KLE Technological University | Creating Value, Leveraging Knowledge

Curriculum Structure and Curriculum Content for the Batch 2019-23
Department of Automation & Robotics
Bachelor of Engineering (Automation & Robotics)

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Vision and Mission of KLE Technological University

Vision

KLE Technological University will be a national leader in Higher Education–recognised globally for innovative culture, outstanding student experience, research excellence and social impact.

Mission

KLE Technological University is dedicated to teaching that meets highest standards of excellence, generation and application of new knowledge through research and creative endeavors.

The three-fold mission of the University is:

- To offer undergraduate and post-graduate programs with engaged and experiential learning environment enriched by high quality instruction that prepares students to succeed in their lives and professional careers.

- To enable and grow disciplinary and inter-disciplinary areas of research that build on present strengths and future opportunities aligning with areas of national strategic importance and priority.

- To actively engage in the Socio-economic development of the region by contributing our expertise, experience and leadership, to enhance competitiveness and quality of life.

As a unified community of faculty, staff and students, we work together with the spirit of collaboration and partnership to accomplish our mission.

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Vision and Mission Statements of the Department of Automation & Robotics

Vision

To develop into a research-oriented department educating engineers to serve the diverse needs of our changing society.

Mission

The mission of the Automation & Robotics Program is to prepare undergraduate students with in-depth technical knowledge in the fields of mechanical, electronics, computer, control systems, and applications.

Program Educational Objectives/Program Outcomes and Program-Specific Objectives

Program Educational Objectives -PEO's
PEO1: Our graduates will provide innovative and state-of-the-art solutions to solve complex problems in automation, robotics, and allied fields and design high-quality systems for diverse applications.
PEO2: Our graduates will work in diverse, multi-disciplinary teams and possess leadership skills, ethical standards, environmental concerns, and social awareness.
PEO3: Our graduates will continue life-long learning and pursue professional development opportunities like graduate degrees or professional studies to adapt to the evolving technological changes.
Program Outcomes-PO's
PO1 - Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization for the solution of complex engineering problems.
PO2 - Problem Analysis: Identify, formulate, research literature, and analyze complex engineering problems, reaching substantiated conclusions using the first principles of mathematics, natural sciences, and engineering sciences.
PO3 - Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.
PO4 - Conduct Investigations of Complex Problems: Use research-based knowledge and research methods, including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5 - Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.
PO6 - The Engineer and Society: Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal, and cultural issues, and the consequent responsibilities relevant to the professional engineering practice.
PO7 - Environment and Sustainability: Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO8 - Ethics: Apply ethical principles and commit to professional ethics, responsibilities, and norms of the engineering practice.
PO9 - Individual and Teamwork: Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings.
PO10 - Communication: Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
PO11 - Project Management and Finance: Demonstrate knowledge and understanding of

the engineering and management principles and apply these to one's own work as a member and leader in a team to manage projects and in multidisciplinary environments.
PO12 - Life-long Learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
Program Specific Objectives -PSO's
PSO1 - Foundations of Robotics: Identify the needs, analyze, design, and develop simple robotic systems and programs for diverse applications.
PSO 2 - Integration and Applications of Automation and Robotics: Identify the needs, design, select, and integrate appropriate automation and robotic subsystems for diverse applications.

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Curriculum Structure-Overall

