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 2021

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.

SEMESTER I

Cat.	Course Code	Title	Credit
SCI	21MAT104	Mathematics for Intelligent System 1	3
SCI	21PHY104	Computational Engineering Mechanics 1	3
ENGG	21AIE105	Object Oriented Programming	4
ENGG	21AIE101	Elements of Computing Systems 1	3
ENGG	21AIE104	Introduction to Electrical Engineering	3
SCI	21BIO103	Intelligence of Biological Systems 1	2
ENGG	21AIE102	Introduction to Digital Manufacturing*	2
ENGG	21AIE103	Introduction to Drones*	2
HUM	19CUL101	Cultural Education I	2
HUM	19ENG111	Technical Communication	3
		TOTAL	27

SEMESTER II

Cat.	Course Code	Title	Credit
SCI	21MAT117	Mathematics for Intelligent Systems 2	3
SCI	21PHY113	Computational Engineering Mechanics 2	3
ENGG	21AIE114	Principles of Measurements & Sensors	3
ENGG	21AIE111	Data Structures & Algorithms 1	3
ENGG	21AIE112	Elements of Computing Systems - 2	3
ENGG	21AIE113	Introduction to Electronics	3
SCI	21BIO112	Intelligence of Biological Systems 2	2
HUM	19CUL111	Cultural Education II	2
		TOTAL	22

SEMESTER III

Cat	Course Code	Title	Cr
SCI	21MAT204	Mathematics for Intelligent Systems 3	3
ENGG	21AIE201	Introduction to Robotics	3
ENGG	21AIE202	Operating Systems	3
ENGG	21AIE203	Data Structures & Algorithms 2	3
ENGG	21AIE204	Introduction to Communication Systems	3
ENGG	21BIO201	Intelligence of Biological Systems 3	3
ENGG	21AIE205	Python for Machine Learning	1
HUM	19LAW300	Indian Constitution	P/F
HUM	19AVP201	Amrita Values Program-1	1
		Total	20

SEMESTER IV

Cat	Course Code	Title	Cr
SCI	21MAT212	Mathematics for Intelligent Systems 4	3
ENGG	21AIE211	Introduction to Computer Networks	3
ENGG	21AIE212	Design and Analysis of Algorithms	3
ENGG	21AIE213	Robotic Operating Systems & Robot Simulation	3
ENGG	21AIE214	Bigdata Analytics	3
ENGG	21BIO211	Intelligence of Biological Systems 4	3
HUM	19AVP211	Amrita Values Program-2	1
HUM	19ENV300	Environmental Science	P/F
HUM	19SSK211	Soft Skills I	2
		Total	21

SEMESTER V

Cat	Course Code	Title	Cr
SCI	21MAT301	Mathematics for Intelligent Systems 5	3
ENGG	21AIE301	Formal language and Automata	3
ENGG	21AIE302	Advanced Computer Networks	3
ENGG	21AIE303	Signal & Image Processing	3
ENGG	21AIE304	Big Data and Database Management	3
ENGG	19LIV390	Professional Elective 1*/Live-in Labs***	3
HUM	19SSK301	Soft. Skills II	2
HUM	19MNG300	Disaster Management	P/F
		Total	20

SEMESTER VI

Cat	Course Code	Title	Cr
SCI	21MAT311	Mathematics for Intelligent Systems 6	3
ENGG	21AIE311	Reinforcement Learning	3
ENGG	21AIE312	Deep Learning for Signal & Image Processing	3
ENGG	21AIE313	Introduction to Modern Compiler Design	3
ENGG	19LIV490	Professional Elective 2*/Live in labs ***	3
ENGG	21AIE314	AI in Natural Language Processing	3
ENGG	21AIE315	AI in Speech Processing	3
HUM	19SSK311	Soft Skills II	2
		Total	23

SEMESTER VII

Cat	Course Code	Title	Cr
ENGG	21AIE401	Deep Reinforcement Learning	3
ENGG		Professional Elective 3*	3
ENGG		Professional Elective 4*	3
ENGG		Free Elective 1**	2
ENGG		Free Elective 2**	2
PRJ	21AIE495	Project Phase - 1	4
		Total	17

SEMESTER VIII

Cat	Course Code	Title	Cr
PRJ	21AIE499	Project Phase - 2	10
		Total	10

		Total Credits		160

@'Hands-on' Project-based Lab.

***Professional Elective - Electives categorised under Engineering, Science, Mathematics, Live-in-Labs, and NPTEL Courses. Student can opt for such electives across departments/campuses. Students with CGPA of 7.0 and above can opt for a maximum of 2 NPTEL courses with the credits not exceeding 8.**

**** Free Electives - This will include courses offered by Faculty of Humanities and Social Sciences/ Faculty Arts, Commerce and Media / Faculty of Management/Amrita Darshanam -(International Centre for Spiritual Studies).**

***** Live-in-Labs - Students undertaking and registering for a Live-in-Labs project, can be exempted from registering for an Elective course in the higher semester.**

PROFESSIONAL ELECTIVES			
POOL 1: AI IN CYBER SECUITY			
Cat	**Course Code**	**Title**	**Cr**
ENGG	**21AIE431**	**Applied Cryptography**	**3**
ENGG	**21AIE432**	**Network and Wireless Security**	**3**
ENGG	**21AIE433**	**Intrusion Detection and Prevention Systems**	**3**
ENGG	**21AIE434**	**Software Vulnerability Analysis**	**3**
ENGG	**21AIE435**	**Cybercrime Forensics and Digital Forensics**	**3**
ENGG	**21AIE436**	**Distributed System Security**	**3**
POOL 2: AI IN HEALTHCARE			
Cat	**Course Code**	**Title**	**Cr**
ENGG	**21AIE451**	**Computational Healthcare**	**3**
ENGG	**21AIE452**	**Basics of Drug Design**	**3**
ENGG	**21AIE453**	**Deep learning in Genomics and Biomedicine**	**3**
ENGG	**21AIE454**	**Clinical Information Systems**	**3**
ENGG	**21AIE455**	**CRISPR Technology**	**3**
ENGG	**21AIE456**	**DNA Sequencing**	**3**

POOL 3: AI IN ROBOTICS			
Cat	**Course Code**	**Title**	**Cr**
ENGG	**21AIE441**	**Kinematics and Kinetics for Robotics**	**3**
ENGG	**21AIE442**	**Robotics Vision**	**3**
ENGG	**21AIE443**	**Dynamics and Control of Robotics**	**3**
ENGG	**21AIE444**	**Sensors for Robotics**	**3**
ENGG	**21AIE445**	**Application of Robotics**	**3**

PROFESSIONAL ELECTIVES UNDER SCIENCE STREAM

CHEMISTRY			
Cat.	**Code**	**Title**	**Credit**
SCI	**19CHY243**	**Computational Chemistry and Molecular Modelling**	**3**
SCI	**19CHY236**	**Electrochemical Energy Systems and Processes**	**3**
SCI	**19CHY240**	**Fuels and Combustion**	**3**
SCI	**19CHY232**	**Green Chemistry and Technology**	**3**
SCI	**19CHY239**	**Instrumental Methods of Analysis**	**3**
SCI	**19CHY241**	**Batteries and Fuel Cells**	**3**
SCI	**19CHY242**	**Corrosion Science**	**3**
PHYSICS			
SCI	**19PHY340**	**Advanced Classical Dynamics**	**3**
SCI	**19PHY342**	**Electrical Engineering Materials**	**3**
SCI	**19PHY331**	**Physics of Lasers and Applications**	**3**
SCI	**19PHY341**	**Concepts of Nanophysics and Nanotechnology**	**3**
SCI	**19PHY343**	**Physics of Semiconductor Devices**	**3**
SCI	**19PHY339**	**Astrophysics**	**3**
Mathematics			
SCI	**19MAT341**	**Statistical Inference**	**3**
SCI	**19MAT342**	**Introduction to Game Theory**	**3**
SCI	**19MAT343**	**Numerical Methods and Optimization**	**3**

FREE ELECTIVES

FREE ELECTIVES OFFERED UNDER MANAGEMENT STREAM			
Cat.	**Code**	**Title**	**Credit**
HUM	**19MNG331**	**Financial Management**	**3**
HUM	**19MNG332**	**Supply Chain Management**	**3**
HUM	**19MNG333**	**Marketing Management**	**3**
HUM	**19MNG334**	**Project Management**	**3**
HUM	**19MNG335**	**Enterprise Management**	**3**
HUM	**19MNG338**	**Operations Research**	**3**
HUM	**19MEE401**	**Industrial Engineering**	**3**
HUM	**19MEE346**	**Managerial Statistics**	**3**
HUM	**19MEE347**	**Total Quality Management**	**3**
HUM	**19MEE342**	**Lean Manufacturing**	**3**
HUM	**19CSE358**	**Software Project Management**	**3**
HUM	**19CSE359**	**Financial Engineering**	**3**
HUM	**19CSE360**	**Engineering Economic Analysis**	**3**
HUM	**19MNG331**	**Financial Management**	**3**
HUM	**19CSE362**	**Information Systems**	**3**

FREE ELECTIVES OFFERED UNDER HUMANITIES / SOCIAL SCIENCE STREAMS			
Cat.	**Code**	**Title**	**Credit**
HUM	19CUL230	Achieving Excellence in Life - An Indian Perspective	2
HUM	19CUL231	Excellence in Daily Life	2
HUM	19CUL232	Exploring Science and Technology in Ancient India	2
HUM	19CUL233	Yoga Psychology	2
HUM	19ENG230	Business Communication	2
HUM	19ENG231	Indian Thought through English	2
HUM	19ENG232	Insights into Life through English Literature	2
HUM	19ENG233	Technical Communication	2
HUM	19ENG234	Indian Short Stories in English	2
HUM	19FRE230	Proficiency in French Language (Lower)	2
HUM	19FRE231	Proficiency in French Language (Higher)	2
HUM	19GER230	German for Beginners I	2
HUM	19GER231	German for Beginners II	2
HUM	19GER232	Proficiency in German Language (Lower)	2
HUM	19GER233	Proficiency in German Language (Higher)	2
HUM	19HIN101	Hindi I	2
HUM	19HIN111	Hindi II	2
HUM	19HUM230	Emotional Intelligence	2
HUM	19HUM231	Glimpses into the Indian Mind - the Growth of Modern India	2
HUM	19HUM232	Glimpses of Eternal India	2
HUM	19HUM233	Glimpses of Indian Economy and Polity	2
HUM	19HUM234	Health and Lifestyle	2
HUM	19HUM235	Indian Classics for the Twenty-first Century	2
HUM	19HUM236	Introduction to India Studies	2
HUM	19HUM237	Introduction to Sanskrit Language and Literature	2
HUM	19HUM238	National Service Scheme	2
HUM	19HUM239	Psychology for Effective Living	2
HUM	19HUM240	Psychology for Engineers	2
HUM	19HUM241	Science and Society - An Indian Perspective	2

