COURES STRUCTURE & SYLLBUS FOR

B. TECH. ROBOTICS & AUTOMATION

SEMESTER- V & VI

(CBCS 2023 COURSE AS PER NEP 2020 GUIDELINES)

Bharati Vidyapeeth

(Deemed to be University)

College of Engineering, Pune

Department of Robotics and Automation Engineering

Vision of the Bharati Vidyapeeth (Deemed to be University) College of Engineering is:

To be a World Class Institute for Social Transformation through Dynamic Education

Missions of the Bharati Vidyapeeth (Deemed to be University) College of Engineering are:

- *To provide quality technical education with advanced equipment, qualified faculty members, and infrastructure to meet needs of profession & society.*
- *To provide an environment conducive to innovation, creativity, research and entrepreneurial leadership.*
- *To practice and promote professional ethics, transparency and accountability for social community, economic & environmental conditions.*

Goals of the Bharati Vidyapeeth (Deemed to be) University College of Engineering are:

- *Recruiting experienced faculty.*
- *Organizing faculty development programs.*
- *Identifying socio-economically relevant areas & emerging technologies.*
- *Constant review &up gradation of curricula.*
- *Up gradation of laboratories, library & communication facilities.*
- *Collaboration with industry and research & development organizations.*
- *Sharing of knowledge, infra-structure and resources.*
- *Training, extension, testing and consultancy services.*
- *Promoting interdisciplinary research.*

Vision of the Robotics and Automation Engineering Department is:

To develop, high quality Robotics & Automation Engineers through dynamic education to meet social and global challenges.

Mission Statements of the Robotics and Automation Engineering Department are:

- *To provide extensive theoretical and practical knowledge to the students with well-equipped laboratories and ICT tools through motivated faculty members.*
- *To inculcate aptitude for research, innovation and entrepreneurial qualities in students.*
- *To acquaint students with ethical, social and professional responsibilities to adapt to the demands of working environment.*

Program Educational Objectives (PEOs) of the B. Tech. Robotics and Automation are:

Graduates will be able,

- *To fulfill need of industry and society with theoretical and practical knowledge.*
- *To engage in research, innovation, lifelong learning and continued professional development.*
- *To fulfill professional ethics and social responsibilities.*

PROGRAM OUTCOMES

Engineering Graduates will be able to:

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.*

Statements of Programme Specific Outcomes (PSOs)

PSO1: *Apply the knowledge of Robotics, design, manufacturing, Automation engineering and computational sciences to solve Robotics & Automation Engineering problems.*

PSO2: *Apply Robotics & Automation Engineering principles for research, innovation and develop entrepreneurial skills.*

PSO3: *Apply concepts of Robotics & Automation engineering to asses' societal, environmental, health and safety issues with professional ethics.*

B. Tech. (Robotics & Automation Engineering): Semester –V (2023 COURSE) As per NEP 2020 Guidelines

S. No.	Category	Course Code	Course	Teaching Scheme			Examination Scheme-Marks					Credits				
				L	P	T	ESE	IA	TW	PR	OR	Total	Th	Pr/Or	Tut	Total
1.	BSC/PCC	C301	Robot Kinematics and Dynamics	3	2	1	60	40	25	-	25	150	3	1	1	5
2.	PCC	C302	Future Factory	3	-	-	60	40	-	-	-	100	3	-	-	3
3.	PCC	C303	Signals and Systems	3	-	-	60	40	-	-	-	100	3	-	-	3
4.	PCC	C304	Introduction to Finite Element Analysis*	3	2	-	60	40	25	25	-	150	3	1	-	4
5.	PCC	C305	Programmable Logic Controller and Human-Machine Interface	3	2	-	60	40	25	-	25	150	3	1	-	4
6.	SBC	C306	Solid Modelling	-	2	-	-	-	25	25		50	-	1	-	1
7.	AC	C307	Environmental Studies**	**4**	-	-	**-**	**100**	-	-	-	**100**	**4**	-	-	**4**
			Total	**19**	**08**	**01**	**300**	**300**	**100**	**50**	**50**	**800**	**15**	**4**	**1**	**24**

*End Sem. Examination of 4Hrs. **Mandatory Audit Course; #Add-on Course

B. Tech. (Robotics & Automation Engineering): Semester – VI (2023 COURSE) As per NEP 2020 Guidelines

S. No.	Category	Course Code	Course	Teaching Scheme			Examination Scheme-Marks					Credits				
				L	P	T	ESE	IA	TW	PR	OR	Total	Th	Pr/Or	Tut	Total
1.	PCC	C308	Electro Hydraulics and Pneumatics	3	2	-	60	40	25	-	25	150	3	1	-	4
2.	PCC	C309	Artificial Intelligence and Data Science	3	2	-	60	40	25	-	-	125	3	1	-	4
3.	PE-I	C310	Program Elective - I	3	-	-	60	40	-	-	-	100	3	-	-	3
4.	PCC	C311	Field & Service Robots	3	2	-	60	40	25	-	25	150	3	1	-	4
5.	PCC	C312	Medical Mechatronics	3	-	-	60	40	-	-	-	100	3	-	-	3
6.	PS	C313	Professional Skills	-	2	-	-	-	25	-	-	25		1	-	1
7.	SBC	C314	Robotic Programming	-	2	-	-	-	25	25	-	50	-	1	-	1
			Total	**15**	**10**	**-**	**300**	**200**	**100**	**25**	**25**	**700**	**15**	**5**	**-**	**20**
8.	MOOC	C315	MOOC-II#	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**
9.	VAC	C316	Value Added Course-II**	**2**	**-**	**-**	**-**	**100**	**-**	**-**	**-**	**100**	**-**	**-**	**-**	**2**

**Mandatory Audit Course; #Add-on Course

Program Elective –I i. Energy Audit and Management ii. Additive Manufacturing and Rapid Prototyping, iii. Computer Vision and Image Processing iv. Robotic System Modelling and Simulations v. Engineering Economics

B. Tech. Robotics & Automation
Sem.-V

ROBOT KINEMATICS AND DYNAMICS
(Course No. C301)

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS:
Theory: 03 Hours/ Week	University Examination Marks: 60 marks	Theory: 03
Practical: 02 Hours/ Week	Internal Assessment Marks: 40 marks	
Tutorial: 01 Hours/ Week	Term Work Marks: 25 marks	Practical: -01
	Oral Examination Marks: 25 marks	Tutorial: - 01
	Total Credits	05

Course Prerequisites: -	1. Concept of degree of freedom 2. Different types of mechanisms, robot coordinate system 3. Matrices and Algebraic Mathematics
Course Objectives: -	1. Different types of robot linkage, frame 2. Kinematics and Dynamics of Robot 3. Motion planning and control of robot manipulator
Course Outcomes: -	The students will be able to 1. Identify Elements of Robots 2. Calculate Kinematics of serial robot 3. Calculate Kinematics of parallel robot 4. Calculate Velocity and static analysis of robot 5. Evaluate dynamics behavior of robots 6. Evaluate Motion, trajectory of robotic arm

Course Contents		**No. of Hours**
Unit-I	**Mechanisms in Robots**	**(08 Hrs.)**

Position and orientation of a robot body such as roll, pitch, yaw, and, Degree of freedom for robot joints and linkages, Different types of robot mechanism, Elements of robot Mechanism, Drive system used for robot mechanism, comparison of different robot mechanism, Types of wheels used in robots.

Unit-II	**Kinematics of serial robots**	**(08 Hrs.)**

Introduction, Homogeneous transformations, Representation of joints, link representation using D-H parameters, Classical and Modified D-H Parameter, Matrix Manipulation Examples of D-H parameters and link transforms Direct and inverse kinematics problems, Examples of kinematics of common serial manipulators, Inverse kinematics of constrained and redundant robots, Inverse kinematics solution for The general 2- and 3-Dimensional serial manipulator.

Unit-III	**Kinematics of parallel robots**	**(08 Hrs.)**

Degrees-of- freedom of parallel mechanisms and manipulators, Active and passive joints, Constraint and loop closure equations, Direct kinematics problem, Closed-from and numerical solution, Inverse kinematics of parallel manipulators and mechanisms (theoretical treatment only)

Unit-IV	**Velocity and static analysis of robot manipulators**	**(08 Hrs.)**

Linear and angular velocity of links, Velocity propagation, Formation of Jacobian matrix,Manipulator Jacobians for serial and parallel manipulators, Velocity ellipse and ellipsoids, Singularity analysis for serial and parallel manipulators, Law of control for Second order system, Loss and gain of degree of freedom, Statics of serial and parallel manipulators, Singularity analysis and statics, Force analysis of robot system.

Unit-V	**Dynamics of serial and parallel manipulators**	**(08 Hrs.)**

Mass/Inertia and their Positions of links, Lagrangian/Eularian/Newtonian/Screw Approaches for formulation of equations of motion for serial and parallel manipulators, Formation using, Lagrangian approach only, Generation of symbolic equations of motion using a computer, Simulation (Direct and Inverse) of dynamic equations of motion, Examples of a planar 2 link/jointand four-bar mechanism, Recursive dynamics, Numerical limited to 2 link and 2 joints (Revolute and Prismatic joint) planar robots.

Unit-VI	**Motion planning and control**	**(08 Hrs.)**

Joint and Cartesian space trajectory planning and generation, Classical control concepts using the example of control of a single link Simulation and experimental case studies on serial and parallel manipulators, Control of constrained manipulators, Cartesian control, Force control and hybrid position/force control, Advanced topics in non-linear control of manipulators

List of Practical /Term work (Any Software tool like Robo Analyzer, Robo DK Simulink / Sim Mechanics)

(Out of 10 and any 8 experiments can be performed)

1. Introduction to Robot Kinematic and Dynamics Analysis software and its commands
2. To study and prepare a model of Robot coordinate frames and transformations by using Robo Analyzer
3. To study and prepare a model of Forward kinematics of robot by using Robo Analyzer
4. To study and prepare a model of Inverse kinematics of robot by using Robo Analyzer
5. Workspace analysis of 6 Axis robot
6. Kinematic Analysis of MITSUBISHI Mini Robot
7. To study and prepare a model of Forward Dynamics of robot by using Robo Analyzer
8. To study and prepare a model of Inverse Dynamics of robot by using Robo Analyzer
9. To Create Robot Joint trajectories by using Robo Analyzer
10. Demonstration of Forward Kinematics by using motors

Project Based Learning

1. Prepare a model showing Forward Kinematics of Robot
2. Prepare a model showing Dynamics of Robot
3. Prepare a model showing Joint trajectories in robot linkages
4. Prepare a model showing Inverse Kinematics of Robot
5. Prepare a model Forward Kinematics by using motors
6. Prepare a model for parallel type of mechanism in robot

Textbooks:

1. Groover M. P., "Industrial Robotics: Technology, Programming and Applications, TataMcGraw Hill Publication
2. Taghirad H.D, "Parallel Robots: Mechanics and Control", CRC Press.
3. Moore S. W., Bohm H., and, Jensen V., "Underwater Robotics: Science, Design &Fabrication", Marine Advanced Technology Education (MATE) Center, 2010
4. Bock T., Linner T., "Robot Oriented Design: Design and Management Tools for the Deployment of Automation and Robotics in Construction", Cambridge University Press
5. Introduction to Robotics, S.K.Shah. McGraw Hill, 2nd EditionSaid Niku Peerson
6. Introduction to Robotics, Mechanics and control by John J Craig, Global edition 4th revesion

Reference Books:

1. Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, „Introduction to Autonomous
   a. Mobile Robots‖, Bradford Company Scituate, USA, 2004
2. RiadhZiaer (Ed) „The future of Humanoid Robots- Research and applications‟, Intech Publications, 2012.
3. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – AnIntegrated Approach", Eastern Economy Edition, Prentice Hall of India P Ltd., 2006.
4. Kelly, Alonzo; Iagnemma, Karl; Howard, Andrew, "Field and Service Robotics ", Springer,2011.
5. Mejia O. D. M., Gomez J. A. E., (eds.), "Aerial Robots: Aerodynamics, Control and Application" InTech Open Publications.

FUTURE FACTORY (Course No. C302)		
TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS: 03
Theory: 03 Hours/ Week	University Examination Marks: 60 marks	Theory:03
Practical: ---Hours/ Week	Internal Assessment Marks:40	
	Term Work Marks: -----	Practical: -----
	Oral/ Practical Examination Marks: ------	
	Total Credits	03

Course Prerequisites: -	The students should have knowledge of 1. Manufacturing Technology 2. Automatic Control System 3. Electro-Hydraulic and Pneumatics 4. Power Electronics & Drives 5. Object Oriented Programming (Using Python) 6. Programmable Logic Controller
Course Objectives: -	To provide Knowledge about 1. Modern manufacturing systems 2. To understand the concepts and applications of flexible manufacturing systems 3. To introduce the concept of smart factories, especially the various technologies involved within the smart manufacturing. 4. To introduce the applications and scope for technology involved in Industry 4.0.
Course Outcomes: -	The students will be able to 1. Understand the various Non-conventional Manufacturing processes and apply them in manufacturing. 2. Understand the various CNC Programming and apply them for manufacturing of components. 3. Recognize the recent manufacturing trends related to Industry 4.0, FMS, and its implementation in manufacturing 4. Understand and apply the concept of agile manufacturing and cyber security in future factory 5. Identify applications of AR and VR in smart manufacturing. 6. Understand and apply the concept of cloud manufacturing and digital twins in future factory

Course Contents		**No. of Hours**
Unit-I	**Advanced Machining Processes**	**(06 Hrs.)**

Mechanical Processes: Mechanical Processes: Ultrasonic machining (USM), Abrasive Jet Machining (AJM) processes-Process principle and mechanism of material removal, Process Parameters; Applications; Operational characteristics; Limitations.