Semester							Total Program Credits: 178
	I	II	III	IV	V	VI	VII	VIII
Course with course code	Basic Electronics 18EECF102	Multivariable Calculus 18EMAB102	Calculus and Integral Transforms 15EMAB231	Vector Calculus and Differential Equations 15EMAB241	Numerical Methods and Statistics 15EMAB301	Hydraulics & Pneumatics 18EARC308	Industrial Data Networks 16EARC401	Smart Manufacturing 17EARE404
	Single Variable Calculus 18EMAB101	Basic Electrical Engineering 18EEEF102	Statistics and Integral Transforms 15EMAB201	Numerical Methods and Partial Differential Equations 15EMAB206	Machine Learning & ROS 18EARC301	AI for Autonomous Robots 17EARE301	Mobile Robotics & Perception 17EARE401	Open Elective
	Basic Mechanical Engineering 15EMEF101	Engineering Physics 15EPHB102	Analog & Digital Electronic Circuits 18EARC201	Machine Design 18EARC206	Real-time Embedded Systems 18EARC303	Power Electronics, Motors & Drives 16EARE301	Design of Automatic Machinery 17EARE402	Capstone Project 18EARW402
	Professional Communication 15EHSH101	Engineering Mechanics 15ECVF102	Kinematics of Machinery 19EARC202	Control Systems 19EARC207	Mechatronics System Design 18EARC304	Computer Vision & Digital Image Processing 15EARE302	ADVANCED MICROCONTROLLER 17EARE403	OR
	Engineering Chemistry 15ECHB101	Social Innovation 15EHSP101	Data Structure Algorithm Design and Analysis 18EARC203	Microcontrollers Programming & Interfacing 18EARC208	Measurement Systems 18EARC305	Robot Dynamics & Control 17EARE302	Research Experience for Undergraduates 17EARE490	Industry Internship – Training 17EARI493
	Engineering Exploration 15ECRP101	Computer-Aided Engineering Drawing 15EMEP101	Mechanics of Materials 18EARC204	Object Oriented Programming & DBMS 19EARC209	Programming Industrial Automation Systems 18EARC302	Digital System Design & FPGA Programming 17EARE304	Institutional Research Project 17EARE491	Industry Internship - Project Work 17EARW494
	C Programming for Problem Solving 18ECSP101	Engineering Physics Lab 16EPHP102	Manufacturing Technology 18EARC205	Object-Oriented Programming & DBMS Lab 19EARP209	Programming Industrial Automation Systems Lab	Hydraulics and Pneumatics Lab16EARP302	Sponsored Research Project 19EARE493	

					18EARP302			
			Analog & Digital Electronic Circuits Lab 18EARP201	Robot Analysis & Design 18EARC210	Machine Learning & ROS Lab 18EARP301	Mechatronics & Measurements Lab 18EARP304	Senior Design Project 19EARW401	
			Kinematics of Machinery Lab 18EARP202	Manufacturing & Metrology Lab 16EARP205	Industrial Robotics Lab 18EARP303	Real-Time Embedded Systems Lab 16EARP307	Constitution of India, Professional Ethics and Environmental Studies 15EHSA401	
			Machine Drawing Lab 18EARP203	Microcontrollers Programming & Interfacing Lab 18EARP208	Mini Project - (Engineering Design) 18EARW301	Minor Project 17EARW302		
						Professional Aptitude & Logical Reasoning 16EHSC301		
Credits	23	21	26	26	24	25	16	17

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Curriculum Structure-Semester wise

Semester - I

No.	Code	Course	Category	L-T-P	Credits	Contact Hours	ISA	ESA	Total	Exam Duration (in hrs)
1	18EECF102	Basic Electronics	BS	4-0-0	4	4	50	50	100	3 Hrs
2	18EMAB101	Single Variable Calculus	BS	4-1-0	5	6	50	50	100	3 Hrs
3	15EMEF101	Basic Mechanical Engineering	ES	2-1-0	3	4	50	50	100	3 Hrs
4	15EHSH101	Professional Communication	HSS	1-1-0	2	3	50	50	100	3 Hrs
5	15ECHB101	Engineering Chemistry	BS	3-0-0	3	3	50	50	100	3 Hrs
6	15ECRP101	Engineering Exploration	ES	0-0-3	3	6	80	20	100	3 Hrs
7	18ECSP101	C Programming for Problem Solving	ES	0-0-3	3	6	80	20	100	3 Hrs
		TOTAL		**14-3-6**	**23**	**32**				