HUM	**19HUM242**	**The Message of Bhagwad Gita**	**2**
HUM	**19HUM243**	**The Message of the Upanishads**	**2**
HUM	**19HUM244**	**Understanding Science of Food and Nutrition**	**2**
HUM	**19JAP230**	**Proficiency in Japanese Language (Lower)**	**2**
HUM	**19JAP2313**	**Proficiency in Japanese Language (Higher)**	**2**
HUM	**19KAN101**	**Kannada I**	**2**
HUM	**19KAN111**	**Kannada II**	**2**
HUM	**19MAL101**	**Malayalam I**	**2**
HUM	**19MAL111**	**Malayalam II**	**2**
HUM	**19SAN101**	**Sanskrit I**	**2**
HUM	**19SAN111**	**Sanskrit II**	**2**
HUM	**19SWK230**	**Corporate Social Responsibility**	**2**
HUM	**19SWK231**	**Workplace Mental Health**	**2**
HUM	**19TAM101**	**Tamil I**	**2**
HUM	**19TAM111**	**Tamil II**	**2**

SYLLABUS

SEMESTER I

21MAT104	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

After completing this course, students will be able to

CO1: Elaborate the introductory concepts and techniques of linear algebra, calculus and probability theory.

CO2: Explain mathematical concepts commonly used in Data science and AI.

CO3: Apply the combinations of learned mathematical concepts in the form of computational and algebraic methods.

CO4: Computationally model electrical and mechanical systems.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	2	-	-	-	3	2	2	2	3	-	-
CO2	3	2	2	1	3	-	-	-	3	2	2	2	3	-	-
CO3	3	3	2	2	3	2	-	-	3	2	3	2	2	2	-
CO4	3	2	2	2	3	-	-	-	3	2	3	2	2	2	1

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, Introduction to Linear Algebra, Fifth Edition, Wellesley-Cambridge Press, 2016.

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.

Stephen Boyd and Lieven Vandenberghe, Introduction to Applied Linear Algebra – Vectors, Matrices, and Least Squares, 2018.

Evaluation Pattern

Assessment	Weightage(%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21PHY104	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

After completing this course, students will be able to

CO1: Apply the principles in statics and dynamics to solve structured problems in computational mechanics
CO2: Implement the state of the art computational techniques to solve the structured problems in mechanics.
CO3: Model engineering problems in the perspective of mechanics.
CO4: Integrate the concepts of mathematics, mechanics and computational thinking.

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	3				3	2	3	3			
CO2	3	3	3	3	3	2			3	2	3	3		3	2
CO3	3	2	3	3	3				3	2	3	3	2		2
CO4	3	3	3	2	3				3	2	3	3	3		

Syllabus

Newton's Laws of Motion, Force as 3D Vector, Resolution of Forces, Resultant of Forces, Equilibrium about a Point, Moment, Couple, Equivalent System, Equilibrium of Rigid Bodies, Free Body Diagram, Degree-of-freedom and Constraints at Supports,Analysis of Beams and Frames, Analysis of Trusses using Method of Joints,Friction, Centroid of an arc and area, Area moment of inertia, parallel axis theorem, Kinematics of particles, assumptions, Cartesian, Cylindrical and Spherical frames and motion of particles in them

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.
Dukkipati R. V., MATLAB: An Introduction with Applications, New Age International; 2010.

Evaluation Pattern

Assessment	Weightage(%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE105	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

After completing this course, students will be able to

CO1: Understand Object Oriented paradigm and represent the problem using objects and classes.

CO2: Observe and Analyze object-oriented concepts and its implementations

CO3: Apply the object oriented concepts to design and visualize programs using UML

CO4: Observe, Analyze and Design application using object oriented features.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	3				3	2	3	3	1	1	1
CO2	3	3	3	3	3				3	2	3	3	1	1	1
CO3	3	2	3	3	3				3	2	3	3	1	1	1
CO4	3	2	3	3	3				3	2	1	3	1	1	1

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, Object-Oriented Concepts, Abstraction, Encapsulation, Inheritance and Polymorphism, Overloading and Overriding, Interfaces, Abstract Class, Exceptions, Exception handling, UML Diagrams, Introduction to Threads, Introduction to Object-Oriented Design Patterns

Textbook / Reference

1. Blaha, Michael. Object-Oriented Modeling and Design with UML: For VTU, 2/e. Pearson Education India, 2005.
2. Object-Oriented Programming in C++ by Lafore
3. 'Head First Java'- O Reilly – second edition

Evaluation Pattern

Assessment	Weightage(%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE101	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

After completing this course, the students will be able to

CO1: Explain the concept of Boolean Algebra and Digital Logic

CO2: Implement different combinational and sequential digital logic systems

CO3: Design the hardware hierarchy of general-purpose computing systems

CO4: Build a general-purpose computer capable of running stored programs written in the machine language

CO – PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	3	-	-	-	3	2	3	3	1	1	1
CO2	3	3	3	3	3	2	-	-	3	2	3	3	2	2	2
CO3	3	2	3	3	3	-	-	-	3	2	3	3	2	2	2
CO4	3	2	3	2	3	-	-	-	3	2	3	3	2	2	2

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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE104 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 isto provide connection between the concepts of electrical engineering, mathematics, and computational thinking.

Course outcomes

After completing this course, the students will be able to

CO1: Summarize a basic understanding of the principles in electrical engineering.

CO2: Implement the state-of-the-art computational techniques that can be employed to analyse the structured problems in electrical engineering.

CO3: Model engineering problems in the perspective of electrical engineering.

CO4: Illustrate the connection between mathematics, electrical engineering, and computational thinking.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	3	1	-	-	3	2	3	3	2	1	1
CO2	3	3	3	3	3	2	-	-	3	2	3	3	2	3	2
CO3	3	2	3	3	3	2	2	-	3	2	3	3	2	2	3
CO4	3	3	3	2	3	2	2	-	3	2	3	3	3	3	2

Syllabus

Fundamentals of solid-state physics- Fundamental electrical laws – Fundamental circuit elements: Charge, Voltage, and Current Resistance -Ohm's Law - Kirchhoff's Voltage Law - Kirchhoff's Current Law - Thevenin Equivalent Circuit - Norton Equivalent Circuit - Inductors and Capacitors - Impedance and AC Sinusoidal Signals – Three Phase Power and Power Factor - Active and Reactive Power – Transformers - Introduction to generators and motors - Operational Amplifier - Fundamentals of Linear Control Systems.

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.

Edward Hughes, "Electrical and Electronic Engineering", Pearson (E-12), 2016.

Evaluation Pattern

Assessment	Weightage (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21BIO103	INTELLIGENCE OF BIOLOGICAL SYSTEMS 1	L-T-P-C: 2- 0- 0- 2

COURSE OBJECTIVES

- This course will initiate the mechanism behind the applied cell and molecular biology.
- This course will help students in understanding the biological processes and the intelligence of cells.
- This course will pave the way for advanced methods in computational biology to understand sequence retrieval processes and structure prediction.
- This course is an initiative to evaluate the models of evolution.

COURSE OUTCOMES

After completing this course, the students will be able to

CO1: Apply the cellular structure and biophysical process for creating engineered models.
CO2: Incorporate the application of molecular mechanisms.
CO3: Develop a durable base for system biology.
CO4: Analyze the process of evolution.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	1	1	1	1	3	-	2	-	3	2	-	3	2	1	-
CO 2	1	1	1	1	3	-	2	-	3	2	-	3	1	1	-
CO 3	1	3	2	2	3	-	2	-	3	2	-	3	2	1	-
CO4	2	1	2	3	-	-	1	-	3	2	1	2	1	-	2

Syllabus

Classification of biological molecules: Carbohydrates, Lipids, Proteins, Nucleic acid;Cellular structures and its functions; Cellular energy production and utilization, the cell cycle and cell division: mitosis, meiosis; Central Dogma of the cell: Replication, Transcription, Translation; Mutation; Evolution and patterns.

Textbooks/References

DM.Vasudevan, Sreekumari S, Kannan Vaidyanathan, Textbook of Biochemistry for Medical Students (As Per Revised MCI Curriculum),9th Edition, Jaypee Publishers, 2019.
Gabi Nindl Waite, Lee R Waite, Applied Cell and Molecular Biology for Engineers, McGraw Hill Publishers, 2007.
George M. Malascinski, Freifelder's Essentials of Molecular Biology, 4th Edition, Jones and Bartlett Student Edition, 2015.
David Nelson, Michael M Cox, LeningerPrinciples of Biochemistry, 8th Edition, Macmillan, 2021.

Evaluation Pattern

Assessment	Weightage (%)
Internals (Minimum 10 assessments)	70
External (Project & Viva)	30

21AIE103	INTRODUCTION TO DRONES	L-T-P-C: 1- 0- 3- 2

Course Objectives

- The main aim of this course is to understand the basics of Unmanned Arial Vehicles (Drones) and its various applications in the age of artificial intelligence.
- The course will take the students to understand the basic dynamics of drone based flying system.
- The course will provide the knowledge of basic electronic components and their working principles in a drone/ Unmanned Aerial vehicle system
- The course will also impart the knowledge of how to fly a drone by considering the rules and regulations to the specific country.

After completing this course, the students will be able to

CO1: Understand the drone / UAV flying regulations specific to India and various applications in the age of AI

CO2: Analyse the working principles of various electronic components to build the drone

CO3: Apply the concept of drone dynamics and different movements during flight

CO4: Understand and exhibit the UAV flying in the given environment.