Electro Chemical Processes: Electrochemical Machining Process (ECM)

Thermal Processes: Electro discharge Machine (EDM), Wire Electro Discharge Machining (WEDM), Laser Beam Machining (LBM), Electron Beam Machining (EBM), Plasma Arc machining (PAM) processes–Process principle and mechanism of material removal; Process parameters and characteristics; Surface finish and accuracy, Applications; Limitations.

Unit-II	**CNC Technology**	**(06 Hrs.)**

Evolution of CNC Technology, principles, features, advantages, applications, CNC and DNC concept, classification of CNC Machines – turning Centre, machining Centre, CNC controllers, CNC Programming: Coordinate system, structure of a part program, G & M Codes, tool length compensation, cutter radius and tool nose radius compensation, canned cycles, programming for machining Centre and turning Centre for well-known controllers such as Fanuc, Siemens. Introduction to CMM.

Unit-III	**Introduction to Smart manufacturing technologies**	**(06 Hrs.)**

Introduction to Industry 4.0, Smart manufacturing, Related technologies, Traditional Factory and Smart Factory, The Smart Factory Opportunity, CIM wheel, CIMS Structure and Functions, Future Trends of smart Factory and applications. Introduction & composition of FMS, hierarchy of computer control, computer control of work center and assembly lines, FMS supervisory computer control, types of software specification and selection.

Unit-IV	**Agile Manufacturing and Safety with Future Factory**	**(06 Hrs.)**

Agile Manufacturing: Introduction to Agile Manufacturing, Agile Manufacturing Principles, Implement Agile Manufacturing, Applications of Agile Manufacturing, Real-Time Data to Guide Iteration, Computer Vision to Augment Operators, Manufacturing Apps to Amplify Training Programs, Mass Customization.

Safety with Future Factory: Introduction to cybersecurity, security principles, risk and opportunities in cybersecurity technology,

Unit-V	**Virtual and Augmented Reality, Machine Learning in Industry 4.0**	**(06 Hrs.)**

Introduction, Difference in AR and VR, Hardware and Software Technology, Industrial Applications of Augmented reality and Virtual reality. Basics of Machine Learning, The Machine Learning Process, Into Machine Learning working cycle, Preparing Data, Running Experiments, Finding the Model, Training the Model, Deploying and using a Model, Machine Learning in practice (examples of existing or future applications in the field of manufacturing)

Unit-VI	**Cloud Manufacturing and Digital Twins**	**(06 Hrs.)**

Cloud Manufacturing: Introduction to Cloud computing, Industrial Internet of Things, supply chain management, Big Data and Analytics, Big Data decision-making, , Automotive Cloud, warehouse operations

Digital Twins: Introduction to Digital Twins, Benefits, impact and challenges, Features and Implementation of Digital Twins, Computational tools, Types of Digital Twins, Applications for digital twins in production (examples of existing or future applications in the field of manufacturing)

Textbooks:

1. P. C. Sharma, Production Engineering, S. Chand Publications
2. R. K. Jain, Production Technology, Khanna Publishers
3. P.Radhakrishnan,V.Raju, CAD/CAM/CIM, New Edge international Publishers.
4. Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press,2020
5. B Joshi, Machine Learning and Artificial Intelligence, Springer, 2020.
6. Parag Kulkarni and Prachi Joshi, "Artificial Intelligence – Building Intelligent Systems", PHI learning Pvt. Ltd., ISBN – 978-81-203-5046-5, 2015
7. Stuart Russell and Peter Norvig (1995), "Artificial Intelligence: A Modern Approach," Third edition, Pearson, 2003
8. Groover M.P., "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall of India Pvt., New Delhi, 1996.
9. Radhakrishnan P. and Subramanyan S., "CAD/CAM/CIM", Wiley Eastern Ltd., New AgeInternational Ltd., 1994.
10. Raouf, A. and Ben-Daya, M., Editors, "Flexible manufacturing systems: recent development", Elsevier Science, 1995.
11. Smid P., CNC Programming Handbook, Industrial Press, 2005
12. Leong W., Nine pillars of technologies for Industry 4.0, IET publishers, 2020
13. Gilchrist A., Industry 4.0: The Industrial Internet of Things, Apress, 2017

Reference Books:

1. HMT Handbook, Production Technology, TMH
2. M. P. Grover, M. Weiss, R. N. Nagel, N. G. Odrey, "Industrial Robotics Technology",ISBN 0-07-100442-
3. Solanki, Kumar, Nayyar, Emerging Trends and Applications of Machine Learning, IGI Global, 2018.
4. Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press, 2018.
5. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.
6. Zsolt Nagy - Artificial Intelligence and Machine Learning Fundamentals-Apress (2018)
7. Artificial Intelligence by Elaine Rich, Kevin Knight and Nair, TMH Web

SIGNALS AND SYSTEMS (Course No. C303)		
TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS:
Theory: 03 Hours/ Week	University Examination Marks: 60 marks	Theory: 03
Practical: ------	Internal Assessment Marks: 40 marks	
	Term Work Marks: -----	Practical: 00
	Oral/ Practical Examination Marks: ------	
	Total Credits	**03**

Course Prerequisites: -	The students should have knowledge of 1. Differential and Integral calculus 2. Vector algebra and algebra of complex numbers
Course Objectives: -	To provide Knowledge about 1. To understand the behavior of signals in time and frequency domain 2. To understand the characteristics of LTI systems 3. To analyze continuous and discrete time systems using different transform techniques.
Course Outcomes: -	The students will be able to 1. Classify signals and perform operations on signals. 2. Analyze LTI systems using convolution. 3. Apply Fourier series and Fourier Transform for analysis of signals. 4. Analyze CT signals and systems using Laplace transform. 5. Apply Z-transform for the analysis of DT signals and systems. 6. Sample and reconstruct the signals using sampling technique

Course Contents		**No. of Hours**
Unit-I	**Introduction and Classification of signals**	**(06 Hrs.)**
Signals and Systems definition, Types of signals, continuous time and Discrete time signal operations, Amplitude scaling, Time shifting, Time reversal, Time scaling, Mathematical operations additions, subtraction, multiplication of signals, Classification of signals according to their property, Periodic/Aperiodic, Even/Odd, Energy/Power/Causal/Non causal, Deterministic/Random signals.		
Unit-II	**Time domain representation of LTI System**	**(06 Hrs.)**
Introduction to systems, Classification of systems according to their properties, Linear/Nonlinear, Static /Dynamic, Time Invariant/Time variant, Causal/non causal, Stable/Unstable, Invertible/Non- Invertible systems, Convolution Integral, convolution sum using graphical method properties and applications.		
Unit-III	**Fourier Analysis of Signals**	**(06 Hrs.)**
Fourier Series: - Review of Fourier series of CT and DT signals and its properties (No derivation), Exponential and Trigonometric Fourier series of periodic signals, Amplitude and phase spectra of periodic signals.		
Unit-IV	**Application of Laplace Transform in Signal processing**	**(06 Hrs.)**
Review of Bilateral and Unilateral Laplace Transform of signals, ROC and its properties (No derivation). Laplace transforms of standard signals, Inverse Laplace Transform, Solution to differential equation, Poles and Zeros representation.		
Unit-V	**Z-transform**	**(06 Hrs.)**
Z-transform, Region of convergence and its properties (No derivation), Inverse z transform, properties of z transform (No derivation), relation between Z and Laplace Transform.		
Unit-VI	**Sampling and Correlation**	**(06 Hrs.)**
Correlation, Autocorrelation and cross-correlation of energy and power signals, properties of correlation functions (No derivation), Application of correlation, Energy Density Spectrum, Power Density Spectrum.		

List of Practical /Term work:

1. Introduction to MATLAB and its basic functions.
2. Generate Continuous and discrete time signals.
3. Perform signal operations on Continuous and discrete time signals.
4. Find even and odd part of the signal and sequence and find real and imaginary parts of signal.
5. Compute linear convolution and convolution integral of sequences/signals.
6. Compute Fourier Transform and Inverse Fourier Transform of a given signal/sequence and plot its Magnitude and Phase Spectra.
7. To compute and plot the impulse response and pole-zero diagram of transfer function using Laplace transform.
8. To compute and plot the impulse response and pole-zero diagram of transfer function using Z- transform.
9. Compute auto correlation and cross correlation between signals and sequences and verify its properties.
10. Verify sampling theorem and reconstruct the signal.

Project Based Learning:

Students in a group of 3 to 4 shall complete any one project from the above list

1. Generate basic signals using C / Python programming.
2. Perform multiple operations on signal using C or MATLAB.
3. Visualize signal/data in time and frequency domain using MATLAB.
4. Find the Trigonometric Fourier Series of a given Signal using C/Python/MATLAB.
5. Create Frame-Based Signals using MATLAB simulink.
6. Create Multichannel Signals by combining single channel signals using simulink.
7. Create Multichannel Signals by combining multichannel signals using simulink.
8. Inspect sample and frame rate using simulink.
9. Perform Linear Convolution of two sequences using SCILAB.
10. Represent, Play and plot audio signals with different sampling frequencies using MATLAB.
11. Study of Signal Processing Sound Effects: Introducing a delay, creating an echo effect by repeating the signal, time scaling, time reversal, volume scaling.
12. Create acoustic environment in Simulink.

Textbooks:

1. Oppenheim, Willsky, S.Hamid Nawab, "Signals and Systems", PHI, 2nd edition, 2002.
2. M.J. Roberts, "Signals and Systems", McGraw-Hill, 1st edition, 2003.
3. B.P Lathi, "Principles of linear systems and signals", Oxford, 2nd edition, 2009

Reference Books:

1. Simon Haykin and Bary Van Veen, "Signals and Systems", Wiley- India Publications.
2. Michal J. Roberts and Govind Sharma, "Signals and Systems", Tata Mc-Graw Hill Publications.

INTRODUCTION TO FINITE ELEMENT ANALYSIS
(Course No. C304)

Designation of Course	**Introduction to Finite Element Analysis**		
Teaching Scheme	**Examination Scheme**		**Credits allotted**
Theory:-3hrs/Week	End Semester Examination	60	03
Practical:-2Hrs/Week	Internal Assessment	40	
	Term Work	25	-
	Practical	25	01
	Total	150	04

Course Prerequisite:-	Basics knowledge of: 1. Engineering Mathematics 2. Engineering Mechanics 3. Strength of Materials 4. Numerical Methods
Course Objective:-	To provide the knowledge of 1. Analyze a physical problem. 2. Develop finite element procedures for accurately investigating the problem, and effectively perform and document findings. 3. Solve 1 D, 2 D and dynamic problems using Finite Element Analysis approach.
Course Outcomes:-	Students should be able to 1. Remember the basic concepts of Solid mechanics and understand the concepts of Nodes and elements. 2. Understand the Formulation of Element Stiffness Matrix and Load Vector and apply it for 1D elements. 3. Understand the Formulation of Element Stiffness Matrix and Load Vector and apply it for 2D elements 4. Understand the concept of Isoperimetric elements and element quality criteria. 5. Understand the concept of 1D Steady State Heat Transfer and apply it solve heat transfer problem. 6. Understand the concept free vibration and evaluate the Eigenvalues and Eigen vectors for stepped bar and beam.

Course Content

Unit I	**Introduction to FEA**	**(06 Hrs)**
Introduction to FEM, Stress strain relations, shape functions- linear and quadratic, Triangular, Quadrilateral, Higher order elements, Variational methods of approximation-Rayleigh Ritz Method, Methods of Weighted Residuals-Least Square Method, Subdomain Method, Collocation Method, Garlekin's method.		
Unit II	**One Dimensional Problems**	**(06 Hrs)**
Finite element modeling, Convergence of results, Potential energy approach, Global stiffness matrix, Properties of stiffness matrix, load vector, Penalty approach, Elimination approach		
Unit III	**Two Dimensional Problems**	**(06 Hrs)**
Plain Stress, Plain Strain, Types of 2D elements, Formulation of elemental stiffness matrix, and load vector for truss element, Formulation of elemental stiffness matrix and load vector for Constant Strain Triangle element.		
Unit IV	**Isoperimetric Elements**	**(06 Hrs)**

Isoperimetric formulation – Natural Co-ordinate system, Lagrangian interpolation polynomials, Isoperimetric element, Numerical Integration Newton Cotes formula, Gauss Quadrature formula in two and three dimensions, triangular elements, rectangular elements.		
Unit V	**1D Steady State Heat transfer**	**(06 Hrs)**
Governing Differential Equation; Steady State Heat Transfer Formulation of 1 D Element for Conduction and Convection; Boundary Conditions and Solving for Temperature Distribution; 1D Heat Transfer Steps involved in Processing Steps.		
Unit VI	**Dynamic Analysis**	**(06 Hrs)**
Lumped mass and Consistent Mass Matrices; Free Vibration Problems, Formulation of Eigen Value and Eigen Vector Problem by Power Method, Step wise solution of Problems on Vibration in Bar Element; FEM Formulation. Time dependent Problems.		