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Semester - II

No.	Code	Course	Category	L-T-P	Credits	Contact Hours	ISA	ESA	Total	Exam Duration (in hrs)
1	18EMAB102	Multivariable Calculus	BS	4-1-0	5	6	50	50	100	3 Hrs
2	18EEEF102	Basic Electrical Engineering	ES	3-0-0	3	3	50	50	100	3 Hrs
3	15EPHB102	Engineering Physics	BS	3-0-0	3	3	50	50	100	3 Hrs
4	15ECVF102	Engineering Mechanics	ES	4-0-0	4	4	50	50	100	3 Hrs
5	15EHSP101	Social Innovation	HSS	0-1-1	2	4	80	20	100	3 Hrs
6	15EMEP101	Computer-Aided Engineering Drawing	ES	0-0-3	3	6	80	20	100	3 Hrs
7	16EPHP102	Engineering Physics Lab	BS	0-0-1	1	2	80	20	100	3 Hrs
		TOTAL		**14-2-5**	**21**	**28**				

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Semester- III

No.	Code	Course	Category	L-T-P	Credits	Contact Hours	ISA	ESA	Total	Exam Duration (in hrs)
1	15EMAB231	Calculus And Integral Transforms	BS	4-0-0	4	4	50	50	100	3 Hrs
2	15EMAB201	Statistics And Integral Transforms	BS	4-0-0	4	4	50	50	100	3 Hrs
3	18EARC201	Analog & Digital Electronic Circuits	ES	4-0-0	4	4	50	50	100	3 Hrs
4	19EARC202	Kinematics of Machinery	ES	4-0-0	4	4	50	50	100	3 Hrs
5	18EARC203	Data Structure Algorithm Design and Analysis	PSC	4-1-0	5	6	50	50	100	3 Hrs
6	18EARC204	Mechanics of Materials	ES	3-0-0	3	3	50	50	100	3 Hrs
7	18EARC205	Manufacturing Technology	PSC	3-0-0	3	3	50	50	100	3 Hrs
8	18EARP201	Analog & Digital Electronic Circuits Lab	PSC	0-0-1	1	2	80	20	100	3 Hrs
9	18EARP202	Kinematics Of Machinery lab	PSC	0-0-1	1	2	80	20	100	3 Hrs
10	18EARP203	Machine Drawing Lab	PSC	0-0-1	1	2	80	20	100	3 Hrs
		TOTAL		**22-1-3**	**26**	**30**				

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Semester- IV

No.	Code	Course	Category	L-T-P	Credits	Contact Hours	ISA	ESA	Total	Exam Duration (in hrs)
1	15EMAB241	Vector Calculus and Differential Equations	BS	4-0-0	4	4	50	50	100	3 Hrs
2	15EMAB206	Numerical Methods and Partial Differential Equations	BS	4-0-0	4	4	50	50	100	3 Hrs
3	18EARC206	Machine Design	PSC	3-0-0	3	3	50	50	100	3 Hrs
4	19EARC207	Control Systems	PSC	4-0-0	4	4	50	50	100	3 Hrs
5	18EARC208	Microcontrollers Programming & Interfacing	PSC	4-0-0	4	4	50	50	100	3 Hrs
6	19EARC209	Object Oriented Programming & DBMS	PSC	4-0-0	4	4	50	50	100	3 Hrs
7	19EARP209	Object-Oriented Programming & DBMS Lab	PSC	0-0-1	1	2	80	20	100	3 Hrs
8	18EARC210	Robot Analysis & Design	PSC	4-0-0	4	4	50	50	100	3 Hrs
9	16EARP205	Manufacturing & Metrology Lab	PSC	0-0-1	1	2	80	20	100	3 Hrs
10	18EARP208	Microcontrollers Programming & Interfacing Lab	PSC	0-0-1	1	2	80	20	100	3 Hrs
		TOTAL		**23-0-3**	**26**	**29**				