CO-PO Mapping

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

Syllabus

Introductions to drones and its applications in the age of AI, Drone regulations specific to India, Basics of drone dynamics for flying - frame types, propellers, types of drones, dynamics specific to quadcopter, Understanding UAV movements (Quadcopter), How to fly a drone, Introduction to drone electronic components, working principle behind each electronic component, Drone frames and electronic assembly, flying experiments.

Textbook / References

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

Barnhart, R. Kurt, Douglas M. Marshall, and Eric Shappee, eds. Introduction to unmanned aircraft systems. Crc Press, 2021.

Garg, P. K. Unmanned Aerial Vehicles: An Introduction. Stylus Publishing, LLC, 2021

Kimon P. Valavanis, Handbook of Unmanned Aerial Vehicles, Volume4, Springer Netherlands, 2014.

Evaluation Pattern

Assessment	Weightage (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

This course will be offered in the workshop mode of duration two weeks.

21AIE102	INTRODUCTION TO DIGITAL MANUFACTURING	L-T-P-C: 1- 0- 3- 2

Course Objectives

- 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.

Course Outcomes

After completing this course, the students will be able to

CO1: Acquire the knowledge of basic working principle of a 3D printer, how to use a 3D printer and how to assemble a 3D printer.
CO2: Acquire basic drawing skills to Design simple 3D design using CAD packages.
CO3: Acquire the knowledge of workflow, Slicing and postprocessing operations in a 3D Printer
CO4: Design small robots and DIY projects where they can accommodate simple electronics to printed parts and make it live.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	3	2	3	2	2	-	3	2	3	3	2	1	-
CO2	2	2	3	2	3	2	2	-	3	2	3	3	2	1	-
CO3	3	2	3	2	3	1	1	-	2	2	3	3	2	1	-
CO4	2	3	3	2	3	2	2	-	3	2	3	3	2	1	-

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.
https://ultimaker.com/en/resources/education/3d-printing-in-the-classroom
Brian Evans, Practical 3d Printers the Science and Art of 3d Printing, Apress, 2018.
Chris Anderson, Makers-The New Industrial Revolution, Crown Publishing, 2018.
Kalani Kirk Hausman and Richard Horne 3D Printing for Dummies, Wiley Publications, 2018.
Ben Redwood, FilemonSchoffer, Brian Garret, 3D Printing Handbook, Technologies design and Applications, 3D Hubs, 2018.

Evaluation Pattern

Assessment	Weightage (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

This course will be offered in the workshop mode of duration two weeks.

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.

19ENG111	TECHNICAL COMMUNICATION	L-T-P-C: 2-0-3-3

Course Objectives

- To introduce the students to the fundamentals of mechanics of writing
- To facilitate them with the style of documentation and specific formal written communication
- To initiate in them the art of critical thinking and analysis
- To help them develop techniques of scanning for specific information, comprehension and organization of ideas
- To enhance their technical presentation skills

Course Outcomes

The course will enable the student:
CO1: To gain knowledge about the mechanics of writing and the elements of formal correspondence
CO2: To understand and summarize technical documents
CO3: To apply the basic elements of language in formal correspondence
CO4: To interpret and analyze information and to organize ideas in a logical and coherent manner
CO5: To compose project reports/ documents, revise them for language accuracy and make technical presentations

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1										3					
CO2				1						2					
CO3										3					
CO4				1						2					
CO5									2	1					

Syllabus

Unit 1
Mechanics of Writing: Grammar rules -articles, tenses, auxiliary verbs(primary & modal) prepositions, subject-verb agreement, pronoun-antecedent agreement, discourse markers and sentence linkers
General Reading and Listening comprehension - rearrangement & organization of sentences

Unit 2
Different kinds of written documents: Definitions- descriptions- instructions-recommendations- user manuals - reports – proposals
Formal Correspondence:Writingformal Letters
Mechanics of Writing: impersonal passive & punctuation
Scientific Reading & Listening Comprehension

Unit 3

Technical paper writing:documentation style - document editing – proof reading - Organising and formatting
Mechanics of Writing: Modifiers, phrasal verbs, tone and style, graphical representation
Reading and listening comprehension of technical documents
Mini Technical project (10 -12 pages)
Technical presentations

Reference Books

Hirsh, Herbert. L "Essential Communication Strategies for Scientists, Engineers and Technology Professionals".II Edition. New York: IEEE press, 2002
Anderson, Paul. V. "Technical Communication: A Reader-Centred Approach". V Edition. Harcourt Brace College Publication, 2003
Strunk, William Jr. and White.EB."The Elements of Style" New York.Alliyan& Bacon, 1999.
Riordan, G. Daniel and Pauley E. Steven."Technical Report Writing Today" VIII Edition (Indian Adaptation). New Delhi: Biztantra, 2004.
Michael Swan. '' Practical English Usage'', Oxford Univ.Press, 2000

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	10	
*Continuous Assessment (Lab) (CAL)	40	
End Semester		30

*CA – Can be Quizzes, Assignments, Projects, and Report

SEMESTER II

21MAT117	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

After completing this course student will be able to,

CO1: Understand and implement the basic concepts and techniques of linear algebra as applied to signal processing.
CO2: Identify the connection between the concepts of linear algebra, differential equation and probability theory.
CO3: Develop an insight into the applicability of linear algebra in business and scientific domains.
CO4: Apply the concepts of calculus and Linear algebra in modelling electrical and mechanical elements.
CO5: Apply the concepts of probability theory in providing data sets for computational experiments in data science.

CO-PO Mapping

PO/ PSO / CO	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	3	---	---	---	3	2	3	3	3	3	3
CO2	3	2	3	3	3	---	---	---	3	2	3	3	-	3	-
CO3	3	3	3	2	3	---	---	---	3	2	3	3	3	2	3
CO4	3	2	3	3	3	---	---	---	3	2	3	3	2	3	-
CO5	3	3	3	3	3	2	---	---	3	2	3	3	2	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 / Reference Books

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.
Stephen Boyd and Lieven Vandenberghe, "Convex Optimization", Cambridge University Press, 2018.
Stephen Boyd and Lieven Vandenberghe, "Introduction to Applied Linear Algebra – Vectors, Matrices, and Least Squares", Cambridge University Press, 2018.

Evaluation Pattern

Assessment	Weightage(%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21PHY113	COMPUTATIONAL ENGINEERING MECHANICS 2	L-T-P-C: 2-0-3-3

Course Objectives

- The course will lay down the basic concepts and techniques of kinetics and kinematics needed for verticals such as robotics.
- The course will explore the concepts initially through computational experiments and then try to understand the concepts/theory behind it.
- The course 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

After completing this course, the students will be able to

CO1: Analyse the motion of planar mechanisms by applying fundamental principles of Kinematics
CO2: Apply the concepts/tools from computational mathematics for the analysis of planar mechanisms
CO3: Synthesize simple planar mechanisms such as inversions of four-bar mechanism & inversions of slider-crank mechanism
CO4: Model planar mechanisms using various simulation environments available in platforms such as MATLAB, Python, RoboAnalyzer etc.

CO - PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	3	-	-	-	3	2	3	3	-	-	-
CO2	3	3	3	3	3	-	-	-	3	2	3	3	3	-	-
CO3	3	3	3	2	3	-	-	-	3	2	3	3	-	-	3
CO4	2	2	3	2	3	-	-	-	3	2	3	3	-	3	-

Syllabus

Translation and rotation of rigid bodies in 2D – Translation and rotation of rigid bodies in 3D - Kinematics of interconnected rigid bodies– Definition of a linkage – Definition of a mechanism – Definition of a machine – Kinematic pairs – Degrees of freedom – Mobility of a pair - Kinematic chains – Inversions of a mechanism- Planar mechanisms- – Four-bar mechanism – Slider-Crank mechanism – Introduction to synthesis of a planar mechanism – Design parameters of a planar mechanism – Computational techniques for the synthesis of a planar mechanism - Analytical, graphical &computational techniques for position, velocity &accelerationAnalysis of planar mechanisms - Simulation of planar mechanisms – Introduction to various simulation platforms.

Text Books/References

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

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

Waldron K.J., Kinzel G. L. and Agarwal S. K., Kinematics, Dynamics and Design of Machinery, Third Edition, Wiley, 2016.

Vinogradov O., Fundamentals of Kinematics and Dynamics of Machines and Mechanisms, CRC Press, 2000.

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

Evaluation Pattern

Assessment	Weightage(%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE114	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 measurement systems and various sensing technologies and various sensors used in engineering and science.
- Students will be inspired to collect data using sensors, analyse and interpret the collected data.
- Further, the course will focus on equipping the students to interface various sensors with computing platforms

Course Outcomes

After completing this course, the students will be able to

CO1: Explain the principals involved in measurement system in general to science and technology

CO2: Analyse the state-of-the-art sensors involved in the measurement systems in various engineering applications

CO3: Apply the knowledge of measurement principle to interface the sensors with computing platforms for data analysis

CO4: Design and develop measurement tools and techniques to solve engineering problems

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	1	3	2	2	3	3	1	1	1	1	1	1
CO2	3	3	3	3	3	2	2	2	3	2	2	1	2	2	2
CO3	3	2	3	3	3	3	3	3	3	2	2	3	3	3	3
CO4	3	3	3	2	3	3	3	3	3	2	2	3	3	3	3

Syllabus

Introduction to measurement systems and sensors, Introduction to Embedded Systems and Arduino, Arduino Programming, Introduction to Single board computers-Raspberry-PI,Measurement System Characteristics-Static and Dynamic Characteristics of measurement systems: Systematic Characteristics, Generalized model, Calibration errors , 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. Introduction to sensor circuits-Review of Op-Amp Circuit, Transistors based sensor circuits, passive- and active-filters, Accuracy of measurement systems in steady state: Measurement error, Error probability function, Error reduction techniques.

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(%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE111	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

After completing this course, the students will be able to

CO1: Choose an appropriate data structure as applied to a specified problem

CO2: Use various techniques for representation of the data in the real world

CO3: Develop applications using data structures.

