algebra, probability and statistics, and data structures are recommended for this course.

Syllabus

Supervised Learning: (a) Decision trees, non-parametric methods for learning, support vector machines, (b) Bio-inspired Learning (from perceptron to deep learning): neural basis of computing, classical neural networks, deep neural networks, deep belief networks, recurrent neural networks, and convolutional neural networks - Unsupervised Learning: basic and advanced clustering techniques, dimensionality reduction (feature selection and feature extraction) Disease progression modeling. Time-series analysis: temporal models (probabilistic reasoning over time) - Physiological and laboratory time-series. Supervised learning for risk stratification - Predicting the outcome of interventions: causal inference from observational data.

Textbooks / References

Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach (3rd ed.). Prentice Hall Press, 2009.
Tony J. Cleophas and Aeilko H. Zwinderman, Machine Learning in Medicine - a Complete Overview. Springer, 2015.
SunilaGollapudi, S, Practical Machine Learning. Packt Publishing Ltd, 2016.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE452	BASICS OF DRUG DESIGN	L-T-P-C: 1-2-0-3

Course Objectives

- The main objective of this course is to explore computer assisted drug design that can speed up the process, reduce surprises and predict the properties, thereby reducing the cost of R&D.
- To explore the recent advances in the use of computational and combinatorial chemistry in drug design.

Course Outcome

CO1: Understand the basics of drug design.
CO2: To explore the open source tools and databases available for computer assisted drug design.
CO3: To develop the skillset in computer assisted drug design.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	3	3	3		3	3		3		
CO2	3	3	3	2	3	3	3		3	3		3		
CO3	3	3	3	2	3	3	3		3	3		3		

Syllabus

Introduction to Drug Discovery – Virtual Screening Techniques – Drug likeness screening – Concept of pharmacophore mapping and pharmacophore based Screening – Molecular Docking – Rigid Docking- flexible docking – manual docking – docking based screening – Informatics & Methods in Drug Design – Introduction to Bioinformatics – cheminformatics – ADME databases – chemical, biochemical and pharmaceutical databases.

Textbooks / References

Kerns, E.H.; Di, L. Drug-Like Properties: Concepts, Structure Design and Methods: from ADME to Toxicity Optimization, Academic Press, Oxford, 2008.
Burger's Medicinal Chemistry and Drug Discovery, 6th Edition, Vol. 1. Principles and Practice, edited by M. E. Wolff, John Wiley & Sons: New York, 2003.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE453	DEEP LEARNING IN GENOMICS AND BIOMEDICINE	L-T-P-C: 1-2-0-3

Course Objectives

- The goal of this course is to cover the overview of the relevant background in genomics and high-throughput biotechnology, focusing on the available data and their relevance.
- It will then cover the ongoing developments in deep learning (supervised, unsupervised and generative models) with the focus on the applications of these methods to biomedical data.
- In addition to predictive modeling, the course emphasizes how to visualize and extract interpretable, biological insights from such models

Course Outcome

CO1: Understand models of human and artificial intelligence, specifically computational models of intelligence.
CO2: Comprehend a collection of machine learning models and their applications in genomics.
CO3: Identify and apply appropriate intelligent system models and computational tools to specific problems in genomics.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	3	3	2		3	3		3		
CO2	3	3	3	2	3	3	2		3	3		3		
CO3	3	3	3	2	3	3	2		3	3		3		

Syllabus

Pre Requisite(s): A basic foundation in linear algebra, probability and statistics, and machine learning are recommended for this course. No prior knowledge of genomics is necessary.

Syllabus

Introduction to deep learning - Applications of deep learning to regulatory genomics, variant scoring and population genetics - Applications of deep learning to predicting protein structure and pharmacogenomics - Applications of deep learning to electronic health records and medical imaging data.

Textbooks / References

Polina Mamoshina, Armando Vieira, Evgeny Putin, Alex Zhavoronkov, Applications of deep learning in Biomedicine, Mol.Pharmaceutics, 2016.
Riccardo Miotto, Fei Wang, Shuang Wang, Xiaoqian Jiang, Joel T Dudley, Deep learning for healthcare: review, opportunities and challenges, Briefings in Bioinformatics, Vol.19, Issue.6, 2018.
Tianwei Yue, Haohan Wang, Deep Learning for Genomics: A Concise Overview, Handbook of Deep Learning Applications, Springer, 2018.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE454	CLINICAL INFORMATION SYSTEM	L-T-P-C: 1-2-0-3

Course Objectives

- The objective of this course is to gain insight and situational experience with clinical information systems.
- To examine the effective use of data and information technology to assist in the migration away from paper-based systems and improve organizational performance.
- To gain insights and understanding of the impacts placed on patients and health care providers.