Term Work

Term work shall consist of

1. Four computer program assignments to be developed for FEA. (Using any programming language.)
2. Two assignments on structural Analysis using FEA Software
3. Two assignments on modal Analysis using FEA Software
4. Two assignments on Automation based Modelling

Project Based Learning

Following is the list of topics for project-based learning (Not Limited to) based on the syllabus contents:

1. Structural analysis of any mechanical component.
2. Thermal analysis of any mechanical component.
3. Modal analysis of any mechanical component.

Text Book

1. T. R. Chandrupatia, A. D. Belegundu, “Introduction to Finite Elements in Engineering”, Third Edition, PHI
2. J. N. Reddy, “An introduction to Finite Element Method Analysis”, MGH

Reference Books

1. K. J. Bathe, “Finite Element Procedures”, PHI
2. R. D. Cook, D. S. Malus, M. E. Plesha, “Concepts and Applications of Finite Element Method Analysis”, John Wiley
3 Desai & Abel, “Introduction to Finite Element Methods”
4. D. L. Logan, “A course in the Finite Element Method”, Third Edition, Thomson Learning
5. John D. Anderson, “Computational Fluid Dynamics: The Basics with Applications”, McGraw Hill, 1995

Programmable Logic Controller and Human Machine Interface

(Course No. C305)

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS:
Theory: 03 Hours/ Week	University Examination Marks: 60 marks	Theory: 03
Practical: 02 Hours/ Week	Internal Assessment Marks: 40 marks	
	Term Work Marks: 25 marks	Practical: 01
	Oral Examination Marks: 25 marks	
	Total Credits	04

Course Prerequisites: -	1. Basic of Electronics Engineering 2. Basic of Electrical Engineering
Course Objectives: -	1. To introduce the functions of given industrial automation system. 2. To introduce input-output devices in PLC. 3. To introduce HMI and PLC interfacing
Course Outcomes: -	The students will be able to 1. Understand the functions and characteristics of given industrial automation system 2. Interface the given I/O device with appropriate PLC module 3 3. 3.Understand working of HMI 4. Identify HMI hardware and software. 5. Interface PLC & HMI. 6. Understand the control panels of various industry HMIs.

Course Contents		**No. of Hours**
Unit-I	**Introduction to Industrial Automation**	**(06 Hrs.)**
Need and benefits of Industrial Automation, Automation Hierarchy, Basic components of automation system, description of each component, Types of automation system: -Fixed, programmable, flexible, Different systems for Industrial automation: PLC, HMI, SCADA, DCS, Drives		
Unit-II	**PLC Programming and Applications**	**(06 Hrs.)**
PLC I/O addressing, PLC programming Instructions : Relay type instructions, timer instructions: On delay, off delay, retentive. Counter instructions, Up. Down. High speed, Logical instructions, Comparison Instructions, Data handling Instructions. Arithmetic instructions, PLC programming language-Functional Block Diagram (FBD). Instruction List, Structured text, Sequential Function Chart (SFC), Ladder Programming, Simple Programming examples using ladder logic: Language based on relay, timer counter, logical, comparison, arithmetic and data handling instructions PLC based applications: Motor sequence control, Traffic light control, elevator control, Tank level control, conveyor system, Stepper motor control, reactor control		
Unit-III	**Human Machine Interface (HMI)**	**(06 Hrs.)**
History of User Interface Designing, I/O channels, Hardware, Software and Operating environments, The Psychopathology of everyday Things, Psychology of everyday actions, Reasoning and problem solving . The computer: Devices, Memory, processing and networks. Interaction: Models, frameworks, Ergonomics, styles, elements, interactivity, Paradigms, Security Features of HMI		
Unit-IV	**PLC & HMI**	**(06 Hrs.)**
Communications - PLC to HMI, operator station design, Operator Interface Types, Textual , Graphical, animation, interlocking tagging, HMI assembling and Wiring, HMI Data Handling		
Unit-V	**HMI Selection and programming**	**(06 Hrs.)**
HMI Interfacing Considerations, HMI Hardware Selection, HMI Software Selection, HMI Ergonomics, Configuring System Communications, Security, Delta HMI programming: Communication to PLC Tags, Alarms, Trends, Data Log Screens, Animation. Download / upload Making Applications Download & Upload the Programs Creating Alarm Messages, Communication with PLC Fault Finding and Trouble Shooting		

Unit-VI	**HMI in Robotics Industry**	**(06 Hrs.)**

Role of HMI in Industries, Hardware & Architecture Source & Sink Concepts Wiring different field devices to PLC, Siemens KTP 600 Basic color PN (Key Touch Panel), Siemens TP177A DP (Touch Panel), Delta DOP-B07S411 (Touch Panel), Mitsubishi GS Series, HMI/SCADA development for the Pressure Control Station.

List of Experiments: -

1. Introduction to ladder programming& to implement basic logic gates.
2. Develop, Simulate and Test Ladder diagram for a. A Doorbell Operation b. A Combination Lock.
3. Develop, Simulate and Test Ladder diagram for Bottle Filling system.
4. Develop, Simulate and Test Ladder diagram for Traffic Light Control System.
5. Develop, Simulate and Test Ladder diagram for Car Parking system.
6. Develop Simulate and Test Ladder diagram for an alarm annunciator system.
7. Develop, Simulate and Test Ladder diagram for Batch Mixer.
8. Develop, Simulate and Test Ladder diagram for Drink Dispenser system.

Project Based Learning: -

1. Develop and test PLC program for three phase motor in both directions.
2. Develop, Simulate and Test Ladder diagram for stepper motor control in forward and reverse direction.
3. Develop and test PLC program for two axis Robotic arm for pick and place application
4. Develop, Simulate and Test Ladder diagram for Packing line system.
5. Develop, Simulate and Test Ladder diagram for an Elevator system.
6. Develop and test PLC program for PID Controller for Temperature control Application.
7. Develop and test PLC program in FBD, SFC, IL, ST, and Ladder Logic Language for Motor starter application.
8. Detail study of PLC Hardware and its interfacing

Textbooks:

1. Frank D. Petro Zella, "Programmable logic controller" McGraw – Hill Publications, 1998
2. PanelView32 and RSView32 Programming Guides, Rockwell Automation

Reference Books:

1. John B. Peatman, PIC programing, McGraw Hill International, USA, 2005
2. Programmable Logic Controllers, Principles and Applications: John W. Webb, Ronold A Reis, 5th Edition, Prentice Hall of India Pvt. Ltd
3. Stuart A. Boyer, SCADA supervisory control and data acquisition, ISA Publication

SOLID MODELLING – Basic and Robotic Application

(Course No. C306)

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS:
Theory ------- Hours/ Week	Term Work Marks: 25 marks	Practical: 01
Practical: 02 Hours/ Week	Oral/ Practical Examination Marks: 25 marks	
	Total Credits	01

Course Prerequisites: -	1. Computer Aided Drafting and Visualisation 2. Computer Aided Machine Drawing
Course Objectives: -	1. To introduce students to the basicconcepts of CAD modelling. 2. To develop the skills in Reading and Interpretation of Engineering Drawings. 3. To familiarize students with SolidWorks Software to Crate 2D and 3D model, Assembly, Drafting and Sheet metal modelling.
Course Outcomes: -	The students will be able to 1. **Understand** the concepts of CAD modelling. 2. **Creating** 3D machine components using SolidWorks Software. 3. **Creating** Assembly of machine components using SolidWorks Software. 4. **Creating** surface model of Automobile Components using SolidWorks Software. 5. **Creating**detail drawing and generating Bill of Material using SolidWorks Software. 6. **Understand** the basic concepts of Sheet metal Modelling and **Create** a machine component using SolidWorks Software.

Course Contents		**No. of Hours**
Unit-I	**Introduction to CAD**	**(04 Hrs.)**
Introduction to CAD and CAE Features of SolidWorks, Various products available in SolidWorks for Product Design, Simulation, Communication SolidWorks Graphical User Interface - Feature manager design tree, Callouts, Handles, Confirmation corner, mouse buttons, keyboard shortcuts, Command Manager. Sketch Entities, Sketch Tools, Block, Relation and Dimensioning		
Unit-II	**Basic Part Modelling**	**(04 Hrs.)**
Part Modelling Tools, Creating Extrude features, Creating Revolve features, Creating Swept features, Creating Loft features, Creating Reference, Creating curves, Fillet features, Inserting Hole types, Creating Chamfer, Shell, rib, pattern and advanced modelling tools.		
Unit-III	**Assembly Modelling**	**(04 Hrs.)**
Introduction to Assembly Modelling & Approaches, Applying Advanced Mates and Mechanical Mates, Manipulating Components, Creating Pattern, Creating Explode Views.		
Unit-IV	**Surface Modelling**	**(04 Hrs.)**
Surface Modelling tools Creating Extrude, Revolve, Swept, loft, Boundary surface. Inserting Planar Surface, Offset Surface, Radiate Surface. Extending a surface, Surface fill, Ruled Surface, Trimming Surface, Mid surface, Replace Face, Delete face, Un-trim surface, Knit surface, Thickening a Surface, Move Face.		
Unit-V	**Drafting of Automation Systems**	**(04 Hrs.)**
Generating Views, Creating Dimensions, Inserting Annotations and Bill of Materials for Automation system		
Unit-VI	**Sheet Metal Modelling**	**(04 Hrs.)**
Constructing the base flange and miter Flange, addition of an Edge Flange, closing corner, Adding Jog, Unfolding the bends, Adding hem and vent.		

Term Work

Term work shall consist of A-3/A4 size printouts of the problems solved in practical's using Solid Works Software.

1. Sketcher drawings
2. Part modelling
3. Parametric Modelling of Automation system
4. Assembly Modelling of Automation system
5. Exploded view of Assembly
6. Surface Modelling
7. Drafting of Automation Systems
8. Sheet metal modelling

Textbooks:

1. Kuang-Hua Chang, "Motion Simulation and Mechanism Design with SOLIDWORKS Motion 2018", SDC Publishers, 2018

Reference Books:

1. Ibrahim Zeid and R. Siva-Subramaniam – "CAD/CAM- Theory and Practice", Tata McGraw Hill, Publishing Co. 2009.
2. Rao P. N., "CAD/CAM", Tata McGraw Hill.
3. Foley, Van Dam, Feiner and Hughes, "Computer Graphics Principles and Practice", Second edition, Addison–Wesley, 2000.
4. Martenson, E. Micheal, "Geometric Modelling", John Wiley & Sons, 1995.
5. Ronald E. Barr, DavorJuricic, Thomas J. Krueger, "Engineering & Computer Graphics Workbook Using SolidWorks 2014", SDC Publication, 2014.
6. John Willis, Sandeep Dogra, "SOLIDWORKS 2019: A Power Guide for Beginners and Intermediate User", published by CADArtifex, 2019.

End Semester Practical/Oral examination:

1. Practical examination duration is Two hours, based on the Term work.
2. Questions provided for practical examination should contain minimum five and not more than ten parts.
3. Evaluation of practical examination to be done based on the performance of students work in laboratory.

***Oral examination should also be conducted to check the knowledge of conventional and SolidWorks drawing.**

B. Tech. Robotics & Automation
Sem.-VI

ELECTRO HYDRAULICS AND ELECTRO PNEUMATICS

(Course No. C308)

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS:
Theory: 03 Hours/ Week	University Examination Marks: 60 Marks	Theory: 3
Practical: 02 Hours/ Week	Internal Assessment Marks: 40 Marks	
	Term Work Marks: 25 Marks	Practical: 1
	Oral/ Practical Examination Marks:25 Marks	
	Total Credits	4

Course Prerequisites: -	The students should have 1. Knowledge of Instrumentation for Robotics & Automation 2. Knowledge of Basics of Sensors, PLC & HMI, Future Factory (FMS) 3. Knowledge of Automatic Control Systems 4. Hydraulics and Pneumatics: Principles
Course Objectives: -	To provide knowledge about 1. Read and interpret standard graphic symbols for electro-pneumatic and electro-hydraulic circuits and diagrams according to ANSI, DIN and ISO. 2. Identify electro-pneumatic and electro-hydraulic components based on ISO/DIN symbols. 3. Prepare and interpret technical drawings of electro-pneumatic and electro-hydraulic control systems. 4. Read and interpret electro-pneumatic and electro-hydraulic schematic diagrams. 5. Hook-up, simulate and troubleshoot electro-pneumatic and electro-hydraulic control systems. 6. Design electro-pneumatic circuits for certain industrial applications.
Course Outcomes: -	The students should be able to 1. To identify Components of electro pneumatic and electrohydraulic system 2. To apply 3. To Develop IoT based circuit in Fluid power system 4. To Develop electro pneumatic circuit, consist of Logic valves 5. To Design and select Fluid Power system components 6. To Examine Trouble shooting of fluid power system

Course Contents		**No. of Hours**
UNIT I	**Introduction to Electro-Hydraulics and Electro-Pneumatics Systems**	**(06 Hrs.)**
Advantages of electro-hydraulic/electro-pneumatic systems, Fields of application of electro-hydraulic/electro-pneumatic systems, Symbols in electro-hydraulic/electro-pneumatic systems, types of solenoid valves, proximity sensors, Different switches:-Relays, Reed, temperature, pressure, flow, level transmitter, Timers, Counters.		
UNIT II	**Advanced Electrical Controls And Simulations for Fluid Power Systems**	**(06 Hrs.)**
Use of PID Controller and PLC, Proportional Direction Control Valve, Electro-hydraulic Servo System, Components of electro-hydraulic Servo System, PID application in fluid power system, PLC logic for various hydraulic and pneumatic circuits. Development of hydraulic and pneumatic circuits using PLC. Conversion of Pneumatic to Electrical Signals-Pressure dependent control, Case studies on PID control implementation in fluid power systems.		
UNIT III	**Electro-Hydraulic Circuits**	**(06 Hrs.)**

Development of Electro-hydraulic Circuits using PLC: Reciprocating, regenerative, speed control (meter in, meter out and bleed off), sequencing, synchronization, automatic reciprocating, IOT Applications. Simulation and implementation of circuits using software tools, Case studies on electro-hydraulic circuits.