CO4: Test the logical ability for solving problems

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	3				3	2	3	3	2	1	0
CO2	3	3	3	3	3				3	2	3	3	3	2	0
CO3	3	2	3	3	3				3	2	3	3	2	2	2
CO4	3	3	3	2	3				3	2	3	3	2	3	2

Syllabus

Data Structure Hierarchy – Primitive – datatypes and their representations, Integer, 2's complement, IEEE756 Floating point-single and double precision – String and character representation types-Unicode and UTF-8 encodings- Basics of Algorithm Analysis- 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(%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE112	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

After completing this course, students will be able to

CO1: Elaborate the important components of a MIPS computer system and the basic organization
CO2: Implement and execute low-level programming on the hardware platform
CO3: Develop and test programs in object-based language 'Jack'
CO4: Practice experiments related to basic concepts and functions of operating systems and compilers.

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	3				3	2	3	3	1	1	1
CO2	3	3	3	3	3				3	2	3	3	2	2	1
CO3	3	2	3	3	3				3	2	3	3	2	2	2
CO4	3	2	3	2	3				3	2	3	3	2	2	2

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.
M. Morris Mano Computer System Architecture, Prentice Hall, Third Edition.

Evaluation Pattern

Assessment	Weightage (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE113	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 Outcomes

After completing this course, students will be able to

CO1: Explain the basic concepts of analog and digital electronics
CO2: Design and implement various applications of diodes and transistor circuits
CO3: Realize the operational amplifier circuits for various applications
CO4: Model engineering problems in the perspective of electronics

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	3				3	2	3	3	1	1	1
CO2	3	3	3	3	3				3	2	3	3	2	2	2
CO3	3	3	3	3	3				3	2	3	3	2	2	2
CO4	3	2	3	3	3				3	2	3	3	3	3	3

Syllabus

Semiconductor materials, PN junction diode, Zener diode, Diode applications (Rectifier, clipper etc.) – BJT-configurations, Fixing of operating points, biasing circuits (fixed bias, voltage divider, etc.).AC Equivalent circuits,BJT amplifier, oscillator, Transistor as switch, MOSFET - DC Power supply– OPAMP based circuits including Schmitt trigger and astable multivibrator -Feedback amplifiers - Oscillators – Review of combinational and sequential digital logic, DAC and ADC

Text Books / 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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21BIO112	INTELLIGENCE OF BIOLOGICAL SYSTEMS 2	L-T-P-C: 1-0-3-2

Course Objectives

- 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
- Another goal of the course is to give students an introduction to probability and statistics for statistical inference for patterns observed in DNA sequences

Course Outcomes

After completing this course, students will be able to

CO1: Formulate and solve biological problems like finding the origin of replication in DNA sequence as a computational problem rather than expensive and time-consuming wet lab experiment problem.
CO2: Computationally explore and find hidden messages in DNA sequences that is utilized to maintain various rhythms like circadian rhythm using appropriate algorithms.
CO3: Apply elementary statistical estimation and test of significance techniques for the observed short patterns of sequences (Motifs) in DNA
CO4: Computationally explore new kind of representations like 'Chaos Game' representation of DNA sequences.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	2	3	2	2		3	2	3	3	2	2	1
CO2	1	3	3	2	3	2	2		3	2	3	3	2	2	1
CO3	1	2	3	3	3	2	2		3	2	3	3	2	2	1
CO4	1	2	3	3	3	2	2		3	2	3	3	2	2	1

Syllabus

Principle of Counting – Permutation and Combination- Basics of Probability-Probability Distributions-Statistics-Statistical Estimation and Inference.
Matlab and Python Programming for Bioinformatics – Introduction to biological databases.
DNA replication – genome - hidden messages in the genome – 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.
Chaos game representation of DNA sequences for comparison of related viral DNA sequences.

Textbooks/References

Philip Compeau and PavelPevzener, Finding Hidden Messages in DNA, Active Learning Publishers 2015.
Phillip Compeau& Pavel Pevzner, Bioinformatics algorithm, An active learning Approach Vol.1. and Vol. 2 , 2015.

Evaluation Pattern

Assessment	Weightage (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

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

*

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

21MAT204 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

After completing this course, students will be able to

CO1: Illustrate the basic concepts and techniques of linear algebra, calculus and basic probability theory needed for AI.
CO2: Integrate the application of these disciplines within the scientific field.
CO3: Identify the connection between the concepts of linear algebra, differential equation and probability theory.
CO4: Develop an insight into the applicability of linear algebra in business and scientific domains.
CO5: Apply the concepts of calculus and linear algebra in modelling electrical and mechanical elements.
CO6: Apply the concepts of probability theory for building datasets for computational experiments in data science

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	3	-	-	-	3	2	3	3	3	3	2
CO2	3	3	3	3	3	2	-	-	3	2	3	3	3	3	3
CO3	3	2	3	3	3	-	-	-	3	2	3	3	3	3	2
CO4	3	3	3	2	3	-	-	-	3	2	3	3	3	3	3
CO5	3	2	3	3	3	-	-	-	3	2	3	3	3	3	3
CO6	3	3	3	3	3	2	-	-	3	2	3	3	3	3	3

Syllabus

Highlights of Linear Algebra: Four Fundamental Spaces, Eigenvalues and Eigen Vectors, SVD, PCA and best low rank matrix. Raleigh Quotients and Generalized Eigen values, 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.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). Moments, cumulants, and inequalities of statistics, Covariance matrices and joint probabilities, Multivariate Gaussian and weighted least squares, Markov chains, Markov decision process -advanced aspects.

Textbooks / References

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

Evaluation Pattern

Assessment	Weightage(%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE201	INTRODUCTION TO ROBOTICS	L-T-P-C: 1- 2- 0- 3

Course Objectives

- To provide an introductory understanding of robots and its components
- To introduce the mathematical concepts needed for understanding basic robotic system operation
- To introduce kinematics, Jacobian, and its application in robotic manipulators
- To introduce kinematics and navigation for a wheeled mobile robot

Course Outcomes
After completing this course, students will be able to

CO1: Describe the fundamentals of robots and its components and mathematically represent a robotic system
CO2: Perform kinematic operations for a robotic manipulator
CO3: Perform trajectory planning for a robotic manipulator using Jacobian
CO4: Apply kinematics to a mobile robot for effective navigation

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	2			3	3		2	3		
CO2	3	2		2	3				3	3					3
CO3	3	2		2	3				3	3				3	
CO4	3	2	2	2	3				3	3		2			3

Syllabus

Introduction to robots – History – Types of robots – Technology and basic principles of robots and its components – Robot Architecture – Mathematical representation of robots – Position and orientation of rigid bodies – Rotation and Orientation – Quaternions and other rotation representations– Transformation Matrix – D-H parameters – Forward and inverse kinematics of robot manipulators - Jacobian – Singularities- Trajectory planning – Introduction to mobile robot navigation.

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(%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE202	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

After completing this course, students will be able to

CO1: Understand the architecture and functionalities of modern OS.
CO2: Understand and apply the algorithms for resource management and scheduling
CO3: Analyze and apply semaphores and monitors for classical and real-world synchronization scenarios.
CO4: Understand and apply memory management schemes for modern OS.

CO-PO Mapping

PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1	-	2	-	-	-	-	-	-	-	3	2	-
CO2	2	2	3	1	3	-	2	-	-	-	-	-	3	2	-
CO3	2	3	3	2	-	-	2	2	-	-	-	-	3	2	-
CO4	2	2	1	2	3	-	-	1	1	-	-	-	3	2	-

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.

Textbooks

Silberschatz and Galvin, "Operating System Concepts", Eighth Edition, Wiley India, 2009.
Tannenbaum A S, "Modern Operating Systems", Prentice Hall India, 2003.
W. Stallings, "Operating Systems: Internals and design Principles", Pearson Ed., LPE, 6th Ed., 2009
M.J. Bach, "Design of Unix Operating system", Prentice Hall, 1986

Evaluation Plan

Assessment	Weightage(%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE203	DATA STRUCTURES & ALGORITHMS 2	L-T-P-C: 2- 1- 3- 4

Course Objectives

- 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: Design suitable data structures for problem solving

CO2: Use appropriate data structures for problem solving scenarios
CO3: Utilize the interoperability of data structures to solve problems
CO4: Visualize multidimensional geometry of data structure and concurrency

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	2			3	3	1	3	3	2	1
CO2	3	3	3	3	3	2			3	3	1	3	3	3	1
CO3	3	3	3	3	2	1			2	3	2	3	3	3	1
CO4	3	2	2	3	3	1			3	3	2	3	2	2	1

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

Textbooks / References

Advanced Data Structures Hardcover: – 8 Sep 2008
Bhim P Upadhyaya, .Data Structures and Algorithms with Scala: A Practitioner's Approach with Emphasis on Functional Programming
Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. 2009. Introduction to Algorithms, Third Edition (3rd ed.). The MIT Pres

Evaluation Plan

Assessment	Weightage(%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE204	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

After completing this course student will be able to,

CO1: Understand basic Analog Communication Engineering

CO2: Understand basic Digital Communication Techniques

CO3: Understand and implement Analog, Digital Modulation and De-modulation techniques using MATLAB/GNURADIO along with supporting hardware like RTL-SDR, ADALM PLUTO etc.

CO4: Develop an appreciation of the role AI in emerging communication systems

CO-PO Mapping

PO/ PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	3	---	---	3	3	2	2	3	3	3
CO2	3	2	2	2	2	3	---	---	3	3	3	2	-	3	-
CO3	3	3	3	3	3	3	---	---	3	3	3	3	3	2	3
CO4	3	3	3	3	3	3	---	---	3	3	3	3	2	3	-

Syllabus

Introduction to signals, types and characteristics; Introduction to communication systems; modulations; Wired and Wireless Communication; Examples of wired and wireless communication systems; Noise: External noise, Internal noise and Noise figure; Amplitude modulation; Generation of AM; Frequency modulation; Generation of FM; Digital modulation and de-modulation techniques (ASK, FSK, BPSK, DPSK and QAM); OFDM; MIMO; MATLAB and GNURADIO for Communication system experiments. Prospects of AI in Communication Systems

Text Books / Reference Books

George Kennedy and Bernard Davis, "Electronics Communication Systems"' Tata McGraw-Hill Edition, 2011.