Course Outcome

CO1: To understand the basics of clinical information systems.
CO2: To learn how to apply information technology and related tools in workflow design.
CO3: To explore the "benefits and barriers" associated with electronic health records.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	3	3	3		3	3		3		
CO2	3	3	3	2	3	3	3		3	3		3		
CO3	3	3	3	2	3	3	3		3	3		3		

Syllabus

Introduction to clinical information systems – contemporary issues in healthcare – workflow and related tools for workflow design – electronic health records databases – Healthcare IT & portable technology – Issues in sustainability and interoperability.

Textbooks / References

Sittig&Ash, Clinical Information Systems – Overcoming Adverse Consequences, Jones & Bartlett Learning Publishers, 2009.
Edward H. Shortliffe; Leslie E. Perreault, Medical Informatics – Computer Applications in Healthcare and Biomedicine, Springer-Verlag New York Inc.Publishers, 2014.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE455	CRISPR TECHNOLOGY	L-T-P-C: 1-2-0-3

Course Objectives

- The goal of this course is to cover the overview of the relevant background in crispr technology and high-throughput biotechnology, focusing on the available data and their relevance.
- It will then cover the ongoing developments with the focus on the applications of these methods to biomedical data.

Course Outcome

CO1: Understand models of human and artificial intelligence, specifically computational models of intelligence.
CO2: Comprehend a collection of various applications of crispr technology
CO3: Identify and apply appropriate intelligent system models and computational tools to specific problems in gene editing.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	3	3	3		3	3		3		
CO2	3	3	3	2	3	3	3		3	3		3		
CO3	3	3	3	2	3	3	3		3	3		3		

Syllabus

Introduction to Genetic Engineering - History of Crispr – Crispr in bacteria – Classification of Crispr – General structure of cas9 protein – Mechanism of Crispr cas9 – Applications – Database of Crispr – Case studies.

Textbooks / References

Maximilian Haeussler, Jean-Paul Concordet, CRISPOR Manual, MIT, 2016.
Singh et al: A Mouse Geneticist's Practical Guide to CRISPR Applications; Genetics, Vol.199, No.1, 2015.
Ran et al, Genome engineering using the CRISPR-Cas9 system, Nature Protocols, 2013.
Fujihara&Ikawaw, CRISPR/Cas9-Based Genome Editing in Mice by Single Plasmid Injection, Methods Enzymol. 2014.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE456	DNA SEQUENCING	L-T-P-C: 1-2-0-3

Course Objectives

- The goal of this course is to cover the overview of the relevant background in DNA sequencing, focusing on the available data and their relevance.
- It will then cover the ongoing developments in deep learning with the focus on the applications of these methods to DNA sequence data.
- The course emphasizes how to visualize and extract interpretable, biological insights from such models.

Course Outcomes

CO1: Understand models of human and artificial intelligence, specifically computational models of intelligence.
CO2: Comprehend a collection of machine learning models and their applications in DNA sequencing.
CO3: Identify and apply appropriate intelligent system models and computational tools to specific problems in DNA sequencing.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	3	3	2		3	3		3		
CO2	3	3	3	2	3	3	2		3	3		3		
CO3	3	3	3	2	3	3	2		3	3		3		

Prerequisites: A basic foundation in linear algebra, probability and statistics, and machine learning are recommended for this course.

Syllabus

Introduction to Genome Sequencing – Applying Euler's theorem to assemble genomes - sequencing antibiotics - Introduction to Structural Variation - Advantages of long-read sequencing for structural variation analysis - Application of long-reads to structural variation analysis - Data Analysis Tools for DNA sequencing - Accurate analysis of targeted genomic regions - Quantifying gene expression and transcriptome analysis - Simultaneous analysis of epigenetic modifications and sequence data – Metagenomic analysis of environmental samples - Applications of nanopore sequencing technologies to whole genome sequencing of human viruses.