UNIT IV	**Electro-Pneumatic Circuits**	**(06 Hrs.)**

Development of Electro-hydraulic Circuits using PLC: Automatic reciprocating circuit, Speed control circuit, Pneumatic circuit involving Shuttle valve/ Quick exhaust valve / Two pressure valve, IOT Applications. Simulation and implementation of circuits using software tools, Case studies on electro-pneumatic circuits.

UNIT V	**Fluid Power System Design and Analysis**	**(06 Hrs.)**

Calculation of piston velocity, thrust under static and dynamic applications, considering friction, inertia loads, design considerations for cylinders, Design of hydraulic/pneumatic circuits for practical application, selection of different components such as reservoir, control elements, actuators, accumulator, intensifier, filters, pumps. Design of hydraulic circuits for Drilling, Planning, Shaping, Surface grinding, Press and Forklift applications.

UNIT VI	**Maintenance and Troubleshooting of Fluid power systems**	**(06 Hrs.)**

Maintenance need, Common Issues in Fluid Power Systems, maintenance schedule, Trouble Shooting and Remedies in Hydraulic and Pneumatic systems, Maintenance Practices, Safety Considerations, flow resistance, seal failures, Tools and Equipment for Maintenance & Troubleshooting, Future Trends in Fluid Power System Maintenance.

Term Work:

Term work shall consist of a record of minimum of 8 experiments from the following.

1. Integration of Solenoid Valves and Sensors in Electro-Hydraulic/ Electro-Pneumatic Systems using PLC
2. Development of regenerative circuit/ sequencing circuit/ speed control circuit on electro-hydraulic trainer
3. Development of automatic reciprocating circuit/ speed control circuit/ Shuttle valve/ Quick exhaust valve / Two pressure valve on electro-hydraulic trainer.
4. Development of fluid power circuits using proportional directional valve/ servo valve using simulation software
5. Development of pneumatic/hydraulic circuits using timers/counters for industrial applications.
6. Study of IOT Based electro-hydraulic/electro-pneumatic systems
7. Design of electro-hydraulic circuits using simulation software
8. Design of electro-pneumatic circuits using simulation software
9. Troubleshooting and Maintenance of fluid power systems
10. Industrial visits to study Electro-Hydraulic / Electro-Pneumatic based Automation systems.
11. Case Studies on Real-Time Applications of Electro-Hydraulic and Electro-Pneumatic Systems

Project Based Learning:

Students have to prepare and submit demonstration models/charts based on the above syllabus

The following are the list of project-based learning (Not limited to)

1. To prepare a demonstration model/chart based on Components of electro pneumatic and electrohydraulic system
2. To prepare a demonstration model/chart based on Advanced electrical controls for fluid power systems
3. To prepare a Case Studies on Fluid Power System Design and Analysis
4. To prepare a demonstration model/chart based on Electro-Hydraulic Circuits
5. To prepare a demonstration model/chart based on Electro-Pneumatic Circuits
6. To prepare a demonstration model/chart based on Maintenance and Troubleshooting of Fluid power systems and applications

Text Books:

1. John.W.Webb & Ronald A. Reis, "Programmable logic controllers: Principles and Esposito A, Fluid Power with application, Prentice Hall
2. Majumdar S.R, Oil Hydraulic system- Principle and maintenance, Tata McGraw Hill
3. Majumdar S.R, Pneumatics Systems Principles and Maintenance, Tata McGraw Hill
4. Stewart H. L, Hydraulics and Pneumatics, Taraporewala Publication

Reference Books:

1. Pipenger J.J, Industrial Hydraulics, McGraw Hill
2. Pinches, Industrial Fluid Power, Prentice Hall
3. Yeaple, Fluid Power Design Handbook
4. Andrew A. Parr, Hydraulics and Pneumatics, Elsevier Science and Technology Books
5. ISO - 1219, Fluid Systems and components, Graphic Symbols, Standard Manufacturer's Catalogues.

ARTIFICIAL INTELLIGENCE AND DATA SCIENCE
(Course No. 309)

Designation of Course	**Artificial Intelligence and Data Science**		
Teaching Scheme	**Examination Scheme**		**Credits Allotted**
Theory: - 3 hrs/Week	End Semester Examination	60	03
Practical: - 2 Hrs /Week	Internal Assessment	40	
	Term Work	25	01
	Total	125	04

Course Prerequisite:-	1. Engineering mathematics-III, Statistics and Numerical Methods, Sensors Technology
Course Objective:-	To provide Knowledge about 1. To understand the artificial intelligence algorithms to robotics problems. 2. To understand the use of data science 3. To compute complex problems in flexible automation
Course Outcomes:-	On completion of the course, students will be able to 1. Understand the basics of various artificial intelligence techniques. 2. Understand the basics of data analytics using concepts of statistics and probability. 3. Demonstrate awareness and a fundamental understanding of AI techniques in intelligent agents and artificial neural networks 4. Evaluate and interpret descriptive statistics (mean, median, mode, variance, standard deviation). 5. Apply various artificial intelligence techniques for robots. 6. Apply various data cleaning and preprocessing methods.

Course Content

Unit I	**Introduction to artificial intelligence techniques**	**(06 Hrs)**
Evolutionary computation, Goals of AI in manufacturing, tools for AI such as Search algorithm, Mathematical optimization, programming in AI environment, developing artificial intelligence system, natural language processing.		
Unit II	**Introduction to Data Science**	**(06 Hrs)**
Definition of data science, Importance and applications of data science in various industries, Foundations of Data Science, Data types (structured, unstructured, semi-structured), Data sources and data collection methods, Data storage and retrieval techniques.		
Unit III	**Artificial neural networks**	**(06 Hrs)**
Fundamentals of neural networks, neural network architectures, Neural Learning, Supervised Learning, Unsupervised Learning, taxonomy of neural network architectures, standard back propagation algorithms.		
Unit IV	**Statistical Inference**	**(06 Hrs)**
Populations and samples - Statistical modeling, probability distributions, fitting a model, Exploratory Data Analysis and the Data Science Process - Basic tools (plots, graphs and summary statistics) of EDA - Philosophy of EDA - The Data Science Process		
Unit V	**Intelligent systems**	**(06 Hrs)**
Robotic vision systems, image processing techniques, application to object recognition and inspection, automatic speech recognition, Path Planning Robot Control in Dynamic Environments, Accurate Motion Control of Fast Mobile Robots.		

Unit VI	Data Cleaning and Preprocessing	(06 Hrs)
Data cleaning techniques (handling missing values, outliers), Data preprocessing techniques (scaling, normalization, feature engineering)		

List of Practical /Term work: -

Term work shall consist of programs listed below based on syllabus

1. Data mining
2. Prescriptive Analytics.
3. Data visualization.
4. Descriptive Analytics.
5. Searching algorithms.
6. Min/MAX search procedure for game Playing.
7. Variants of Min/ Max search procedure.

Project based learning:-

Following is the list of topic for project based learning (Not Limited to) based on the syllabus contents: Create a demo model/ chart/ Working Block diagram for any application of the following topics using any programing language:

1. Search algorithm
2. Neural Learning
3. Supervised Learning,
4. Unsupervised Learning
5. Robotic vision systems
6. Path Planning Robot Control
7. Genetic algorithms

Text Book

1. Brunton, S. L., & Kutz, J. N. (2022). Data-driven science and engineering: Machine learning, dynamical systems, and control. Cambridge University Press.
2. Dunn, P. F., & Davis, M. P. (2017). Measurement and data analysis for engineering and science. CRC press.

Reference Book:-

1. Luger " Artificial Intelligence", Edition 5, Pearson, 2008
2. Bhattacharya S., Artificial Intelligence, Laxmi Publications, Ltd., 2008, ISBN: 9788131804896
3. Chopra Rajiv, Artificial Intelligence, S. Chand Publishing, 2012, ISBN9788121939485
4. Pawar P. J., Evolutionary Computations for Manufacturing, Studium Press, 2019, ISBN: 978-93- 85046-52-0
5. Jain N, Artificial Intelligence: making a system intelligent, 2018, ISBN: 9788126579945
6. "Practical Statistics for Data Scientists: 50 Essential Concepts" by Peter Bruce and Andrew Bruce

PE-I ENERGY AUDIT AND MANAGEMENT
(Course No. C310.1)

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS:
Theory: 03 Hours/ Week	University Examination Marks: 60 Marks	Theory: 03
Practical: -- Hours/ Week	Internal Assessment Marks: 60 Marks	
	Term Work Marks: -----	Practical: --
	Oral/ Practical Examination Marks: ------	
	Total Credits	03

Course Prerequisites: -	The student should have knowledge of 1. Basic Physics 2. Basic Electrical Engineering 3. Basic Thermal Engineering 4. Mathematics
Course Objectives: -	1. Understand basic energy conversion, conservation, and management principles. 2. Identify sources of energy loss and target savings. 3. Understand design of waste heat recovery systems, efficient power cycle, and power generation systems. 4. To enable students in carrying out life cycle cost analysis and budgeting.
Course Outcomes: -	The students will be able to 1. Analyze about energy scenario nationwide and worldwide 2. To know the procedure for the balance of energy and material in different processes 3. To conduct an economic analysis of energy conservation measures 4. To understand a system of electrical energy management 5. To understand a system of thermal energy management 6. Conduct energy audits and formulate & implement energy conservation strategies.

Course Contents		**No. of Hours**
Unit-I	**Energy Scenario**	**(06 Hrs.)**
Energy needs of a growing economy, Long-term energy scenario, Energy pricing, Energy sector reforms, Energy and Environment: Air pollution, Climate change, Energy Security, Energy conservation and its importance, Energy strategy for the future, Energy conservation Act-2001 and its features.		
Unit-II	**Energy Audit**	**(06 Hrs.)**
Energy Audit: Types and Methodology; Scope of Energy Audit, Energy Audit Reporting Format; Understanding Energy Costs; Benchmarking and Energy Performance; Matching Energy Usage to Requirement; Maximizing System Efficiency Fuel and Energy Substitution; Energy Audit Instruments; Duties and responsibilities of energy auditors. Energy Management of Building and Energy audit of Building- Energy management matrix monitoring and targeting Case Studies		
Unit-III	**Economic Analysis of Energy Conservation Measures**	**(06 Hrs.)**
Economics: Fundamentals: Cash flows, Inflation Rates, Time Points and Periods, Discount Rates, Cost of Capital, Present value, Taxes, Uncertainty and Risk Economic Measures: Net Present Value, Total Life-Cycle Cost, Revenue Requirements, Internal Rate of Return, Modified Internal Rate of Return, Simple Payback Period, Discounted Payback Period, Benefit-to-Cost Ratios, Savings-to Investment Ratios, Profitability index estimation		

Unit-IV	**Electrical energy management**	**(-- Hrs.)**

Electricity tariff, Load management and maximum demand control, Power factor improvement, Distribution, and transformer losses. Losses in induction motors, Motor efficiency, Factors affecting motor performance, Rewinding and motor replacement issues, energy efficient motors, Light source, Choice of lighting, Luminance requirements, and Energy conservation avenues. Case Studies

Unit-V	**Thermal energy management**	**(-- Hrs.)**

Energy conservation in boilers, steam turbines and industrial heating systems; Application of FBC; Cogeneration and waste heat recovery; Thermal insulation; Heat exchangers and heat pumps; Building Energy Management. Case Studies on Thermal Energy Management. Case Studies.

Unit-VI	**Material and Energy Balance**	**(-- Hrs.)**

Basic Principles, Sankey diagrams, Material balances for different processes, Energy balances, heat balances, Methods for preparing process flow chart, Procedures to carry out the material and energy balance in different processes.