Simon Haykin, "Digital Communication Systems", John Wiley & Sons, Inc., 2013

K C Raveendranathan, "Communication Systems Modelling and Simulation Using MATLAB and Simulink",Universities Press (INDIA) Private Limited, 2011
Robert W Stewart Robert W. Stewart Software Defined Radio Using MATLAB & Simulink and the Rtl-Sdr, On-line book, 2015.
Qasim Chaudhari, Wireless Communications from the Ground Up: Fundamentals of Digital Communication Systems, Createspace Independent Publishers , 2016
Reinventing Wireless with Deep Learning, https://www.deepsig.ai/

Evaluation Pattern

Assessment	Weightage (%)
Internal (Minimum 10 assessments)	70
External (Project)	30

21BIO201	INTELLIGENCE OF BIOLOGICAL SYSTEMS 3	L-T-P-C: 1- 2 - 0 -3

Course Objectives

- To incorporate the concepts of bioinformatics using statistics.
- To enhance the application of programming for bioinformatics.
- To explore the challenges in bioinformatics and apply AI for solutions.
- To articulate the process of pathway reconstruction.

Course Outcomes

After completing this course student will be able to,

CO1: Understand the process of genome assembling genomes by computational methods.

CO2: Learn the application of python programming for bioinformatics.

CO3: Explore the potential challenges in applications of computational methods to solve biological problems.

CO4: Apply the concepts of graph theory for the explicit understanding of the signal transduction process and biochemical pathways.

CO-PO Mapping

PO/ PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	3	3	-	3	3	3	3	3	2
CO2	3	3	3	3	3	3	3	-	3	3	3	3	1	2
CO3	3	3	3	3	3	3	3	-	3	3	3	3	-	3
CO4	2	3	-	2	1	-	2	-	3	2	1	1	-	1

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. Cell Signaling and Signal transduction, a case study on Signaling Pathways.

Text Book / Reference

Karthik Raman, an Introduction to Computational Systems Biology (Systems Level Modeling of Cellular Networks), CRC Press, 2021.

Bioinformatics algorithm, An active learning Approach', Phillip Compeauand Pavel PevznerVol.1. and Vol. 2 ,2015.

'Essential Bioinformatics', JinXiong, Cambridge University Press, 2006

Gerald Karp, Chapter 15- Cell Signaling and Signal Transduction: Communication Between Cells, In Cell and Molecular Biology: Concepts and Experiments, 7e, Wiley, 2013

Evaluation pattern

Assessment	Weightage (%)
Internal (Minimum 10 assessments)	70
External (Project)	30

121AIE205	PYTHON FOR MACHINE LEARNING	L-T-P-C: 0- 0- 3- 1

Course Objectives

- 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 Modelling relates to Machine Learning, and do a comparison.
- 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

After completing this course, the students will be able to

CO1: Summarize the basics of python programming for machine learning.
CO2: Implement the machine learning algorithms in python from scratch without using built-in functions.
CO3: Apply pre-processing methods in python for different datasets.
CO4: Implement machine learning algorithms in python to analyse different datasets.

CO-PO Mapping

PO/ PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	3	2	3	2	2	-	3	2	3	3	3	3	1
CO2	2	2	3	2	3	2	2	-	3	2	3	3	3	3	3
CO3	2	3	3	2	3	2	2	-	3	2	3	3	2	2	2
CO4	2	3	3	2	3	2	2	-	3	2	3	3	3	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 pre-processing 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 –Introduction to Neural Networks – Basics of Loss Functions.

Textbooks/References

'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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

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

21MAT212	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

After completing this course student will be able to,

CO1: Illustrate the basic concepts and techniques of linear algebra, calculus and basic probability theory needed for AI.
CO2: Integrate the application of these disciplines within the scientific field.
CO3: Identify the connection between the concepts of linear algebra, differential equation and probability theory.
CO4: Develop an insight into the applicability of linear algebra in business and scientific domains.
CO5: Apply the concepts of calculus and linear algebra in modelling electrical and mechanical elements.
CO6: Apply the concepts of probability theory for building datasets for computational experiments in data science

CO-PO Mapping

PO/ PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	3	---	---	---	3	2	3	3	3	3	3
CO2	3	3	2	2	3	---	---	---	3	2	3	3	3	3	3
CO3	3	2	3	3	3	---	---	---	3	2	3	3	-	3	-
CO4	3	3	3	2	3	---	---	---	3	2	3	3	3	2	3
CO5	3	2	3	3	3	---	---	---	3	2	3	3	2	3	-
CO6	3	3	3	3	3	2	---	---	3	2	3	3	2	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.

Textbooks / References

Gilbert Strang, Linear Algebra and learning from data, Wellesley, Cambridge press, 2019.

Bradley Efron , Trevor Hastie, Computer Age Statistical Inference, Algorithms, Evidence and Data Science.

Stephen Boyd, Lieven Vandenberghe, Convex Optimization, Cambridge University Press, 2018.

Stephen Boyd , Lieven Vandenberghe, Introduction to Applied Linear Algebra – Vectors, Matrices, and Least Squares, Cambridge University Press, 2018.

Evaluation Pattern

Assessment	Weightage (%)
Internal (Minimum 10 assessments)	70
External (Project)	30

21AIE211	INTRODUCTION TO COMPUTER NETWORKS	L-T-P-C:2-0-3-3

Course Objective

- 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 provides insights into concepts of the internet of things and its various applications. The course will enrich the students with hands on experience in building real time networks and develop network applications using simulator/emulator/Raspberry-PI.
- The course also provides an introduction to the modern software defined networks and its applications.

Course Outcomes

After completing this course student will be able to,

CO1: Examine the function and aspects of Internet protocol stack
CO2: Determine the IP addressing for hosts in subnets and configure the routing protocols
CO3: Build and manage computer networks using simulator/emulator/Raspberry Pi.
CO4: Lay down the networking concepts to develop network applications based on internet of things.

CO-PO Mapping

PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	3	-	-	-	-	-	-	2	2	2	-
CO2	3	3	2	1	3	-	-	-	-	-	-	2	2	2	-
CO3	3	3	3	3	3	2	2	-	3	2	-	3	3	3	3
CO4	3	3	3	3	3	3	3	1	3	2	-	3	3	3	3

Syllabus

Introduction to applications, topologies, hardware and software elements in a network.Internet standards and organization.Protocols in the context of the Internet protocol stack.Data link and Physical layer concepts for wired and wireless network, Network Layer – Internet Protocol, Host Addressing for subnets, Routing and Forwarding principles, Router configuration. Transport Layer – connection oriented and connection less service using sockets.Application Layer – Protocols in Web and Email applications.Internet of Things – Components like controllers, services, Fog and cloud computing, Applications.Configuration and implementation of local area networks and intranets in simulator or emulator or real time hardware devices like Raspberry Pi. Introduction to Software Define Networks.

Textbooks / References

Kurose, James F. Computer networking: A top-down approach featuring the internet, 3/E. Pearson Education India, 2005.
Andrew, S. "Tanenbaum–Computer Networks –Prentice Hall." New Jersey (2003).
'Raspberry Pi networking Cook Book – Second Edition', Rick Golden, 2017

Evaluation Pattern

Assessment	Weightage (%)
Internal(Minimum 10 assessments)	70 %
External	30 %

21AIE212	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

After completing this course student will be able to,

CO1: Develop an understanding of algorithmic strategies

CO2: Analyse and apply appropriate algorithmic technique for a given problem

CO3: Gain expertise on implementing standard algorithms on arrays, strings, trees and graphs

CO4: Map problems to known classes of tractable or intractable problems.

CO-PO Mapping

PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	3	1	---	3	3	2	3	3	1	1
CO2	3	3	3	2	3	2	---	---	3	3	2	3	3	2	2
CO3	3	3	3	3	2	1	---	---	3	3	3	3	3	3	3
CO4	3	3	3	3	2	1	---	---	3	3	3	3	2	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.

Textbooks / References

Analysis of Algorithms', Jeffrey J McConnel,Jones and Bartlett Publishers,Inc; 2nd Revised 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 (%)
Internal (Minimum 10 assessments)	70 %
External	30 %

21AIE213	ROBOTIC OPERATING SYSTEMS & ROBOT SIMULATION	L-T-P-C:2-0-3-3

Course Objectives

- To provide an introductory understanding on robotics operating system and gazebo simulation environment.
- To introduce the students with module developments in ROS for mobile robot control, navigation and environment mapping.
- To introduce the students with module developments in ROS for industrial robot control, path planning and trajectory planning.

Course Outcomes

After completing this course student will be able to,

CO1: Explain the basics of ROS module development for robotic system.
CO2: Analyse and visualize various robotic systems using ROS integrated simulation platforms.
CO3: Apply the knowledge of robotic system and ROS for mobile robot control, navigation and environment mapping using ROS simulators.
CO4: Design and development of prototype robotic systems using ROS for real-time problems.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	1	1	3	2	-	-	3	3	-	2	1	1	1
CO2	3	2	1	2	3	2	-	-	3	3	-	-	1	2	2
CO3	3	2	3	2	3	-	3	3	3	3	3	2	3	3	3
CO4	3	2	3	2	3	-	3	3	3	3	3	2	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 model and Simulators – Sub systems – Actuation: Mobile platform – Actuation manipulator arm – Cameras and Scanners

Text Book /Reference Books

Joseph, Lentin, and Jonathan Cacace. Mastering ROS for Robotics Programming: Design, build, and simulate complex robots using the Robot Operating System. Packt Publishing Ltd, 2018.
Programing Robots with ROS ', M. Quigley, B. Gerkey, and W. D. Smart , Oreilly Publishers, 2015.
Koubâa, Anis, ed. Robot Operating System (ROS). Vol. 1. Cham: Springer, 2017.
'ROS Robotics by example ', Fairchild & Harman, PACKT Publishing, 2016

Evaluation Pattern

Assessment	Weightage (%)
Internal (Minimum 10 assessments)	70 %
External	30 %

21AIE214	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 (CO)

After completing this course student will be able to,

CO1: Understand the basic data abstraction and imbibe the map-reduce skillset
CO2: Know about general data pipelining and use to design data analytics solutions
CO3: Understand and apply scaling up machine learning techniques and associated computing techniques and technologies.
CO4: Identify the characteristics of datasets and compare the trivial data and big data for various applications.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	1	---	---	2	2	3	2	3	1	1
CO2	3	3	3	3	3	2	---	---	3	3	3	3	1	2	2
CO3	3	3	3	3	3	1	---	---	2	3	3	2	3	3	3
CO4	2	2	3	2	3	1	---	---	2	2	2	2	3	3	3

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. Data frames, datasets, 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 andBillVenners,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
Hadoop: The Definitive Guide

Evaluation Pattern

Assessment	Weightage (%)
Internal (Minimum 10 assessments)	70 %
External	30 %

21BIO211	INTELLIGENCE OF BIOLOGICAL SYSTEMS 4	L-T-P-C:1-2-0-3

Course Objectives

- Introduce students to the current bioinformatics algorithms/concepts and their implementations
- To introduce the concepts of sequence alignment
- To explore the challenges and the potential applications of bioinformatics databases for practical problems.