Textbooks / References

Sudmant, P.H. et al, An integrated map of structural variation in 2,504 human genomes. Nature. 2015.
Lu, H., Giordano, F. and Ning, Z, Oxford Nanopore MinION Sequencing and Genome Assembly. Genomics Proteomics Bioinformatics, Vol.15, Issue.5, 2016.
Stankiewicz, P. and Lupski, J.R, Structural variation in the human genome and its role in disease. Annu Rev Med. Vol. 61, 2010.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

Pool 3: AI in Robotics

19AIE441	KINEMATICS & KINETICS FOR ROBOTICS	L-T-P-C:1-2-0-3

Course Objectives

- To introduce the basic concepts of Kinetics & Kinematics of robotic systems and investigate the connections between Kinetics and Kinematics of robotic systems.
- The course will introduce the state of the art computational tools to solve the Kinetics and Kinematics problems

Course Outcome

CO1: To understand the fundamentals of Kinematics & Kinetics for Robotics.
CO2: To apply the concepts of vector mechanics for solving Kinematics problems.
CO3: To apply computational techniques to solve Kinematics & Kinetics problems.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	1			3	2	3	3		
CO2	3	3	2	2	2	1			3	2	3	3		
CO3	3	3	3	3	3	2			3	2	3	3		

Syllabus

Components and Mechanisms of a Robotic System – Link – Joint – Manipulator – Actuator – Sensor – Controller – Kinetics and Kinematics of Robots – Rotation Kinematics – Rotation about Global and Local Axes – Euler angles – Transformation Matrices – Rotation Matrix – Quaternion – Composition and decomposition of Rotations - Homogeneous transformation – Inverse Homogeneous transformation – Compound homogeneous transformation – Forward Kinematics – D-H Notation – Inverse Kinematics – Angular Velocity – Velocity Kinematics – Numerical Methods in Kinematics.

Textbooks / References

Theory of Applied Robotics: Kinematics, Dynamics & Control – R. Jazar, Springer, 2010.
Statics and Kinematics with application to Robotics : J. Duffy, Cambridge University Press, 1996.
Kinematics and Dynamics of Machinery – Wilson & Sadler, Third Edition, Pearson Publication, 2003.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE442	ROBOTIC VISION	L-T-P-C:1-2-0-3

Course Objectives

- To introduce the basic concepts of robotic vision and develop an appreciation towards various computational tools used for object/image recognition.
- The course will enable the students to understand various robotic vision and object recognition applications.

Course Outcome

CO1: To understand the basic concepts of robotic vision.
CO2: To appreciate various computational tools used for robotic vision.
CO3: To develop simple and specific applications involving robotic vision.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	2	1			3	3	3	3		
CO2	3	3	2	3	3	1			3	3	3	3		
CO3	2	3	3	3	3	3			3	3	3	3		

Syllabus

Introduction to Computer Vision – Light and Color – Color Temperature – Color Constancy – Image Formation – Perspective Camera – Camera Calibration – Unified Imaging – Novel Cameras – Image Processing – Spatial Operations – Mathematical Morphology – Shape Changing – Image Feature Extraction – Using Multiple Images – Stereo Vision – Vision based control – Visual Servoing – Advanced Visual Servoing.

Textbooks / References

Robotics, Vision & Control, P. Corke, 2nd edition, Springer 2011
Robotic object recognition using vision and touch – Peter K Allen – Kluwer Academic Publishers, 1987.
Learning – Based Robot Vision – Joseph Pauli – Springer Publishers, 2001.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE443	DYNAMICS & CONTROL OF ROBOTICS	L-T-P-C:1-2-0-3

Course Objectives

- To provide a mathematical foundation to dynamics and control of robotic systems and introduce a set of analytical and computational tools for the modelling and control of robots.
- This will enable the students to simulate and control robotic motion for various types of robotic systems.