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Semester- V

No.	Code	Course	Category	L-T-P	Credits	Contact Hours	ISA	ESA	Total	Exam Duration (in hrs)
1	15EMAB301	Numerical Methods and Statistics	BS	3-0-0	3	3	50	50	100	3 Hrs
2	18EARC301	Machine Learning & ROS	PSC	3-0-0	3	3	50	50	100	3 Hrs
3	18EARC303	Real-time Embedded Systems	PSC	4-0-0	4	4	50	50	100	3 Hrs
4	18EARC304	Mechatronics System Design	PSC	4-0-0	4	4	50	50	100	3 Hrs
5	18EARC305	Measurement Systems	PSC	3-0-0	3	3	50	50	100	3 Hrs
6	18EARC302	Programming Industrial Automation Systems	PSC	4-0-0	4	4	50	50	100	3 Hrs
7	18EARP301	Machine Learning & ROS Lab	PSC	0-0-1	1	2	80	20	100	3 Hrs
8	18EARP303	Industrial Robotics Lab	PSC	0-0-1	1	2	80	20	100	3 Hrs
9	18EARP302	Programming Industrial Automation Systems Lab	PSC	0-0-1	1	2	80	20	100	3 Hrs
10	18EARW301	Mini Project - (Engineering Design)	PRJ	0-0-3	3	6	80	20	100	3 Hrs
		TOTAL		**18-0-6**	**24**	**30**				

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Semester- VI

No.	Code	Course	Category	L-T-P	Credits	Contact Hours	ISA	ESA	Total	Exam Duration (in hrs)
1	18EARC308	Hydraulics & Pneumatics	PSC	4-0-0	4	4	50	50	100	3 Hrs
2	17EARE301	AI for Autonomous Robots	PSE	3-0-0	3	3	50	50	100	3 Hrs
3	16EARE301	Power Electronics, Motors & Drives	PSE	3-0-0	3	3	50	50	100	3 Hrs
4	15EARE302	Computer Vision & Digital Image Processing	PSE	3-0-0	3	3	50	50	100	3 Hrs
5	17EARE302	Robot Dynamics & Control	PSE	3-0-0	3	3	50	50	100	3 Hrs
6	17EARE304	Digital System Design & FPGA Programming	PSE	3-0-0	3	3	50	50	100	3 Hrs
7	16EARP302	Hydraulics and Pneumatics Lab	PSC	0-0-1	1	2	80	20	100	3 Hrs
8	18EARP304	Mechatronics & Measurements Lab	PSC	0-0-1	1	2	80	20	100	3 Hrs
9	16EARP307	Real-Time Embedded Systems Lab	PSC	0-0-1	1	2	80	20	100	3 Hrs
10	17EARW302	Minor Project	PRJ	0-0-6	6	12	80	20	100	3 Hrs
11	16EHSC301	Professional Aptitude & Logical Reasoning	HSC	3-0-0	3	3	50	50	100	3 Hrs
		TOTAL		**16-0-9**	**25**	**34**				

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Semester- VII

No.	Code	Course	Category	L-T-P	Credits	Contact Hours	ISA	ESA	Total	Exam Duration (in hrs)
1	16EARC401	Industrial Data Networks	PSC	4-0-0	4	4	50	50	100	3 Hrs
2	17EARE401	Mobile Robotics & Perception	PSE	3-0-0	3	3	50	50	100	3 Hrs
3	17EARE402	Design of Automatic Machinery	PSE	3-0-0	3	3	50	50	100	3 Hrs
4	17EARE403	Advanced Microcontroller	PSE	3-0-0	3	3	50	50	100	3 Hrs
5	17EARE490	Research Experience for Undergraduates	PRJ	0-0-6	6	12	50	50	100	3 Hrs
6	17EARE491	Institutional Research Project	PRJ	0-0-6	6	12	80	20	100	3 Hrs
7	19EARE493	Sponsored Research Project	PRJ	0-0-6	6	12	80	20	100	3 Hrs
8	19EARW401	Senior Design Project	PSC	0-0-6	6	12	80	20	100	3 Hrs
9	15EHSA401	Constitution of India, Professional Ethics and Environmental Studies	HSC	0-0-0	0	0	50	50	100	3 Hrs
		TOTAL		**10-0-6**	**16**	**22**				