Course Outcomes

After completing this course student will be able to,

CO1: Understand and appreciate the role of bioinformatics in solving biological problems.
CO2: Implement the sequence alignment for searching and comparison
CO3: Demonstrate working proficiency with sequence search and alignment (local, global, pairwise multiple sequence alignment algorithms.) algorithms.
CO4: Apply the concepts of deep learning problems in bioinformatics

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	3	3		3	3	3	3	2	2	2
CO2	3	3	3	3	3	3	3		3	3	3	3	2	2	2
CO3	3	3	3	3	3	3	3		3	3	3	3	2	2	2
CO4	3	3	3	3	3	3	3		3	3	3	3	2	2	2

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.

Textbooks / References

Phillip Compeau& Pavel Pevzner, Bioinformatics algorithm, An active learning Approach Vol.1. and Vol. 2 , 2015.

JinXiong , Essential Bioinformatics , Cambridge University Press, 2006.

Evaluation Pattern

Assessment	Weightage (%)
Internal (Minimum 10 assessments)	70 %
External	30 %

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.

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

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

21MAT301	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

After completing this course student will be able to,

CO1: Understand and implement basic concepts and techniques of probabilistic graphical models needed for causal reasoning in AI
CO2: Apply the concepts of linear algebra, optimization and probability theory for controlling real-world systems
CO3: Identify the connection between the concepts of linear algebra, differential equation and probability theory
CO4: Understand and implement latest data-driven modelling of linear and non-linear dynamical systems through modern matrix/tensor decomposition techniques

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	3	-	-	-	3	2	3	3	3	3	3
CO2	3	3	3	3	3	2		-	3	2	3	3	3	3	3
CO3	3	2	3	3	3	-	-	-	3	2	3	3	3	2	-
CO4	3	3	3	2	3	-	-	-	3	2	3	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
Probabilistic graphical models: principles and techniques. Koller, Daphne, and Nir Friedman. MIT press, 2009.
Risk assessment and decision analysis with Bayesian networks, Fenton, Norman, and Martin Neil. CRC Press, 2018.

Evaluation Pattern

Assessment	Weightage (%)
Internal (Minimum 10 assessments)	70
External (Project)	30

21AIE301	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

After completing this course student will be able to,

CO1: Analyse 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 the problem-solving avenues
CO4: Acquire concepts relating to the theory of computation and computational models including decidability and intractability

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	3	3	3	2	-	-	3	2	3	2	3	1	1
CO2	3	3	3	3	3	3	-	-	2	3	3	3	3	1	1
CO3	3	3	3	3	3	3	-	-	2	2	3	3	3	2	2
CO4	3	3	3	3	3	3	-	-	2	2	3	3	3	2	1

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.MotwaniandandJ.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 (%)
Internal (Minimum 10 assessments)	70
External (Project)	30

21AIE302	ADVANCED COMPUTER NETWORKS	L-T-P-C:2-0-3-3

Course Objectives

- The course delivers the basic introduction to the networking concepts and terminologies.
- It will also expose students 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 open Swicth 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

After completing this course student will be able to,

CO1: Understand the fundamentals of conventional networking and software defined networking

CO2: Implement software defined networks using Mininet and raspberry pi.

CO3: Understand 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	PSO1	PSO2	PSO3
CO1	2	1	3	2	3	2	2	-	3	2	1	3	1	1	1
CO2	2	2	3	2	3	2	2	-	3	2	1	3	1	1	1
CO3	2	3	3	2	3	2	2	-	3	2	1	3	1	1	3

Syllabus

Basic network components, Internet Technologies, Web, http, 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

'Computer Networking – A top-down approach', J. Kurose, 7th Edition, Pearson, 2017

Evaluation Pattern

Assessment	Weightage (%)
Internal(Minimum 10 assessments)	70
External	30

21AIE303	SIGNAL & IMAGE PROCESSING	L-T-P-C:2-0-3-3

Course Objectives

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

Course outcomes

After completing this course, the students will be able to

CO1: Apply signal processing techniques to understand and analyze 1-dimensional and 2-dimensional signals.

CO2: Implement the standard approaches to process 1-dimensional signals and 2-dimensional images.

CO3: Apply image enhancement, segmentation and feature extraction methods in various applications of image analysis.

CO4: 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	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	3	-	-	3	3	-	3	2	3	3
CO2	3	3	3	2	3	3	-	-	3	3	-	3	2	3	3
CO3	3	3	3	2	3	3	-	-	3	3	-	3	2	3	3
CO4	3	3	3	2	3	3	-	-	3	3	-	3	2	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 - Morphological Image Processing: Dilation and Erosion - Opening and Closing - Some basic morphological algorithms. Image Segmentation Region based, edge based, clustering based- Representation and Description - GLCM HOG, SIFT.

Textbooks / 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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE304	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

After completing this course, the students will be able to

CO1: Understand RDBMS and basic entity relations, normalization and Functional Dependencies as well as time series and sequence data.

CO2: Select a data model that suits the characteristics of the data

CO3: Differentiate between a traditional Database Management System and a Big Data Management System

CO4: Recognize different data elements in your own work and in everyday life problems

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	3	-	-	3	3	2	3	3	3	3
CO2	3	3	3	3	3	3	-	-	3	3	3	3	3	3	3
CO3	3	3	3	2	3	3	-	-	3	3	3	3	2	3	3
CO4	3	3	3	3	3	3	-	-	3	3	3	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.

Textbooks / Reference Books

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

Evaluation Pattern

Assessment	Weightage (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

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.

SEMESTER VI

21MAT311	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

After completing this course student will be able to,

CO1: Apply mathematical and probabilistic principles to understand and reason about machine learning tools and algorithms like advanced Kalman Filters, back propagation algorithms in Neural Network and Kernel methods

CO2: Convert and implement probabilistic graphical model inference problem as an optimization problem (variational inference)

CO3: Model and devise control methods for control problems that involve electrical and mechanical elements

CO4: Apply data reduction techniques in control theory for controlling high dimensional systems

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	-	-	-	3	2	3	3	3	3	3
CO2	3	3	3	3	3	-	-	-	3	2	3	3	3	3	3
CO3	3	3	3	3	3	-	-	-	3	2	3	3	3	3	3
CO4	3	3	3	3	3	-	-	-	3	2	3	3	3	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, Balanced Models for control, Data driven control
Statistics and Probability -6: Expectation-Maximization, Variational Inference, Variational Learning, Support Vector Machines, Neural Networks, Bayesian Modelling.

Text Books / Reference Books

Gilbert Strang, Linear Algebra and learning from data, Wellesley, Cambridge press, 2019.

Kevin Murphy and Francis Bach, 'Machine Learning: A Probabilistic Perspective', Penguin Publishers, 2012

Steve Brunton and Nathan Kutz, 'Data Driven Science and Engineering', Cambridge University Press, 2018

Evaluation Pattern

Assessment	Weightage (%)
Internal (minimum 10 assessments)	70
External (Project)	30

21AIE311	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

After completing this course, the students will be able to

CO1: Define the key features of reinforcement learning that distinguishes it from AI and non-interactive machine learning

CO2: Decide if an application problem should be formulated as a RL problem; if yes be able to define it formally (in terms of the state space, action space, dynamics and reward model), state what algorithm (from class) is best suited for addressing it

CO3: Implement in code common RL algorithms

CO4: Describe (list and define) multiple criteria for analysing RL algorithms and evaluate algorithms on these metrics: e.g., regret, sample complexity, computational complexity, empirical performance, convergence, etc.

CO5: Describe the exploration vs exploitation challenge and compare and contrast at least two approaches for addressing this challenge (in terms of performance, scalability, complexity of implementation, and theoretical guarantees)

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	-	-	-	3	2	3	3	3	3	3
CO2	3	3	3	3	3	-	-	-	3	2	3	3	3	3	3
CO3	3	3	3	3	3	-	-	-	3	2	3	3	3	3	3
CO4	3	3	3	3	3	-	-	-	3	2	3	3	3	3	3
CO5	3	3	3	3	3	-	-	-	3	2	3	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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE312	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 skill set of problem-solving pertaining to real-time signal and image data.

Course Outcomes

After the course completion, the students will be able to,

CO1: Summarizethe fundamentals of Deep Learning.

CO2: Develop the practical Engineering tricks to train and fine-tune the deep neural networks.

CO3: Develop the skill to use multiple packages required to build AI systems for signal and image analysis.