Project-Based Learning:

1. Conduct preliminary energy audit and prepare report on electrical plant.
2. Conduct preliminary energy audit and prepare report on thermal plant.
3. Prepare energy audit report on small scale industry with payback period.
4. Conduct energy audit on residential house/own house with payback period.
5. Prepare economical audit sheet of any small scale industry.
6. Prepare social instructions charts for energy saving tricks.
7. Write one research paper on audit carried out in small scale industry.
8. Prepare standard energy efficient model for residential house.

Textbooks:

1. Electric Energy Utilization and Conservation by S C Tripathy, Tata McGraw hill publishing company Ltd. New Delhi.
2. Energy management by Paul o' Callaghan, Mc–Graw Hill Book company–1st edition, 1998.
3. Energy management handbook by W. C. Turner, John Wiley, and sons.
4. Energy management and conservation –k v Sharma and Venkata shariah-I K International Publishing House Pvt ltd, 2011.

Reference Books:

1. Barney L. Capehart, Wayne C. Turner and William J. Kennedy, "Guide to Energy Management", Seventh Edition, The Fairmont Press Inc., 2012.
2. Albert Thomann, "Handbook of Energy Audits", Sixth Edition, The Fairmount Press, 2003.
3. G. G. Rajang, "Optimizing Energy Efficiencies in Industry", Tata McGraw Hill, 2001
4. Wayne C. Turner, "Energy Management Hand Book", The Fairmount Press, Inc., 2001.
5. Charles M. Gottschalk, "Industrial Energy Conservation", John Wiley and Sons, 1996.
6. Craig B. Smith, "Energy Management Principles", Pergamon Press, 2015.
7. IEEE Recommended "Practice for Energy Management in Industrial and Commercial Facilities", IEEE std 739 – 1995. (Bronze book).
8. Hamis, "Energy Auditing and Conservation; Methods, Measurements, Management and Case Study", Hemisphere Publishers, Washington, 1980.
9. C.W. Gelling's and J.H. Chamberlin, "Demand-Side Management Planning", Fairmount Press, 1993.
10. Wayne C Turner, "Energy Management Handbook", The Fairmount Press, 2006.
11. Bureau of Energy Efficiency Study material for Energy Managers and Auditors Examination: Paper I to IV.

PE-II: ADDITIVE MANUFACTURING & RAPID PROTOTYPING
(Course No. C310.2)

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS:
Theory: 03 Hours/ Week	University Examination Marks: 60 marks	Theory: 03
Practical: -- Hours/ Week	Internal Assessment Marks: 40 Marks	
	Term Work Marks: -----	Practical: --
	Oral/ Practical Examination Marks: ------	
	Total Credits	03

Course Prerequisites: -	The students should have knowledge of 1. Solid Modelling, Auto CAD 2. Manufacturing Technology I & II 3. Design & Analysis of Machine Component
Course Objectives: -	1. To understand the fundamental concepts of Additive Manufacturing (i.e., Rapid Prototyping) and 3-D printing, its advantages, and limitations. 2. To classify various types of Additive Manufacturing Processes and know their working principle, advantages, limitations etc. 3. To have a holistic view of various applications of these technologies in relevant fields such as mechanical, Bio-medical, Aerospace, Electronics etc
Course Outcomes: -	The students will be able to 1. Understand the importance of additive manufacturing process and AM process chain 2. Understand and apply Liquid-based and Solid Based additive manufacturing processes. 3. Understand and apply powder based additive manufacturing processes. 4. Understand and apply various Metal Additive Manufacturing process for different products 5. Apply various AM data formatting and data processing techniques for different products 6. Select suitable material for AM process and explore different applications of AM parts from various fields like Automobile, Aerospace, Bio-medical etc.

Course Contents		**No. of Hours**
Unit-I	**Introduction to Rapid Prototyping**	**(06 Hrs.)**
Introduction: Prototyping fundamentals, Historical development, Fundamentals of Rapid Prototyping, Advantages and Limitations of Rapid Prototyping, Commonly used Terms, Classification of RP process, AM process chain: Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, Machine setup, build , removal and clean up, post processing.		
Unit-II	**Liquid-based and Solid Based Rapid Prototyping**	**(06 Hrs.)**

Liquid-based Rapid Prototyping Systems: Stereo lithography Apparatus (SLA), Solid ground curing (SGC). Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies.

Solid-based Rapid Prototyping Systems: Laminated Object Manufacturing (LOM), Fused Deposition Modeling (FDM), Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies.

Unit-III	**Powder Based Rapid Prototyping**	**(06 Hrs.)**

Powder Bed Fusion AM Processes: Selective laser Sintering (SLS), Materials, Indirect and direct SLS, Powder fusion mechanism and powder handling, Process Modelling, SLS Metal and ceramic part creation, post processing, post curing, surface deviation and accuracy, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes, Post processing of AM parts

Laser Engineered Net Shaping (LENS): Processes, materials, products, advantages, limitations, and applications– Case Studies.

Unit-IV	**Design for Additive Manufacturing**	**(06 Hrs.)**

Design tools for AM, Part Orientation, Removal of Supports, Hollowing out parts, Inclusion of Undercuts and Other Manufacturing Constraining Features, Interlocking Features, Reduction of Part Count in an Assembly, Identification of markings/ numbers etc.

Guidelines for process selection: Introduction, selection methods for a part, challenges of selection, example system for preliminary selection, production planning and control

Unit-V	**AM Data Formatting and Data Processing**	**(06 Hrs.)**

Rapid Prototyping Data Formats: STL Format, STL File Problems, Consequence of Building Valid and Invalid Tessellated Models, STL file Repairs: Generic Solution, Other Translators, Newly Proposed Formats. Rapid Prototyping Software's: Features of various RP software's like Magics, Mimics, Solid View, View Expert, 3 D View, Velocity 2, Rhino, STL View 3 Data Expert and 3 D doctor.

AM Data Processing: Part Orientation and Support Structure Generation, Model Slicing and Contour Data Organization, Direct and Adaptive Slicing, Hatching Strategies and Tool Path Generation.

Unit-VI	**AM Materials and Applications**	**(06 Hrs.)**

3D Printing Materials: properties, characteristics, and application of all types (ABS, PLA, PVA, HDPE, PET, PETG etc.) Types of Composites Materials, properties, characteristics, and application of all types. (N6, N12, ABS Carbon Fiber, etc.)

RP Applications: Material Relationship, Application in Design, Application in Engineering, Analysis and Planning, Aerospace Industry, Automotive Industry, Jewelry Industry, Coin Industry, GIS application, Arts and Architecture.

RP Medical and Bioengineering Applications: Planning and simulation of complex surgery, Customized Implants & Prosthesis, Design and Production of Medical Devices, Forensic Science and Anthropology, Visualization of Biomolecules.

Project-Based Learning:

Students have to prepare and submit a demonstration models based on above syllabus (Not limited to)

1. To prepare a demonstration model/chart of AM Processes chain
2. To prepare a demonstration model of liquid-based AM technologies
3. To prepare a demonstration model of solid based AM technologies
4. To prepare a demonstration model of powder-based AM technologies
5. To prepare a 3D printed model for various applications (Bio-medical, aerospace etc.)
6. To prepare a document on data formatting and data process by selecting one application

Textbooks:

1. Ali K. Kamrani, Emand Abouel Nasr, "Rapid Prototyping: Theory and Practice", Springer, 2006.
2. Anupam Saxena, Birendra Sahay, "Computer Aided Engineering Design", Springer, 2005.
3. Patri K. Venuvinod and Weiyin Ma, "Rapid Prototyping: Laser-based and Other Technologies", Springer, 2004.
4. Chua Chee Kai, Leong Kah Fai, "3D Printing and Additive Manufacturing: Principles & Applications", 4th Edition, World Scientific, 2015.
5. Rafiq Noorani, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 2006.
6. Khanna Editorial, "3D Printing and Design", Khanna Publishing House, Delhi.

Reference Books:

1. Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles and Applications", World scientific, 2003.
2. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010
3. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001.
4. David F. Rogers, J. A. Adams, "Mathematical Elements for Computer Graphics", TMH, 2008.
5. Kevin N. Otto, Kristin L. Wood, "Product Design", Pearson Education, 2004.

PROGRAM ELECTIVE -I COMPUTER VISION AND IMAGE PROCESSING
(Course No. C310.3)

Designation of Course	**Program Elective I- Computer Vision and Image Processing**		
Teaching Scheme	**Examination Scheme**		**Credits allotted**
Theory:-3hrs/Week	End Semester Examination	60	03
Practical:-0 Hrs/Week	Internal Assessment	40	
	Total	100	03

Course Prerequisite: -	Basics knowledge of: 1. Linear algebra, Calculus, Probability and statistics. 2. Signal Processing 3. Python, C++, Matlab
Course Objective: -	To provide the knowledge of 1. techniques in the digital image processing for image enhancement 2. restoration of noisy image processing for image enhancement 3. segmentation and various machine learning techniques
Course Outcomes: -	Students should be able to 1. Understand fundamentals of image processing and computer vision. 2. Understand and apply concepts of Image formation and Image Enhancement. 3. Understand and apply image segmentation and feature extraction methods. 4. Acquire knowledge about various Object Detection, Object Recognition, Motion estimation techniques and their applications. 5. Ability to apply various Image processing and Computer vision algorithms to solve real time problems.

Course Content

Unit I	**Introduction**	**(06 Hrs)**
Digital Image fundamentals, Image Sensing and acquisition, Sampling and Quantization, Image formation models, Overview of Computer Vision, Applications of Image processing and Computer Vision.		
Unit II	**Image Enhancement**	**(06 Hrs)**
Image enhancement in spatial domain, Basic grey level Transformations, Histogram Processing Techniques, Spatial Filtering, Image smoothing and Image Sharpening, Image enhancement process in frequency domain, Low pass filtering, High pass filtering		
Unit III	**Image Segmentation**	**(06 Hrs)**
Point, line and edge detection, Thresholding, Regions Based segmentation, Edge linking and boundary detection.		
Unit IV	**Feature Extraction**	**(06 Hrs)**
Importance of Features, Feature extraction techniques, Histogram of Oriented Gradient (HOG), Scale Invariant Feature Transform (SIFT), Background subtraction techniques, Image Matching, Principal Component Analysis (PCA).		
UnitV	**Object Recognition and Motion Estimation**	**(06 Hrs)**
Object Recognition techniques: Viola-Jones, Yolo algorithms, Deep learning algorithms for Object Recognition. Optical Flow, Gaussian Mixture Model (GMM), Structure of Motion, Motion Estimation.		
UnitVI	**Applications of Image Processing and Computer vision**	**(06 Hrs)**
Face Recognition, Facial Expression Recognition, Optical Character Recognition, Automated Video Surveillance.		

Project Based Learning

Following is the list of topics for project-based learning (Not Limited to) based on the syllabus contents:

1. Implement various grey level transformations for Image Enhancement.
2. Implement Histogram Equalization technique.
3. Write a Program to apply convolution processes on an input image for image smoothing.
4. Implement Histogram of Oriented Gradient (HOG) for Feature extraction.
5. Write a Program to apply Scale Invariant Feature Transform on input image.
6. Implement frame differencing technique for background subtraction from video.
7. Implement Principal Component Analysis for the computation of Eigenvector to reduce the dimensionality.
8. Implement object detection algorithm YOLO.
9. Implement R-CNN algorithms for object detection.
10. Implement motion estimation using optical flow technique.
11. Implement Object recognition.
12. Implement Facial Expression Recognition.

Text Book

1. Digital Image Processing- Refael C. Gonzalez and Richard E. Woods, Wesley
2. Computer Vision, D. H. Ballard, C. M. Brown, Prentice-Hall, Englewood Cliffs, 1982.

Reference Books

1. Computer Vision - A modern approach, by D. Forsyth and J. Ponce, Prentice Hall Robot Vision, by B. K. P. Horn, McGraw-Hill.
2. Introductory Techniques for 3D Computer Vision, by E. Trucco and A. Verri, Publisher: Prentice Hall.

Elective I:PE-I: Robotic System Modelling and Simulations

(Course No. C310.4)

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS:
Theory: 03 Hours/ Week	University Examination Marks: 60 marks	Theory: 03
Practical ------Hours/ Week	Internal Assessment Marks: 40 marks	
	Term Work Marks: -----	Practical: --
	Oral/ Practical Examination Marks: ------	
	Total Credits	03

Course Prerequisites: -	1. Engineering mathematics, Differential Equation, Transfer Function 2. Modelling and design of Mechanism, Mechanical system
Course Objectives: -	To provide Knowledge about 1. Different types of Modelling strategies 2. Optimization and design of system techniques 3. Different types of simulation software
Course Outcomes: -	The students will be able to 1. To Define Different type of Modelling strategies 2. To Develop Mathematical Model by using different modelling technique 3. To Understand Fuzzy system components and its logic. 4. To Design and optimize the system 5. To Design Fuzzy Model 6. To Simulate Model by different simulation software

Course Contents		**No. of Hours**
Unit-I	**Introduction to Modelling strategy**	**(06 Hrs.)**

System, environment, input and output variables, State variables; Static and Dynamic systems; Hierarchy of knowledge about a system and Modeling Strategy. Introduction of Physical Modeling: Dimensions analysis, Dimensionless grouping of input and output variables of find empirical relations, similarity criteria and their application to physical models, Simplification techniques of physical models.