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Semester- VIII

No.	Code	Course	Category	L-T-P	Credits	Contact Hours	ISA	ESA	Total	Exam Duration (in hrs)
1	17EARE404	Smart Manufacturing	PSE	3-0-0	3	3	50	50	100	3 Hrs
2	XXXXX	Open Elective	OE	3-0-0	3	3	50	50	100	3 Hrs
3	18EARW402	Capstone Project	PRJ	0-0-11	11	22	50	50	100	3 Hrs
		TOTAL		**6-0-11**	**17**	**28**				
				OR						
4	17EARI493	Industry Internship - Training	IE	0-0-6	6	12	50	50	100	3 Hrs
5	17EARW494	Industry Internship - Project Work	IEPRJ	0-0-11	11	22	50	50	100	3 Hrs
		TOTAL		**0-0-17**	**17**	**34**				

Semester	I	II	III	IV	V	VI	VII	VIII	**Total**
Credits	23	21	26	26	24	25	16	17	178

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List of Open Electives

Sr. No	Name of the Course	Course Code

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List of Program Electives

Sr. No	Name of the Course	Course Code
1	AI for Autonomous Robots	17EARE301
2	Power Electronics, Motors & Drives	16EARE301
3	Computer Vision & Digital Image Processing	15EARE302
4	Robot Dynamics & Control	17EARE302
5	Digital System Design & FPGA Programming	17EARE304
6	Mobile Robotics & Perception	17EARE401
7	Design of Automatic Machinery	17EARE402
8	Industrial Internet of Things	23EARE403
9	Research Experience for Undergraduates	17EARE490
10	Institutional Research Project	17EARE491
11	Sponsored Research Project	19EARE493
12	Smart Manufacturing	17EARE404

Curriculum Content- Course wise

Program: Automation & Robotics Engineering		Semester: I
Course Title: Basic Electronics		Course Code: 18EECF102
L-T-P: 4-0-0	Credits: 4	Contact Hours: 4hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50 hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Overview of Electronics in Mechanical Engineering

Definition & overview of Mechatronics, Mechatronics and Design Innovation, Mechatronics and Manufacturing, Mechatronics and Education; Typical Mechatronics Components; Sensors and Transducers.

Chapter 2: Semiconductor Devices and Applications:

PN junction diode, characteristics and parameters, diode approximations, half wave rectifier, full wave bridge rectifier, full wave bridge rectifier capacitor filter, Zener diode, Voltage regulator design, BJT, Darlington Pair, JFET, MOSFET, UJT, SCR.

Chapter 3: Operational Amplifiers:

Ideal op-amp characteristics, op-amp applications: Comparator, Inverting amplifier, Non-inverting amplifier, Voltage follower, Integration, Differentiation, Adder, Subtractor and numerical as applicable.

Unit II

Chapter 4: Digital Logic

Digital Number system: Binary & Hexadecimal number systems, Conversion, BCD Number system, Gray code, Data word representation, Binary Arithmetic, Boolean Algebra, Logic gates, Combinational & Sequential circuits, Adders, Flip-Flops, Registers, Counters, Multiplexer.

Chapter 5: Sensors and Transducers

Introduction, Classification of sensors and transducers, Contact type – Mechanical switches, Non-contact type - proximity sensors & Hall sensors, principle of working of light sensors, Future Challenges

Unit III

Chapter 6: Signal Conditioning

Analog & Digital signals, Digital to Analog Conversion, R-2R DAC, Analog to Digital Conversion, SAR ADC, Data Acquisition.