CO4: Implement standard deep convolutional architectures and use the pre-trained models for signal and image analysis.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	2	2	-	2	2	2	2	3	-	-
CO2	3	3	3	3	3	3	2	1	3	3	3	3	-	3	3
CO3	3	3	3	3	3	3	2	1	3	3	3	3	-	3	3
CO4	3	3	3	3	3	3	2	1	3	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 trade-off, 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 (%)
Internal Assessment (Minimum 10 assessments)	70
Project (External component)	30

21AIE313	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

After completing this course, the students will be able to

CO1: Design and implement lexical analyser using LEX
CO2: Identify and design suitable parsing strategies for appropriate CFG
CO3: Implement parsers using YACC and Constructor of Useful Parsers (CUP)
CO4: Elaborate various techniques for intermediate code generation and machine code optimization

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	1			3	3	1	3	2	2	2
CO2	3	3	3	3	3	1			3	3	1	3	2	2	2
CO3	3	3	3	3	3	1			3	3	1	3	2	2	2
CO4	3	3	3	3	3	1			3	3	1	3	2	2	2

Syllabus

Structure of compiler, Lexical analysis, Tokens, Finite Automata, NFA TO DFA conversion, Regular Expression, Lexical Analyzer generators LEX, JAVACC, SABLACC
Parser, Context Free Grammar, derivations, Parse trees, Ambiguous Grammar, Top-down parser - Recursive Descent parser, LL (1) Parser, Predictive Parser construction, eliminating left recursion, left factoring. Bottom-up parser - LR Parser-LR (0), Item Construction of SLR Parsing Table, SLR, LR (1), LALR Parser, LR parsing of ambiguous grammar, YACC, Constructor of Useful Parsers (CUP)
Abstract Syntax tree, Semantic actions in 'JCUPS', Symbol Table, Activation Records,Type Checking(MiniJava), error handling.
Intermediate code generation**,** Three Address Code, Code Optimization **-** Principal Sources of Optimization - Peep-hole optimization -DAG.

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 (%)
Internal Assessment (Assignment, Quiz and Viva)	70
Project	30

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 Presentation Round 1	**2**
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**

21AIE314	AI IN NATURAL LANGUAGE PROCESSING	L-T-P-C:2-0-3-3

Course Objective

- The main objective of the course is to understand the leading trends and systems in Natural Language Processing.
- To understand the basic representations used in syntax, the semantics of Natural Language Processing.
- To understand and explore the models used for word/sentence representations for various NLP applications.
- To understand how machine learning and deep learning algorithms are used for Natural Language Processing applications.
- To implement deep learning algorithms in Python and learn how to train deep networks for NLP applications

Course Outcomes

After completing this course, the students will be able to

CO1: Generate word representation to solve NLP problems
CO2: Implement machine learning models for NLP
CO3: Implement sequence-to-sequence models for NLP
CO4: Assess NLP models using various evaluation metrics

CO-PO Mapping

PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	3	-	3	3	3	2	3	3	3	3
CO2	3	3	3	3	3	3	-	3	3	3	2	3	3	3	3
CO3	3	3	3	3	3	3	-	3	3	3	2	3	3	3	3
CO4	2	3	2	3	3	3	-	3	3	3	2	2	1	1	1

Syllabus

Computational linguistics- Introduction, syntax, semantics, morphology, collocation and other NLP problems. Word representation: One-hot encoding, Bag-of-Words (BoW) Dictionary: Term Frequency – Inverse Document Frequency (TF-IDF), Embedding: Word2vec, Glove and Fasttext. Language Model-n-gram, Sequences and sequential data: Part-of-Speech tagging-HMM and CRF, Named Entity recognition, Dependency parsing. Evaluation metrics for NLP models and Visualization

Machine learning and deep learning for NLP, Sequence to sequence modelling (Encoder decoder), Attention mechanism, Transformer Networks – BERT, A brief introduction to Reinforcement learning for NLP. NLP application introduction- Sentiment Analysis, Machine translation, Question answering, Text summarization.

Text Books / References

'Foundations of Statistical Natural Language Processing', Christopher Manning and Hinrich Schütze, MIT press, 1999
'Natural Language Processing with Python', Steven Bird, Ewan Klein and Edward Loper, O'Reilly Media, Inc.", 2009.
'Deep Learning for Natural Language Processing: Develop Deep Learning Models for your Natural Language Problems (Ebook)', Jason Browlee, Machine Learning Mastery, 2017.
'Speech & language processing' , Daniel Jurafsky, James H Martin, preparation [cited 2020 June 1] Available from: https://web. stanford. edu/~ jurafsky/slp3 (2018).

Evaluation Pattern

Assessment	Weightage (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE315	AI IN SPEECH PROCESSING	L-T-P-C:2-0-3-3

Course Objective

- 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

After completing this course, students will be able to

CO1: Explain the acoustics of speech production and perception
CO2: Differentiate the characteristics of different speech sounds
CO3: Analyse the time-domain and frequency domain features of the speech signal
CO4: Realize various algorithms on AI based speech modelling

CO-PO Mapping

PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	2	---	---	2	2	1	3	1	1	1
CO2	3	3	3	3	3	2	---	----	3	2	3	3	3	2	1
CO3	3	3	3	3	3	2	---	----	3	2	3	3	3	2	2
CO4	3	3	3	3	3	3	---	---	3	3	3	3	3	3	3

Syllabus

Overview of Speech Processing Systems, Speech Production, Speech Perception, Speech Signal Characteristics, Properties of speech sounds. Short time processing of speech- Time Domain parameters, Frequency domain parameters, Spectrograms, Cepstral Analysis, MFCC, Linear Prediction Analysis - Speech Recognition- Basic speech models- GMM, HMM, Deep neural network models (DBN, TDNN, LSTM) used for speech modeling, Speech synthesis, End-to-End Deep neural network Models (DeepSpeech, WaveNet).

Text Books / References

'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
Hannun, Awni, et al. "Deep speech: Scaling up end-to-end speech recognition." arXiv preprint arXiv:1412.5567 (2014).
Collobert, Ronan, Christian Puhrsch, and Gabriel Synnaeve. "Wav2letter: an end-to-end convnet-based speech recognition system." arXiv preprint arXiv:1609.03193 (2016).

Evaluation Pattern

Assessment	Weightage (%)
Internal Assessment (Minimum 10 assessments)	70
Project (External component)	30

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

21AIE401	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 Outcomes

After completing this course, the students will be able to

CO1: Decide whether a given application problem should be formulated as a Deep Reinforcement Learning (DRL) problem.

CO2: Correctly define the problem formulation, design the most suitable algorithm from the different possible classes of DRL algorithms, providing a justification

CO3: Implement and apply temporal-difference reinforcement learning algorithms

CO4: Apply the multiple criteria for analysing and evaluating the DRL algorithms on the relevant metrics: regret, sample complexity, computational complexity, empirical performance, convergence.

CO5: Implement in code the main DRL algorithms and apply it to solve several practical problems in different application domains, evaluating experimentally their performance

CO-PO Mapping

PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	-	-	-	3	2	2	3	3	3	3
CO2	3	3	3	3	3	-	-	-	3	2	2	3	3	3	3
CO3	3	3	3	3	3	-	-	-	3	2	2	3	3	3	3
CO4	3	3	3	3	3	-	-	-	3	2	2	3	3	3	3
CO5	3	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.

Text Books / Reference Books *'Reinforcement Learning', Richard.S.Sutton and Andrew G.Barto, Second edition, MIT Press, 2018*

Evaluation Pattern

Assessment	Weightage (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE495	PROJECT PHASE – 1	L-T-P-C: 0- 0- 12- 4

Course Objectives

- Project Phase – 1 aims at helping students to identify the research problems by conducting a thorough literature review
- The course introduces the students to real world problems associated with AI
- The course also aims at helping students to publish scientific articles in peer reviewed scientific publications.

Course Outcomes

After completing the course the students will be able to

CO1: Identify a valid research problem by conducting literature review in the appropriate area.

CO2: Identify the appropriate methodology to solve the research problem.

CO3: Apply the AI tools & techniques to solve the identified problem.

CO4: Communicate scientific discoveries through peer-reviewed publications.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	2	2	2	3	3	3	3	-	-	3
CO2	3	3	3	3	3	2	2	2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	2	2	2	3	3	3	3	3	3	3
CO4	3	3	3	3	3	2	2	2	3	3	3	3	-	-	-

Evaluation Pattern

Assessment	Weightage (%)
Internal	70
External	30

SEMESTER VIII

21AIE499	PROJECT PHASE –2	L-T-P-C: 0- 0- 30- 10

Course Objectives

- Project Phase – 2 aims at helping students to solve the identified research problem
- The course introduces the students to real world problems associated with AI
- The course also aims at helping students to publish scientific articles in peer reviewed scientific publications.

Course Outcomes

After completing the course the students will be able to

CO1: Solve a valid research problem by employing appropriate tools & techniques.

CO2: Implement the appropriate methodology to solve the research problem.

CO3: Apply the AI tools & techniques to solve the identified problem.

CO4: Communicate scientific discoveries through peer-reviewed publications.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	2	2	2	3	3	3	3	-	-	3
CO2	3	3	3	3	3	2	2	2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	2	2	2	3	3	3	3	3	3	3
CO4	3	3	3	3	3	2	2	2	3	3	3	3	-	-	-

Evaluation Pattern

Assessment	Weightage (%)
Internal	70
External	30

PROFESSIONAL ELECTIVES

Pool 1: AI in Cyber Security

21AIE431	APPLIED CRYPTOGRAPHY	L-T-P-C: 2-0-3-3

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

After completing this course, the students will be able to
CO1: Understandthe concepts of classical and modern cryptography.
CO2: Understand about the common attacks and the preventive systems.
CO3: Apply appropriate cryptographic techniques to a security engineering problem.
CO4: Implement canonical security protocols.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	3	2	3	2	1	2	3	2	1	3	3		
CO2	2	2	3	2	3	2	1	2	3	2	1	3		2	
CO3	2	3	3	2	3	2	1	3	3	2	1	3		3	2
CO4	2	3	3	3	3	2	1	3	3	2	1	3		2	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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE432	NETWORK & WIRELESS SECURITY	L-T-P-C: 2-0-3-3

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

After completing this course, the students will be able to

CO1: Gain knowledge of information security technology and methods for communication systems that provide services for mobile users by wireless access networks.

CO2: Understand 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: Gain knowledge about some of the models, design principles, mechanisms and solutions used in wireless network security to obtain authentication and key transport protocols.