Unit-II	**Modelling of System with Known Structure**	**(06 Hrs.)**

Deterministic model-(a) distributed parameter models in terms of partial identification and their solutions and (b) lumped parameter models in terms of differential and difference equations, state space model, transfer functions block diagram and sub systems, stability of transfer functions, modelling for control.

Unit-III	**Modeling Based on Expert Knowledge**	**(06 Hrs.)**

Fuzzy sets, Membership functions, Fuzzy Inference systems, Expert Knowledge, and Fuzzy Models, Design of Fuzzy Controllers. Testing of Fuzzy controller.

Unit-IV	**System Simulation**	**(06 Hrs.)**

Basics of simulation, Steps in simulation, Discrete event system simulation, Advantages and disadvantages of simulation, Decision making with simulation. Techniques of simulation, Monte Carlo method, Experimental nature of simulation, Distributed lag models, Cobweb models Continuous system models, Analog and Hybrid simulation, Feedback systems, Computers in simulation studies.

Unit-V	**Introduction to Simulation Software**	**(06 Hrs.)**

Comparison of simulation packages with programming languages, classification of simulation software, Description of a general-purpose simulation package, Design of scenario and modules, dialog box, database, animation, plots and output, interfacing with other software, summary of results. Examples with MATLAB Simulink/ AWESIM / ARENA/LAB VIEW/SIEMENS NX MCD/ Robo DK, Gazebo , Automation Studio ,ROBO Analyzer.

Unit-VI	**Optimizations and Design of Systems**	**(06 Hrs.)**

Summary of gradient-based techniques: Nontraditional Optimizations techniques genetic Algorithm (GA)- coding, GA operations elitism, Modified GA, Application using MATLAB: Simulated Annealing.

Project Based Learning: -

1. Simulate Cartesian Configuration type of Robot for any application
2. Simulate Cylindrical Configuration type of Robot for any application
3. Simulate Spherical Configuration type of Robot for any application
4. Simulate SCARA Configuration type of Robot for any application
5. Build and Simulate Kinematic joints in 2 link manipulators
6. Build and Simulate Kinematic joints in 3 link manipulators
7. Simulation of Robot Manipulator for Assembly operation in Smart Factory “
8. Industrial Visit to any automation industry using Robot Simulation Software

Textbooks:

1. Shannon, R. E., “System Simulation: the Art and Science”, Prentice Hall Inc. 1990
2. Pratap. Rudra " Getting started with MATLAB" Oxford university Press 2009
3. New Books in MATLab

Reference Books:

1. Zeigler B.P. Praehofer. H. and Kim I.G. "Theory of modeling and simulation", 2 nd Edition. Academic press, 2000
2. Ogata K , “Modern control Engineering" 3 rd edition. Prentice hall of India 2001
3. Jang J.S.R. sun C.T and Mizutani E,, "Neuro-Fuzzy and soft Computing ", 3 rd edition, Prentice hall of India, 2002.

Program Elective-I: Engineering Economics

(Course No. 310.5)

Designation of Course	**Engineering Economics (Elective-I)**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory:-03 Hours/Week	End Semester Examination	60 Marks	03
Tutorial:---Hours/Week	Internal Assessment	40 Marks	
Practical:---Hours/Week	Term Work	-- Marks	00
	Oral/Practical	-- Marks	
	Total	**100 Marks**	**03**

Course Prerequisites:-	The students should know Basics of Mathematics
Course Objectives:-	Students will be able to understand the economics behind running a successful engineering project
Course Outcomes:-	Student should be able to 1. Understand the basic concepts of economics and apply them for selection and planning 2. Understand time value of money and calculate the value of money at any given time in a project 3. Understand Basic Methodologies of Engineering Economic Analysis and use them to for selection of project 4. Use various methods to compare two different projects to check their viability 5. Use replacement analysis for panning and changing of resources in a project 6. Plan for Depreciation and Corporate Income Taxes

Course Contents

Unit 1	**Introduction to Economics**	**(06 Hrs.)**

Introduction to Economics-Flow in an economy, Law of supply and demand, Concept of Engineering Economics – Engineering efficiency, Economic efficiency, Scope of engineering economics –Element of costs, Marginal cost, Marginal Revenue, Sunk cost, Opportunity cost, Break-even analysis–V ratio, Elementary economic Analysis–Materials election for product Design selection for a product, Process planning.

Unit 2	**Interest and Time Value of Money**	**(06 Hrs.)**

Introduction to Time Value of Money; Simple Interest; Compound Interest; Nominal Interest rate;EffectiveInterestrate;ContinuousCompounding;EconomicEquivalence;DevelopmentofInterest Formulas; The Five Types of Cash flows; Single Cash flow Formulas; Uneven Payment Series;EqualPaymentSeries;LinearGradientSeries;GeometricGradientSeries.

Unit 3	**Basic Methodologies of Engineering Economic Analysis**	**(06 Hrs.)**

Minimum Attractive (Acceptable) Rate of Return (MARR); Payback Period Method; Equivalent Worth Methods: Present Worth Method, Future Worth Method, Annual Worth Method; Rate of Return Methods: Internal Rate of Return Method; External/Modified Rate of Return Method; Public Sector Economic Analysis (Benefit Cost Ratio Method); Introduction to Lifecycle Costing; Introduction to Financial and Economic Analysis

Unit 4	**Comparative Analysis of Alternatives**	**(06 Hrs.)**

Comparing Mutually Exclusive Alternatives having Same useful life by
1. Payback Period Method and Equivalent Worth Method
2. Rate of Return Methods and Benefit Cost Ratio Method

Comparing Mutually Exclusive Alternatives having different useful lives by
1.Repeatability Assumption 2.Co-terminated Assumption 3.Capitalized Worth Method
Comparing Mutually Exclusive, Contingent and Independent Projects in Combination.

Unit 5	**Replacement Analysis**	**(06 Hrs.)**

Fundamentals of Replacement Analysis: Basic Concepts and Terminology; Approaches for Comparing Defender and Challenger; Economic Service Life of Challenger and Defender Replacement Analysis When Required Service Life is Long: Required Assumptions and Decision Framework; Replacement Analysis under the Infinite Planning Horizon; Replacement Analysis under the Finite Planning Horizon

Unit6	**Depreciation and Corporate Income Taxes**	**(06 Hrs.)**

Concept and Terminology of Depreciation; Basic Methods of Depreciation: Straight line method, Declining Balance Method, Sinking Fund Method, Sum of the Year Digit Method, Modified Accelerated Cost Recovery System (MACRS); Introduction to Corporate Income Tax; After Tax Cash-flow Estimate; General Procedure for Making After Tax Economic Analysis.

Project Based Learning

1. Case study on break even analysis of a company
2. Case study on Calculation of time value of money
3. Case study on feasibility of a project by economic analysis
4. Case study on Comparing Mutually Exclusive Alternatives having Same useful life by Payback Period Method and Equivalent Worth Method
5. Case study on Comparing Mutually Exclusive Alternatives having Same useful life by Payback Rate of Return Methods and Benefit Cost Ratio Method
6. Case study on Comparing Mutually Exclusive Alternatives having different useful lives
7. Case study on Replacement analysis of a machine
8. Case study on Calculation of depreciation of a machine
9. Case study on Calculation of corporate taxes.

Textbooks

1. R. Paneerselvem, Engineering Economics, Prentice Hall India.
2. M. P. Groover, "Automation, Production Systems & Computer Integrated Manufacturing", PHI, 3rd Edition, 2012.

Reference Books

1. Chan S. Park, Contemporary Engineering Economics, Prentice Hall, Inc.
2. E. Paul DeGarmo, William G. Sullivan and James A. Bontadelli, Engineering Economy,

MC-Milan Publishing Company.
3. James L. Riggs, David D. Bedworth and Sabah U. Randhawa, Engineering Economics, Tata MC-Graw Hill Education Private Limited.

FIELD & SERVICE ROBOTS
(Course Code: C311)

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS:
Theory: 03 Hours/ Week	University Examination Marks: 60 Marks	Theory: 3
Practical: 02 Hours/ Week	Internal Assessment Marks: 40 Marks	
	Term Work Marks: 25 Marks	Practical: 2
	Oral Examination Marks: 25 Marks	
	Total Credits	05

Course Prerequisites: -	The students should have knowledge of 1. Sensor technology 2. Artificial Intelligence for robotics 3. Robot programming
Course Objectives: -	To impart knowledge on 1. The applications and current trend in field and service robot (FSR) 2. Path planning algorithms inside a field/service robot for navigation 3. Interaction interface concepts for humanoid robot
Course Outcomes: -	The students should be able to 1. Describe the applications and current trend in field and robot service. 2. Explain about the kinematic modeling of mobile robots. 3. Identify, formulate, and solve algorithm related to localization, obstacle avoidance, and mapping. 4. Apply and program robot for reactive concepts for robot interaction with human, between machines and among robots. 5. Analyze the concepts of balancing legged robots and interaction interface concepts for humanoid robot. 6. Implement path planning algorithms inside a field/service robot for navigation.

Course Contents		**No. of Hours**
Unit-I	**Introduction**	**(06 Hrs.)**
History of service robotics, Present status and future trends, Need for service robots, applications examples and Specifications of service and field Robots. Non-conventional Industrial robots.		
Unit-II	**Localization**	**(06 Hrs.)**
Introduction-Challenges of Localization, Map Representation, Probabilistic Map based Localization, Monte Carlo localization, Landmark based navigation, Globally unique localization, Positioning beacon systems, Route based localization.		
Unit-III	**Planning and Navigation**	**(06 Hrs.)**
Introduction-Path planning overview, Road map path planning, Cell decomposition path planning, Potential field path planning, Obstacle avoidance, Case studies: Tiered robot architectures.		
Unit-IV	**Field Robots**	**(06 Hrs.)**
Ariel robots, Collision avoidance, Robots for agriculture, mining, exploration, underwater, Civilian and military applications, nuclear applications, Space applications.		
Unit-V	**Humanoids**	**(06 Hrs.)**
Wheeled and legged, Legged locomotion and balance, Arm movement, Gaze and auditory orientation control, Facial expression, Hands and manipulation, Sound and speech generation, Motion capture/Learning from demonstration.		
Unit-VI	**Human Recognition and Application of FSR**	**(06 Hrs.)**

Image Human activity recognition using vision, touch, sound, Vision, Tactile Sensing, Models of emotion and motivation. Performance, Interaction, Safety and robustness, Applications - Case studies.

Project-Based Learning:

1. Need for service robot.
2. Experiment on robot kinematics.
3. Probabilistic Map based Localization-Monte carlo localization
4. Global & Local path planning in robotics.
5. Assignment on Metrical maps - Grid maps - Sector maps – Hybrid Maps.
6. Case study on Human activity recognition using vision, touch, sound etc.
7. Use of PUDU Bot mobile robot for office work

Textbooks:

1. Kelly, Alonzo; Iagnemma, Karl; Howard, Andrew, "Field and Service Robotics ", Springer, 2011.
2. Sebastian Thrun, Wolfram Burgard, Dieter Fox, "Probabilistic Robotics", MIT Press, 2005.
3. Karsten Berns, Ewald Von Puttkamer, "Autonomous L and Vehicles Steps towards Service Robots", Vieweg Teubner Springer, 2009.
4. Bruno Siciliano, Oussama Khatib, Springer Hand book of Robotics, Springer, 2008.

Reference Books:

1. 1. Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, „Introduction to Autonomous Mobile Robots‖, Bradford Company Scituate, USA, 2004
2. Riadh Siaer, „The future of Humanoid Robots- Research and applications", Intech Publications, 2012.
3. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India P Ltd., 2006.
4. Howie Choset, Kevin Lynch Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, "Principles of Robot Motion-Theory, Algorithms, and Implementation", MIT Press, Cambridge, 2005.

MEDICAL MECHATRONICS

(Course Code: C312)

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS:
Theory: 03 Hours/ Week	University Examination Marks: 60 marks	Theory: 03
Practical --------Hours/ Week	Internal Assessment Marks: 40 marks	
	Term Work Marks: -----	Practical: -----
	Oral/ Practical Examination Marks: ------	
	Total Credits	**03**

Course Prerequisites: -	Basic of Engineering Science, Electronic circuits
Course Objectives: -	To Provide knowledge about 1. Sources of Bioelectric potential, Electrodes and Transducers 2. Biopotential Amplifiers and Recorders 3. Measurement and analysis techniques 4. Therapeutic and Prosthetic Equipment 5. Fundamentals of medical imaging 6. Medical Robots and its Application
Course Outcomes: -	The students will be able to 1. Select proper electrodes and electrolyte for different measurement of parameters. 2. Explain the principle and working of any biomedical equipment. 3. Identify different types of biomedical unit for measurement and analysis techniques. 4. Design suitable orthotic and prosthetic devices and applications 5. Explain the working of different imaging techniques in Biomedical Engineering 6. Demonstrate the significance of safety, telemetry, and hospital information system in biomedical Instrumentation.