Chapter 7: Case Studies of Mechatronic Systems

Automatic Camera, Drilling Machine, Bar code reader.

Text Books

1. David A Bell, “Electronic devices and Circuits”, PHI New Delhi, 2004.
2. Morris Mano, “Digital logic and Computer design” 21st Indian print Prentice Hall India, 2000.
3. W.Bolton, "Mechatronics - Electronic Control Systems in Mechanical and Electrical

Engineering", 3rd edition Pearson Education, 2005.
4. David Bradley and David W., “Mechatronics in Action”, 2nd edition, Springer, 2010

Reference Books:

1. David G Alciatore, Michael B Histand, “Introduction to Mechatronics and Measurement Systems”, TMH 3rd edition, 2007.
2. K.A Krishnamurthy and M. R. Raghuveer, “Electrical, Electronics and Computer Engineering for Scientist and Engineers”, Second Edition New Age International Publishers, Wiley Eastern, 2001.
3. P. Malvino, “Electronic Principles” Sixth edition Tata McGraw Hill, 1999.
4. Floyd, “Digital fundamentals” Third Edition Prentice Hall India, 2001
5. Boylestead Nashelsky, “Electronic devices & Circuit theory” Sixth Edition Prentice Hall India, 2000.
6. Ramakant Gayekawad, “Operational Amplifiers & applications” 3rd Edition, PHI, 2000

Back

Program: Automation & Robotics Engineering		**Semester: I**
Course Title: Single Variable Calculus		**Course Code: 18EMAB101**
L-T-P: 4-1-0	**Credits: 5**	**Contact Hours: 6 hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: hrs	**Examination Duration: 3 hrs**	

Unit I

Chapter 1: Functions, Graphs and Models

Functions, types of functions, transformations and models (Linear, exponential, trigonometric).

MATLAB: Graphing functions, Domain-Range and Interpreting the models

Chapter 2: Functions, Graphs and Models

Functions, types of functions, transformations and models (Linear, exponential, trigonometric).

MatLab: Graphing functions, Domain-Range and Interpreting the models

Chapter 2: Calculus of Functions and Models

Limit of a function, Infinite limits- graph, Continuity and discontinuity, Intermediate value theorem statement, Roots of the equation using Bisection Method and Newton- Raphson Method

Interpretation of derivative as a rate of change, All the rules of derivatives (List only), Maxima, Minima and optimization problems. Curvature and Radius of Curvature, Indeterminate forms, L- Hospital's rule-Examples

MATLAB: optimization problems. Curvature problems

Unit II

Chapter 4: Infinite Series

Definition, Convergence of series, Tests of convergence – p-series, Alternating series. Power series, radius of convergence, Taylor's and Maclaurin's series, Applications of Taylor's and Maclaurin's series

MATLAB: Convergence of series

Chapter 5: Integral Calculus

Tracing of standard curves in Cartesian form, Parametric form and Polar form; Beta and gamma function, relation between them, evaluation of integrals using Beta and gamma functions; Applications to find arc length, Area, Volume and surface area (Cartesian, parametric and polar curves). Approximate integration- Trapezoidal rule, Simpson's 1/3 rule

MATLAB: problems on arc length, area, volume and surface area

Unit III

Chapter 6: Ordinary Differential Equations of First Order

Introduction to Initial Value problems. Linear and Bernoulli's equations, Exact equations and reducible to exact form, Numerical solution to Initial Value problems-Euler's method, Modified Euler's method and Runge-Kutta method

Applications of first order differential equations-Orthogonal trajectories growth and decay

problems, mixture problems, Electrical circuits, falling bodies.
MATLAB: Solve differential equations

Text Books

1. Early Transcendental Calculus- James Stewart, Thomson Books, 7ed 2010.

Reference Books:

1. Calculus Single and Multivariable, Hughues-Hallett Gleason, Wiley India Ed, 4ed, 2009.
2. Thomas Calculus, George B Thomas, Pearson India, 12ed, 2010

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Program: Automation & Robotics Engineering		Semester: I
Course Title: Basic Mechanical Engineering		Course Code: 15EMEF101
L-T-P: 2-1-0	Credits: 3	Contact Hours: 4hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50 hrs	Examination Duration: 3 hrs	

Chapter	Contents	Hours	Tutorial	Sessions
	UNIT I			
1	**Introduction to Mechanical Engineering:** Definition of engineering, Mechanical Engineering, Branches of Mechanical Engineering, Who are Mechanical Engineers? Mechanical Engineers' top ten achievements.	2	Visit to Workshop and Machine Shop, Tools, Safety Precautions Video presentations	1
2	**Manufacturing Engineering:** Basics of Manufacturing What is manufacturing? The main manufacturing sectors, The importance of the main manufacturing sectors to the Indian economy, Scales of production Classification of manufacturing Processes. Advances in Manufacturing: CNC machines, Mechatronics and applications	8	Demonstration on working of Lathe, milling, drilling, grinding machines Demonstration on Welding (Electric Arc Welding, Gas Welding, Soldering) Demonstration and Exercises on Sheet metal work. Visit to Learning Factory	5
	UNIT II			
3	**Design Engineering: Power Transmission Elements** Overview Design Application: • Belt Drives. Types, Length of Belt. Velocity Ratio, Initial Tension. Ratio of Tensions. Power Transmitted, Numerical Problems. • Gears. Spur Gear, Rack and Pinion, Worm Gear, Bevel Gear, Helical Gears. Speed,	6	Design Problems like a moving experience, aluminium can crusher Video presentations	5

	Torque, and Power in Gear pair. Simple and Compound Gear trains. Numerical Problems. Ball and Roller Bearings, Types, Applications.			
4	**Thermal Engineering 1: Prime Movers.** Internal Combustion Engines: Classification, IC engine parts, 2 stroke SI and CI engine, 4 Stroke SI and CI Engine, PV diagrams of Otto and Diesel cycles, Comparison of 2 stroke and 4 stroke engine, comparison of CI and SI engine, Problems on Engine Performance, Future trends in IC engines.	4	Case study on power requirement of a bike, car or any machine Video presentations	1
UNIT III				
5	**Thermal Engineering 2: Thermal Systems' Applications** Refrigeration system, Air conditioning system, Pumps, Blowers and Compressors, Turbines, and their working principle and specifications.	5	Case study on selection of various thermal systems Video presentations	1

Text Books:

1. Jonathan Wickert and Kemper Lewis, An Introduction to Mechanical Engineering, Third Edition, 2013- Cengage Learning.
2. K.R.Gopalkrishna, SudhirGopalkrishna, S.C. Sharma. A Text Book of Elements of Mechanical Engineering, 30th Edition, Oct 2010, Subhash Publishers, Bangalore.

Reference Books:

1. Course Material developed by the Department of Mechanical Engineering.
2. SKH Chowdhary, AKH Chowdhary, Nirjhar Roy, The Elements of Workshop Technology - Vol I & II, 11th edition 2001, Media Promoters and Publishers.
3. Basic Manufacturing, Roger Timings, Third edition, Newnes, An imprint of Elsevier

Back

Program: Automation & Robotics Engineering		**Semester: I**
Course Title: Professional Communication		**Course Code: 15EHSH101**
L-T-P: 1-1-0	**Credits: 2**	**Contact Hours: 3 hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 42hrs	**Examination Duration: 3 hrs**	

Chapter 1: Basics- English Communication

Course Introduction, Explanation of template mix-ups with correct usages & necessity of grammar in error detection, Usage of tenses

Chapter 2: Vocabulary and grammar

Vocabulary, Word Formation and Active and Passive Voice

Chapter 3: Bouncing Practice

Definition and types of bouncing and its practice with examples, reading skills, free style speech. Individual presentation.