CO4: Implement the security mechanisms and protocols using canonical models

CO-PO Mapping

CO/PO	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	1	2	2
CO2	2	2	3	2	3	2	2	2	3	2	1	3	1	2	2
CO3	2	3	3	2	3	2	2	3	3	2	1	3	1	2	2
CO4	2	3	3	2	3	2	2	3	3	2	1	3		2	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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE433	INTRUSION DETECTION & PREVENTION SYSTEMS	L-T-P-C: 2-0-3-3

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.
- Analyse intrusion detection alerts and logs to distinguish attack types from false alarms.

Course Outcome

After completing this course, the students will be able to

CO1: Understand basic issues, concepts, principles, and techniques in intrusion detection
CO2: Analyse intrusion detection systems for particular security requirements**.**
CO3: Design preventive systems for various engineering applications.
CO4: Implement preventive systems for various engineering applications.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	3	2	3	2	2	2	3	2	1	3	3		
CO2	2	2	3	2	3	2	2	2	3	2	1	3	2	2	2
CO3	2	3	3	2	3	2	2	3	3	2	1	3		2	3
CO4	2	3	3	2	3	2	2	3	3	2	1	3		2	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 Educat**ion, 2006.***

Evaluation Pattern

Assessment	Weightage (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE434	SOFTWARE VULNERABILITY ANALYSIS	L-T-P-C: 2-0-3-3

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 Modelling, and Rational AppScan software.

Course Outcome

After completing this course, the students will be able to

CO1: Analyse the security risk of a system under development.
CO2: Understand secure coding practices to prevent common vulnerabilities from being injected into software.
CO3: Design security requirements (which include privacy requirements).
CO4: Validate security requirements

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		1		2		3		2	2
CO2	2	2	3	2	3	2		2		2		3		2	2
CO3	2	3	3	2	3	2	3	3	3	2	2	3		2	3
CO4	2	3	3	2	3	2	3	3	3	2	2	3		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, Défense 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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE435	CYBERCRIME INVESTIGATIONS & DIGITAL FORENSICS	L-T-P-C: 2-0-3-3

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

After completing this course, the students will be able to
CO1: Define the nature and scope of cybercrime.
CO2: Develop knowledge of major incidents of cybercrime and their resulting impact.
CO3: Analyse national and global digital law enforcement efforts
CO4: 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	PSO3
CO1	2	1	2	2	3	3		3		1		3		2	1
CO2	2	2	3	2	3	3		3		2		3		2	1
CO3	2	3	3	2	3	3	2	3	3	2	2	3		2	3
CO4	2	3	3	2	3	3	2	3	3	2	2	3		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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE436	DISTRIBUTED SYSTEMS SECURITY	L-T-P-C: 2-0-3-3

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
After completing this course, the students will be able to

CO1: Understand threats against distributed systems and the protection measures against such threats

CO2: Design secure distributed systems to evaluate the security of existing solutions.

CO3: Gain knowledge of principles and standards of security protocols

CO4: Implement cryptographic mechanisms to secure modern distributed systems.

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		3	2	1	3		2	
CO2	2	2	3	2	3	2	2	1	3	2	1	3		2	3
CO3	2	3	3	2	3	2	2	1	3	2	1	3	2		
CO4	2	3	3	2	3	2	2	1	3	2	1	3		2	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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

Pool 2: AI in Healthcare

21AIE451	COMPUTATIONAL HEALTHCARE	L-T-P-C: 2-0-3-3

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 modelling, 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

After completing this course, the students will be able to

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 appropriate intelligent system models and computational tools to specific problems in healthcare
CO4: 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	PSO3
CO1	3	3	3	2	3	3	2		3	3		3	3		
CO2	3	3	3	2	3	3	2		3	3		3	2	2	2
CO3	3	3	3	2	3	3	2		3	3		3	2	2	3
CO4	3	3	3	2	3	3	2		3	3		3		2	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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE452	BASICS OF DRUG DESIGN	L-T-P-C: 2-0-3-3

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

After completing this course, the students will be able to
CO1: Understand the basics of drug design.
CO2: Analyse the open source tools available for computer assisted drug design.
CO3: Analyse databases available for computer assisted drug design.
CO3: Implement methodologies for computer assisted drug design.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	3	3		3	3		3	2		
CO2	3	3	3	2	3	3	3		3	3		3		3	2
CO3	3	3	3	2	3	3	3		3	3		3		3	2
CO4	3	3	3	2	3	3	3		3	3		3		2	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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE453	DEEP LEARNING IN GENOMICS AND BIOMEDICINE	L-T-P-C: 2-0-3-3

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

After completing this course, the students will be able to

CO1: Understand models of human and artificial intelligence, specifically computational models of intelligence.

CO2: Understand a collection of machine learning models and their applications in genomics.

CO3: Analyse appropriate intelligent system models and computational tools to specific problems in genomics.

CO4: Implement 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	PSO3
CO1	3	3	3	2	3	3	2		3	3		3	3		
CO2	3	3	3	2	3	3	2		3	3		3	3	3	2
CO3	3	3	3	2	3	3	2		3	3		3	2	3	2
CO4	3	3	3	2	3	3	2		3	3		3		2	3

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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE454	CLINICAL INFORMATION SYSTEM	L-T-P-C: 2-0-3-3

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

After completing this course, the students will be able to
CO1: Understand the basics of clinical information systems.
CO2: Apply information technology and related tools in workflow design.
CO3: Analyse the "benefits and barriers" associated with electronic health records.
CO4: Implement the clinical information protocol for canonical systems.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	3	3		3	3		3		2	
CO2	3	3	3	2	3	3	3		3	3		3		3	2
CO3	3	3	3	2	3	3	3		3	3		3		3	2
CO4	3	3	3	2	3	3	3		3	3		3		2	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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE455	CRISPR TECHNOLOGY	L-T-P-C: 2-0-3-3

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

After completing this course, the students will be able to

CO1: Understand models of human and artificial intelligence, specifically computational models of intelligence.

CO2: Understand a collection of various applications of Crispr technology

CO3: Analyse appropriate intelligent system models and computational tools to specific problems in gene editing.

CO4: Implement 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	PSO3
CO1	3	3	3	2	3	3	3		3	3		3	3		
CO2	3	3	3	2	3	3	3		3	3		3		3	2
CO3	3	3	3	2	3	3	3		3	3		3		3	2
CO4	3	3	3	2	3	3	3		3	3		3		2	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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE456	DNA SEQUENCING	L-T-P-C: 2-0-3-3

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

After completing this course, the students will be able to

CO1: Understand models of human and artificial intelligence, specifically computational models of intelligence.

CO2: Understand a collection of machine learning models and their applications in DNA sequencing.

CO3: Analyse appropriate intelligent system models and computational tools to specific problems in DNA sequencing.

CO4: Implement 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	PSO3
CO1	3	3	3	2	3	3	2		3	3		3	3		
CO2	3	3	3	2	3	3	2		3	3		3		3	2
CO3	3	3	3	2	3	3	2		3	3		3		3	2
CO4	3	3	3	2	3	3	2		3	3		3		2	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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

Pool 3: AI in Robotics

21AIE441	KINEMATICS & KINETICS FOR ROBOTICS	L-T-P-C:2-0-3-3

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

After completing this course, the students will be able to

CO1: Understand the fundamentals of Kinematics & Kinetics for Robotics.

CO2: Apply the concepts of vector mechanics for solving Kinematics problems.

CO3: Apply computational techniques to solve Kinematics & Kinetics problems.

CO4: Implement computational models for Kinematics & Kinetics problems.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	2	1			3	2	3	3	3		
CO2	3	3	2	2	2	1			3	2	3	3	3		
CO3	3	3	3	3	3	2			3	2	3	3		3	2
CO4	3	3	3	3	3	2			3	2	3	3		2	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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE442	ROBOTIC VISION	L-T-P-C:2-0-3-3

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

After completing this course, the students will be able to

CO1: Understand the basic concepts of robotic vision.
CO2: Analyse various computational tools used for robotic vision.
CO3: Develop simple and specific applications involving robotic vision.
CO4: Evaluate 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	PSO3
CO1	2	2	2	2	2	1			3	3	3	3		2	2
CO2	3	3	2	3	3	1			3	3	3	3		3	2
CO3	2	3	3	3	3	3			3	3	3	3		3	2
CO4	2	3	3	3	3	3			3	3	3	3		2	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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE443	DYNAMICS & CONTROL OF ROBOTICS	L-T-P-C:2-0-3-3

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

After completing this course, the students will be able to

CO1: Develop mathematical models for dynamics and control of robotic systems.

CO2: Apply analytical and computational tools for modelling and control of robots.

CO3: Simulate simple robotic motion.

CO4: Control simple robotic motion.

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	1			3	3	3	3	3		
CO2	3	3	3	3	3	1			3	3	3	3	2	3	2
CO3	3	2	3	3	3	2			3	3	3	3		3	3
CO4	3	2	3	3	3	2			3	3	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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE444	SENSORS FOR ROBOTICS	L-T-P-C:2-0-3-3

Course Objectives

- The major objective of this course will be integrating various sensor systems required for the designed robotic system.
- This will lead to programming 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

After completing this course, the students will be able to

CO1: Understand the working of most common sensors used in robotics.

CO2: Understand the sensor processing algorithms.

CO3: Evaluate simple robotic systems with sensors for specific applications.

CO4: 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	PSO3
CO1	3	2	2	2	3	2			3	3	3	3	2		
CO2	3	3	3	2	3	2			3	3	3	3	2		
CO3	3	2	3	2	3	2			3	3	3	3		3	2
CO4	3	2	3	2	3	2			3	3	3	3		2	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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30

21AIE445	APPLICATION OF ROBOTICS	L-T-P-C: 2-0-3-3

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

After completing this course, the students will be able to

CO1: Understand the various types of robots and its application
CO2: Analyse robotic systems for industrial and societal application.
CO3: Analyse robotic systems for self-driving vehicles, medical applications and agriculture.
CO4: Develop simple robotic applications.

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	2	3	2	3	3		2	
CO2	2	2	3	2	3	2	2	2	3	2	3	3		3	2
CO3	2	3	3	2	3	2	2	2	3	2	3	3		3	2
CO4	2	3	3	2	3	2	2	2	3	2	3	2		2	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 (%)
Internal (Minimum 10 assessments)	70
Project (External component)	30