Course Contents		**No. of Hours**
Unit-I	**Sources of Bioelectric Potential, Electrodes and Transducers**	**(06 Hrs.)**
Generation of electrical signals in human cell, Resting and Action potential Different types of Electrodes, Electrolytes and their significance, Biosensors, Biomaterials		
Unit-II	**Bio-potential Amplifiers and recorders**	**(06 Hrs.)**
The origin of bio-potential ECG, EMG, EEG etc. The signal conditioners and amplifiers. Recording systems for the bio-potential listed above and patient monitoring system		
Unit-III	**Measurement and analysis techniques**	**(06 Hrs.)**
Blood flow meters, Cardiac output measurement, and Pulmonary Function Testing machine. Blood gas analysers, Oximeters, Audiometers, Blood Pressure measurement		

Unit-IV	Therapeutic and Prosthetic Equipment	(06 Hrs.)

Cardiac Pacemakers, Cardiac defibrillators, Hemodialysis machine, Electrosurgical unit, Ventilators, Infant incubator, drug delivery devices. Orthotic and Prosthetic devices, Normal Human Locomotion, Gait Cycle, Upper and Lower limb Prosthetic devices. Upper and Lower limb Orthotic devices.

Unit-V	Fundamentals of medical imaging	(06 Hrs.)

Clinical use & Biological effects and safety: X-ray computed Tomography, Spiral or Helical C T: Slip Ring Technology, C T Angiography, Magnetic resonance imaging, Nuclear medical imaging, Infrared imaging, Liquid crystal thermography. Microwave Hermography. Study of Endoscopy, gastroscope, bronchoscope, cystoscope, colonoscope

Unit-VI	Medical Robots and its Application	(06 Hrs.)

Classification of medical robots, Robots for surgical navigation , Movement replication, Robotic Surgery , Robots for imaging Rehabilitation and prosthetics, Robot Assisted laparoscopic surgery – Haptic feedback in robotic heart surgery – Robotic applications in neurosurgery
– Miniature robotic guidance for spine surgery. Robotic arm application in dental -root canal, dental surgery. Application of AI/ML in medical field

Project Based Learning

1. Study and prepare chart of Electromyography (EMG)
2. Study and prepare chart of Electrocardiogram (ECG)
3. Study and prepare chart of Electroencephalogram (EEG)
4. Demonstration of Pulmonary Function Testing machine.
5. Study and prepare chart of Endoscopy
6. Study and prepare chart of Gastroscope,
7. Study and prepare chart of cystoscope,
8. Study and prepare chart of colonoscope
9. Study and prepare chart of Blood flowmeters

Textbooks:

1. Khandpur R. S., Handbook of Biomedical Instrumentation, Tata McGraw Hill, second edition, 2003
2. Carr and Brown, Introduction to biomedical equipment technology, fourth edition, Pearson press, 2003
3. Sujata V. Bhat, Biomaterials, Narosa Publishing House, 2002.
4. W. R. Hendee & E. R. Ritenour, Medical Imaging Physics (3rd eds), Mosbey Year Book, Inc., 1992.
5. Lesslie Cromwell, Fred J. Weibell, rich J. Pfeiffer Biomedical Instrumentation and Measurements, 2nd Edition, PHI
Robotics Surgery Book (Springer

Reference Books:

1. John G. Webster, Bioinstrumentation John Wiley and sons, 2004
2. Joseph Bronzino (Editor-in-Chief), Handbook of Biomedical Engineering, CRC Press, 1995.
3. L. A. Geddes and L. E. Baker, Principles of Applied Bio-Medical Instrumentation. John Wiley & Sons 1975.
4. Harold E. Smalley, .Hospital Management Engineering A guide to the improvement of hospital management system. PHI.
5. Dr. Archana B. Kanwade, Dr. Vinayak Bairagi, Chronic Obstructive Pulmonary Disease (COPD) Diagnosis using Electromyography (EMG), Elsevier, Academic Press, 1st Edition - 2022.

PROFESSIONAL SKILLS (Course No. C-313)		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS:**
Practical: - 2 Hours/ Week	Semester End Examination: Term work: 25 Marks	Credits:1

Course Pre-requisites: The students should know	
1	Basic mathematical concepts, reasoning skills, and comprehension abilities.
2	Fundamentals of communication processes and soft skills.
3	Basic understanding of leadership qualities, ethics, etiquettes, and values.
Course Objective:	
	This course is structured to provide students with a well-rounded foundation in quantitative aptitude, logical and verbal reasoning, professional communication, employment skills, leadership development, and business ethics. By integrating these components, students will be better equipped to excel in recruitment processes and succeed in their professional careers.
Course Outcomes: The student will be able to	
1	Apply shortcut techniques to solve quantitative aptitude questions efficiently in recruitment and competitive exams.
2	Utilize logical reasoning methods and mnemonics to enhance problem-solving skills in placement tests.
3	Improve verbal communication skills, including vocabulary, sentence patterns, and reading comprehension, for effective professional interactions.
4	Develop proficiency in job application writing, resume building, and interview skills to enhance employability..
5	Understand and apply soft skills, leadership qualities, and professional ethics in the workplace.
6	Demonstrate appropriate corporate etiquette, business ethics, and values in professional settings.

Course Content:		
Unit-I	• **QUANTITATIVE APTITUDE**: • Number System, Percentage, Profit and Loss, Simple & Compound Interest • Ratio, Proportion, and Average • Mixture and Allegation • Time, Speed & Distance, Time & Work • Permutation & Combination, Probability • Pipes and Cisterns	**(4 Hrs)**
Unit-II	**LOGICAL REASONING:** • Coding-Decoding, Number Series, Blood Relation, Directions • Cubes & Dices, Data Interpretation, Data Sufficiency • Set Theory & Syllogisms, Matching, Selection & Arrangement • Clocks & Calendars, Visual Reasoning • Input-Output & Flow Charts	**(4 Hrs)**
Unit-III	**VERBAL REASONING:** • Sentence Patterns, Sentence Correction, Spotting Errors • Vocabulary, Antonyms & Synonyms, Analogy • Phrasal Verbs, Idiomatic Expressions • Reading Comprehension, Cloze Test • Sentence Rearrangement and Theme Detection	**(4 Hrs)**

Unit-IV	**HONING EMPLOYBILITY AND PRESENTATION SKILLS:** • Job Application Letters: Layout, Structure, Covering Letter • Resume & CV Building: Structure, Effective Writing Tips • Group Discussion: Skills, Strategies, and Evaluation • Interview Skills: Telephonic & Face-to-Face Interviews • Body Language, Grooming & Etiquette for GD & PI • Extempore Speaking Techniques • Presentation Skills: Structure, Layout, Flow, and PPT Creation	**(4 Hrs)**
Unit-V	**SOFT SKILLS AND LEADERSHIP DEVELOPMENT:** • Soft Skills: Definition, Importance, and Differences from Hard Skills • Life Skills & Personal Development • Team Building & Conflict Resolution • Problem-Solving, Time & Stress Management • Pareto Principle (80/20 Rule), Time Management Matrix • Leadership Skills: Importance, Types, Attributes of a Good Leader • Motivational Theories and Emotional Intelligence in Professional Life	**(4 Hrs)**
Unit-VI	**BUSINESS ETHICS, ETIQUETTES AND VALUES:** • Ethics & Values in the Business World • Respect for Individuality and Workplace Diversity • Key Features of Corporate Etiquette • Corporate Grooming & Dressing • Social & Office Etiquette • Importance of Professional Behavior in the Workplace • Corporate Social Responsibility (CSR): Need and Importance.	**(4 Hrs)**
Reference Books:		

1	Quantitative Aptitude by R. S. Agarwal published by S. Chand
2	The Book of Numbers by Shakuntala Devi
3	A Modern Approach To Logical Reasoning by R. S. Agarwal published by S. Chand
4	A New Approach to Reasoning Verbal & Non-Verbal by Indu Sijwali
5	Business Communication by Meenakshi Raman, Prakash Singh published by Oxford University press, second edition
6	Communication Skills by Sanjay Kumar, Pushp Lata, published by Oxford University press, second edition
7	Technical Communication by Meenakshi Raman, Sangeeta Sharma published by Oxford University press
8	Developing Communication Skills by Krishna Mohan, Meera Banerji published by Macmillan India Pvt Ltd
9	Soft Skills by Meenkashi Raman, published by Cengage publishers
10	Soft Skills by Dr. K Alex published by Oxford University press
11	Soft skills for Managers by Dr. T. Kalyana Chakravarthi and Dr. T. Latha Chakravarthi published by biztantra

Term Work

Unit I: Quantitative Aptitude

1. Solve 20 practice problems on Number System, Percentage, and Profit & Loss.
2. Create a comparative analysis of Simple Interest vs. Compound Interest with real-world examples.

Unit II: Logical Reasoning

1. Solve a set of logical reasoning problems covering Coding-Decoding, Blood Relations, and

Directions.

2. Prepare a case study on how logical reasoning skills are used in competitive exams and corporate assessments.Unit III: Verbal Reasoning
    1. Identify and correct errors in 10 sentences focusing on sentence structure and grammatical mistakes.
    2. Develop a vocabulary list with antonyms, synonyms, and phrasal verbs commonly used in professional settings.

Unit IV: Honing Employability and Presentation Skills

1. Draft a job application letter along with a structured resume tailored for a technical position.
2. Participate in a mock group discussion and receive peer and instructor feedback.
3. Conduct a mock interview (telephonic & face-to-face) and submit an evaluation report

Unit V: Soft Skills and Leadership Development (Term Work Assignments)

1. Conduct a self-assessment on personal soft skills and identify areas for improvement.
2. Develop a time management plan using the Pareto Principle (80/20 Rule) and Time Management Matrix.
3. Prepare a report on different leadership styles and their impact on the corporate world.

Unit VI: Business Ethics, Etiquettes, and Values

1. Write a report on corporate ethics and how companies implement ethical policies.
2. Conduct a role-play activity demonstrating appropriate corporate etiquette in business interactions.
3. Prepare a presentation on the significance of Corporate Social Responsibility (CSR).

ROBOT PROGRAMMING
(Course No. C314)

Designation of Course	**Robot Programming**		
Teaching Scheme	**Examination Scheme**		**Credits allotted**
Theory:-0hrs/Week	Term Work	25	-
Practical:-2Hrs/Week	Practical	25	01
	Total	50	01

Course Prerequisite:-	Basics knowledge of: 1. Programming language C++/Python /MATLAB
Course Objective: -	To provide Knowledge about 1. To Understand different types of robot programming 2. To learn different robot commands 3. To understand different robot programming applications
Course Outcomes: -	On completion of the course, students will be able to 1. Classify different programming languages 2. Identify and execute different commands in VAL-I 3. Identify and execute different commands in VAL-II 4. Identify and execute different commands in RAPID 5. Develop robot simulation model in Virtual software 6. develop robot programming applications

Course Content

Unit I	**Basics of Robot Programming**	**(06 Hrs)**
Robot programming-Introduction-Types- Flex Pendant- Lead through programming, Coordinate systems of Robot, Robot controller- major components, functions-Wrist Mechanism-Interpolation-Interlock commands Operating mode of robot, Jogging Types, Robot specifications- Motion commands, end effectors and sensors commands.		
Unit II	**VAL Language**	**(06 Hrs)**
Robot Languages-Classifications, Structures- VAL language commands- motion control, hand control, program control, pick and place applications, palletizing applications using VAL, Robot welding application using VAL program-WAIT, SIGNAL and DELAY command for communications using simple applications		
Unit III	**VAL-II**	**(06 Hrs)**
VAL-II programming-basic commands, applications- Simple problem using conditional statements-Simple pick and place applications-Production rate calculations using robot. AML Language-General description, elements and functions, Statements, constants and variables-Program control statements-Operating systems, Motion, Sensor Commands-Data processing.		
Unit IV	**RAPID Language**	**(06 Hrs)**
RAPID language basic commands- Motion Instructions-Pick and place operation using Industrial robot-manual mode, automatic mode, subroutine command-based programming. Move master command language-Introduction, syntax, simple problems		
UnitV	**Practical Study of Virtual Robot**	**(06 Hrs)**
Robot cycle time analysis-Multiple robot and machine Interference-Process chart Simple Problems-Virtual robotics, Robot studio online software-Introduction, Jogging, components, work planning, program modules, input and output signals-Singularities Collision Detection-Repeatability measurement of robot-Robot economics., Simulation by RboDK and Siemens Delmia		
UnitVI	**Robot Programming Applications**	**(06 Hrs)**
Robot programming synthesis, robot programming for foundry, press work and heat treatment, welding, machine tools, material handling, warehousing assembly, etc., automatic storage and retrieval system, Robot economics and safety, Robot integration with CAD/CAM/CIM, Collision free motion planning.		