Course Outcome

CO1: To develop mathematical models for dynamics and control of robotic systems.
CO2: To apply analytical and computational tools for modelling and control of robots.
CO3: To simulate and control simple robotic motion.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2	3	2	1			3	3	3	3		
CO2	3	3	3	3	3	1			3	3	3	3		
CO3	3	2	3	3	3	2			3	3	3	3		

Syllabus

Dynamics of Robotics – Acceleration Kinematics – Motion Dynamics – Review of Rigid body Kinetics – Translational Kinetics – Rotational Kinetics – Rigid link acceleration – Newton-Euler dynamics – Recursive Newton – Euler Dynamics – Lagrange Equations – Robot Statics – Introduction to control of robotics – Path Planning – Polynomial Path – Non-Polynomial Path – Cartesian Path – Rotational Path – Manipulator Motion – Time optimal control – Bang – Bang control – Open Loop and Closed Control – Classical Control Techniques – Modern Control Techniques – Sensing and Control.

Textbooks / References

Theory of Applied Robotics: Kinematics, Dynamics & Control – R. Jazar, Springer, 2010.

Advances in Robotics, automation and control: Aramburo& Trevino, In-Tech Publishers, 2008.

Robotics: Modelling, Planning & Control- B Siciliano, L Sciavicco , L Villani & G Oriolo. Springer Text books in Control and Signal Processing, 2009.

Aspects of Soft Computing, Intelligent Robotics and Control –Janos Fodor – Springer Publishers, 2009.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE444	SENSORS FOR ROBOTICS	L-T-P-C:1-2-0-3

Course Objectives

- The major objective of this course will be integrating various sensor systems required for the designed robotic system.
- This will lead to programing the sensor module to retrieve data and process to make decisions for the robot.
- This will equip the students with the skill and knowledge to design simple robotic systems with sensors for specific applications

Course Outcome

CO1: To understand the working of most common sensors used in robotics.
CO2: To understand the sensor processing algorithms.
CO3: To design simple robotic systems with sensors for specific applications.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	3	2			3	3	3	3		
CO2	3	3	3	2	3	2			3	3	3	3		
CO3	3	2	3	2	3	2			3	3	3	3		

Syllabus

Introduction to sensing in robotics – Sensor Development - Force and Torque Sensors – Tactile Sensors – Acoustic Sensors – Optical Sensors – Other Kind of Sensors – Multi Sensor Integration – Algorithms for sensing data.

Textbooks / References

Sensory Systems for Robotic Control: Casals A., Springer – Verlag, 1989.

Traditional and Non-Traditional Robotic Sensors – Henderson, T. C., Springer –Verlag, 1990.

Robotics, Vision & Control, P. Corke, 2nd edition, Springer 2011.

Robotic object recognition using vision and touch – Peter K Allen – Kluwer Academic Publishers, 1987.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20

19AIE445	APPLICATION OF ROBOTICS	L-T-P-C: 1-2-0-3

Course Objectives

- The objective of the course is to equip students with fundamental knowledge on industrial robots.
- Learners will be aware of the benefits of using robots, able to perform basic robot programming and able to select suitable robots and associated components for different applications.
- Design and implementation of robotic systems like 3d printers, robotic arms, industrial robots, medical aiding robotic system.
- The students will get exclusive hands on developing robotic systems for converting conventional vehicles to self-driving vehicles

Course Outcome

CO1: Understanding the various types of robots and its application

CO2: Design and development of industrial and societal application based robotic systems

CO3: Design and development of robotic systems for self-driving vehicles, medical applications and agriculture.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	3	2	3	2	2	2	3	2	3	3		
CO2	2	2	3	2	3	2	2	2	3	2	3	3		
CO3	2	3	3	2	3	2	2	2	3	2	3	3		

Syllabus

Introduction to robotics and benefits of industrial robots, and relevant technical terms ,Common/Typical robot applications such as welding, painting, medical aiding, for amputees and pick-and-place, Robot system specifications and requirements for different applications, Robot programming, AI based control for robotics system, Reinforcement learning for robotics systems.

Textbooks / References

Niku, S. B, Introduction to robotics: analysis, control, applications. John Wiley & Sons, 2010.
Nicholas Odrey, Mitchell Weiss, Mikell Groover, Roger Nagel and Ashish Dutta,Industrial Robotics - SIE: Technology - Programming and Applications, McGraw Hill Education; 2nd edition,2017.

Evaluation Pattern

Assessment	Weightage(%)
Assignments(10 assignments with equal credit)	50
Quiz(5 Quizzes with equal credit)	30
Project	20