Term Work (Following experiments need to be carried out by offline robot programming software)

1. Write a program for palletizing operation by robot
2. Write a program for depalletizing operation by robot
3. Write a program for Pick Place operation by robot
4. Write a program for Assembly operation by robot
5. Write a program for gauge inspection operation by robot
6. Write a program for Welding operation by robot manipulator
7. Write a program for interfacing of robot manipulator with CNC Machine
8. Write a program for object sorting by robot manipulator based on colour , shape, material etc.
9. Interfacing of 7 axis robot with any machine for industrial application

Text Book

1. Deb. S. R. "Robotics Technology and Flexible Automation", Tata McGraw Hill publishing company limited.
2. Mikell. P. Groover, "Industrial Robotics Technology", Programming and Applications, McGraw Hill Co, 1995.
3. Klafter. R.D, Chmielewski.T.A and Noggin's, "Robot Engineering: An Integrated Approach", Prentice Hall of India Pvt. Ltd.,1994

Reference Books

1. Fu .K. S, Gonzalez .R. C. & Lee .C.S.G, "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill Book co, 1987.
2. Craig .J. J, "Introduction to Robotics Mechanics and Control", Addison- Wesley, 1999. 3Robotics Lab manual, 2007.

Massive Open Online Courses (MOOC)-II

(Course Code: C315)

Designation of Course	**Massive Open Online Courses (MOOC)-II**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory:- -- Hours/ Week	End Semester Examination	-- Marks	--
Practical: -- Hours/ Week	Internal Evaluation	-- Marks	
	Term Work:	-- Marks	--
	Total	**-- Marks**	**02**

The students shall be encouraged to complete two MOOCs during their B. Tech. Mechanical programme. Students shall register to MOOCs which are offered by any one the following agencies:

(i) SWAYAM: www.swayam.gov.in

(ii) NPTEL: www.onlinecourse.nptel.ac.in

(iii) Course Era: www.coursera.org

(iv) edX online learning: www.edx.org

(v) MIT Open Course ware: www.ocw.mit.edu

(vi) Udemy: www.udemy.com

(vii) IIT Bombay Spoken Tutorial: www.spoken-tutorial.org

(viii) Artificial Intelligence-CDAC Pune: https://futureskillsprime.in/

(ix) AR- VR - CDAC Pune:
https://futureskillsprime.in/https://tinyurl.com/jx93jwft

Student shall take a prior approval from the department before registering for a given MOOCs. Students shall complete MOOCs during their tenure of a given B. Tech. programme. Students shall submit a passing certificate of MOOCs to obtain two credits per MOOC. The credits obtained for MOOC will be reflected in the mark sheet of Semester VIII.

VAC-II: DRONE TECHNOLOGY AND APPLICATION
(Course Code: C316)

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS:
Theory: 02 Hours/ Week	University Examination Marks: 100 marks	Theory: 02
Practical: ------ Hours/ Week	Internal Assessment Marks: -----	
	Term Work Marks: -----	Practical: -----
	Oral/ Practical Examination Marks: ------	
	Total Credits	02

Course Prerequisites: -	Arial Dynamics, Electrical Actuator, Basic of Mechanisms.
Course Objectives: -	To impart knowledge on 1. Drone Fundamentals, components, and flight dynamic 2. Drone Simulator and rules and regulation 3. Drone Programming 4. Maintenance of drone equipment's 5. Real world application of drones
Course Outcomes: -	The students will be able to At the end of the course, the students will be able to 1. Identify drone components comparison with other aerial vehicle. 2. Understand Drone hardware 3. Create and Analyze drone model using simulation 4. Prepare drone program 5. Define Maintenance method of drone equipment's 6. Develop Drone real world application

Course Contents		**No. of Hours**
Unit-I	**Flight Dynamics of Aerial Vehicles**	**(04 Hrs.)**
Definitions of Drone, UAV, RPA, Quad copters -Basic Components and Categories – Principles of Flight - Flight Maneuvers – Airframes - Creating a Frame: Materials, Different Frame Shapes – Building Airframes - Flight dynamics - Applications - Future potential - Comparison with other aerial vehicles		
Unit-II	**Hardware Anatomy of Drone**	**(04 Hrs.)**
Power Train – Propellers, Motors- Total Lift - Electronic Speed Controllers – Flight Battery – Radio transmitter and receiver – Flight Controller – GPS, Compass, Camera Assembling for Quad copter – Connectors, Mounting of Propellers and Powering up.		
Unit-III	**Introduction to Flight Simulator and DGCA Rules and Regulation**	**(04 Hrs.)**
Flight stimulator: computer-based software, Basic operating features of simulator, selecting different aircrafts and aerodromes, demo flight, pre-flight checks and start-up, preparation cum coordination for flight, approach for landing, DGCA regulations category of RPA, air regulations of drones, requirement for, drone equipment, acquisition of RPAS, eligibility to become drone pilot was done		
Unit-IV	**Drone Programming**	**(04 Hrs.)**
Creating flight plans and missions using GPS and other navigation systems, Autonomous flight modes		

(waypoints, follow-me, etc.), Programming languages for drone control (Python, C++), Perform programming and configure the flight control board (FCB)

Unit-V	**Drone Equipment Maintenance**	**(04 Hrs.)**

Maintenance of drone: storage, safe place, free from dirt, cleaning, fire hazard. precautions for storing drone batteries, maintenance of drone batteries, storage, balance charge, discharge, transportation, balance connectors, power connectors and connectors classification XT, as, Lipo battery puffed, Lipo battery cell layout, RPAS maintenance, unmanned aircraft system traffic management (UTM).

Unit-VI	**Real World Applications and Case Studies**	**(04 Hrs.)**

Beneficial Drones, Aerial Photography, Mapping and Surveying, Precision Agriculture, Search and Rescue, Infrastructure Inspection, and Conservation. Case Studies: Agriculture Weed Classification, Microdrone surveillances.

ternal assessment:

Assignment /Quizzes based on Unit I,II,III,IV,V and VI 20 Marks each

ase studies /poster presentation/Seminar 20 marks each

Textbooks:

1. Reg Austin "Unmanned Aircraft Systems UAV design, development and deployment", Wiley, 2010.
2. Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, Inc, 1998.
3. Kimon P. Valavanis, "Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy", Springer, 2007

Reference Books:

1. Paul G Fahlstrom, Thomas J Gleason, "Introduction to UAV Systems", UAV Systems, Inc, 1998
2. Dr. Armand J. Chaput, "Design of Unmanned Air Vehicle Systems", Lockheed Martin Aeronautics.

B. Tech. – (All branches)

Rules and Regulations

(I) Theory

(A) Theory Examination

Theory examination consists of: (i) End semester examination (ESE), and (ii) Internal assessment (IA).

(i) ESE is of 60 marks for theory courses.

(ii) The existing internal assessment system, totaling 40 marks, currently utilizes two components: a Unit Test and Project-Based Learning (PBL), each allocated 20 marks. To further enhance the teaching-learning experience, the following additional innovative assessment tools will be incorporated into the current framework. These additions are intended to improve the assessment of student learning outcomes and ensure thorough syllabus coverage through engaging and effective methods.

a) Poster presentation

b) Quiz

c) Case study

d) Presentation/Seminar

e) Open book test

f) Assignment

g) MCQ

h) Modelling

i) Group discussion

j) Role play

k) Term paper/Review

paper Note

1. Each semester shall include two Internal Assessments: Internal Assessment–I and Internal Assessment–II.

2. Internal Assessment–I will be based on Units I, II, and III, while Internal Assessment–II will cover Units IV, V, and VI.

3. It is mandatory to categorize the courses within each discipline into appropriate groups based on their nature. For each group, a set of 2 to 4 suitable assessment tools shall be identified and used for evaluation.

4. The Course Coordinator shall prepare a unit-wise plan for conducting the Internal Assessments using the selected tools and submit it to the Head of the Department before the commencement of the academic term. A maximum of 2–3 tools may be selected for each course.

5. The Course Coordinator is also responsible for maintaining proper documentation of the Internal Assessments and shall submit the same to the Head of the Department at the end of the semester, if required.

(B) All Internal Assessments must be designed, conducted, and evaluated in alignment with the appropriate

levels of Bloom's Taxonomy.Standard of Passing

(i) There is a separate passing of 40% of 60 marks, i.e. 24 marks, for ESE for a given course.

(ii) There is a separate passing of 40% of 40 marks, i.e. 16, for IA for a given course.

(iii) candidate who fails at ESE in a given course has to reappear only at ESE as a backlog candidate and clear the head of passing. Similarly, a candidate who fails at IA in a given course has to reappear only at IA as a backlog candidate and clear the head of passing

(II) Practical

(A) Practical Examination

Practical examination consists of: (i) Term work, and (ii) Practical/Oral examination for a given course.

(i) Term work (TW): TW marks are as mentioned in the curriculum structure.

(ii) Practical/Oral (PR/OR): PR/OR marks are as mentioned in the curriculum structure.

(B) Conduction of practical/oral examination

(i) A candidate will be permitted to appear for practical/oral examination only if he/she submits term work of a given course.

(ii) Practical/oral examination shall be conducted in the presence of internal and external examiners appointed by university.

(C) Standard of Passing

(i) A candidate shall pass both heads TW and PR/OR separately with minimum 40% of total marks of respective head.

(III) MOOC and Social Activity Course

(i) If a student completes one MOOC during a programme, he/ she will earn additional TWO credits, subjected to submission of the certificate of completion of the respective course. It is mandatory for a student to complete atleast two MOOC to obtain degree in a given discipline. Students shall register to MOOCs which are offered by any one the following agencies:

(a) SWAYAM : www.swayam.gov.in

(b) NPTEL : www.onlinecourse.nptel.ac.in

(c) Course Era : www.coursera.org

(d) edX online learning : www.edx.org

(e) MIT Open Course ware : www.ocw.mit.edu

(f) Udemy : www.udemy.com

(g) Spoken tutorial : www.spoken-tutorial.org

(ii) If a student completes social activity, he/she will earn additional TWO credits, subjected to submission of the certificate of completion of the respective course/ activity from the relevant authorities. It is mandatory for

a student to complete atleast one social activities to obtain degree in a given discipline.

(iii) Theadditional credits for MOOC and Social Activity will be given only after verification of the authentic document by the Head of the Department and a separate mark-sheet will be submitted by the Head of the Department along with the course examiner.

(IV) Value Added Course (VAC) and Indian Knowledge System (IKS) Course

(i) The VAC and IKS courses are mandatory and must be passed by students during the designated semester to earn two credits.

(ii) These courses have an internal assessment worth 100 marks, which are distributed as follows: (a) three assignments, each worth 20 marks, and (b) two case studies, presentations, or quizzes, each worth 20 marks. Faculty members have the flexibility to choose between conducting two case studies, two presentations, two quizzes, or any combination thereof.

(V) Minor Programme

(i) A students shall receive a MINOR degree when he/she acquires additional 20 credits in a given specialization defined by the UG programmes offered at the institute.

(ii) The theory and practical/oral components for a given course are mentioned in curriculum structure. The theory and examination for a given course are mentioned in Section I and II.

(iii) The grade point, grade letter and equivalent marks system for MINOR programme is mentioned in Section V.

(iv) The MINOR DEGREE programme is OPTIONAL. The interested students may opt MINOR programme.

(v) A student shall complete the MINOR program prior to his/her graduation.

(VI) A. T. K. T

(i) A student who is granted term for B. Tech. Semester-I, III, V, VII will be allowed to keep term for his/her B. Tech. Semester-II, IV, VI, VIII examination, respectively even if he/she appears and fails or does not appear at

B. Tech. Semester-I,III, V, VII examination respectively.

(ii) A student shall be allowed to keep term for the B. Tech. Semester-III course if he/she has a backlog of any number of Heads of passing at B. Tech. Semester-I & II taken together.

(iii) A student shall be allowed to keep term for the B. Tech. Semester-V of respective course if he/she has no backlog of B. Tech. Semester-I & II and he/she has a backlog of any number of Heads of passing at B. Tech. Semester-III & IV taken together.

(iv) A student shall be allowed to keep term for the B. Tech. Semester- VII of respective course if he/she has no backlog of B. Tech. Semester-I, II, III, IV and he/she has a backlog of any number of Heads of passing

at B.

Tech. Semester-V & VI taken together.

(VII) Grade Point, Grade Letter and Equivalent Marks

The student must obtain a minimum Grade Point of 5.0 (40% marks) in ESE and also in combined ESE + IA. A student who fails in ESE of a course has to reappear only to ESE as a backlog student and clear that head of passing.

Award of the Class for the Degree considering CGPA: A student who has completed the minimum credits specified for the programme shall be declared to be passed in the programme. The CGPA will be computed every year of all the courses of that year. The grade will be awarded according to the CGPA of every year.

Range of CGPA	**Final Grade**	**Performance Descriptor**	**Equivalent range of Marks (%)**
9.50 ≤ CGPA ≤10.00	O	Outstanding	80 ≤ Marks ≤ 100
9.00 ≤ CGPA ≤ 9.49	A+	Excellent	70 < Marks <80
8.00 ≤ CGPA ≤ 8.99	A	Very Good	60 < Marks < 70
7.00 ≤ CGPA ≤ 7.99	B+	Good	55 < Marks < 60
6.00 ≤ CGPA ≤ 6.99	B	Average	50 < Marks < 55
5.00 ≤ CGPA ≤ 5.99	C	Satisfactory	40 ≤ Marks < 50
CGPA below 5.00	F	Fail	Marks Below 40

NOTE:

Amendment in Internal assessment tools:

The Internal Assessment for B. Tech. Sem. I, II, III, IV from the A.Y. 2025-26 will be as per the above guidelines.