Chapter 4: Rephrasing and Structures

Comprehension and Rephrasing, PNQ Paradigm and Structural practice

Chapter 5: Dialogues

Introduction of dialogues, Situational Role plays,

Chapter 6: Business Communication

Covering letter, formal letters, Construction of paragraphs on any given general topic.

Reference Books:

1. Collins Cobuild Advanced Learner's English Dictionary
2. Raymond Murphy - Intermediate English Grammar, Cambridge University Press
3. Martin Hewings- Advanced English Grammar, Cambridge University Press.

Back

Program: Automation & Robotics Engineering		Semester: I
Course Title: Engineering Chemistry		Course Code: 15ECHB101
L-T-P: 3-0-0	Credits: 3	Contact Hours: 3 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40 hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Pure substances

Properties of pure substance (Steam), two property rule, T-H diagram, formation of steam at constant pressure. Different states of steam: Wet steam-dryness fraction, determination by separating-throttling calorimeter, Dry saturated steam, Superheated steam, thermodynamic parameters of steam, steam table, numerical problems.

T-V, P-V & P-T diagrams of pure substance taking water as example. Triple point & critical point. Sub-cooled liquid, saturated liquid, mixture of saturated liquid & vapor, Saturated vapor & superheated vapor states

Chapter 2: Real and ideal gases

Properties of Real and Ideal gases. Vander Waal's equation, Vander Waal's constant in terms of critical properties –numerical problems. Compressibility factor, compressibility chart and Law of corresponding state. Ideal gas: equation of state, internal energy and enthalpy as functions of temperature. Ideal gas mixture: Dalton's law of additive pressures and Amagat's law of additive volumes. Terms used in the analysis of mixture of gases - numerical problems.

Chapter 3: Engineering Materials

Ferrous metals – properties and applications of Iron and Steel. Ferrous metal s – properties and

Applications of copper and aluminium.

Cement- properties, mechanism of setting & hardening of cement and applications.

Lubricants- Properties –viscosity, flash point, fire point, cloud point and pour point, mechanism-

hydrodynamic and boundary lubrication and applications.

Unit II

Chapter 3: Fuel Chemistry

Fuels, classification, determination of calorific value of a fuel (solid / liquid fuel by Bomb calorimeter), coal analysis- Numerical problems. Petroleum - cracking, Octane number, Cetane number, reforming, and mechanism of knocking in Petrol and Diesel engines. Renewable energy sources – power alcohol and bio diesel.

Chapter 3: Energy Storage and Conversion Systems

Electrode potential, Nernst equation, Formation of a cell; Reference electrodes – Calomel electrode and Determination of electrode potential using calomel electrode, numerical problems on E, Ecell, E0cell.

Batteries: Classification, characteristics, Lead-acid and Li ion batteries.

Fuel cells: Methanol-O2 fuel cell.

Chapter 4: Surface Chemistry

Corrosion: Electrochemical theory of corrosion taking iron as an example; corrosion control – galvanization and tinning.

Metal Finishing: Technological importance of metal finishing, Electroplating, factors affecting nature of electrodeposit- Throwing power of plating bath solution- numerical problems. Electro less plating – advantages over electroplating, lector less plating of copper and its applications in the manufacture of printed circuit board

Unit III

Chapter 5: Polymers

Introduction, free radical mechanism of addition polymerization taking Ethylene as an example; commercial polymers - Plexi glass, polyurethane and polystyrene. Adhesives – synthesis, properties as applications of Epoxy resins; Polymer Composites - structure, properties and applications of Kevlar and carbon fiber.

Chapter 6: Environmental Chemistry:

Water: Sources and ill effects of water pollutants- fluoride and nitrate; Determination of total hardness of water by EDTS method – numerical problems. Sewage: Determination of biological oxygen demand by Winkler's method – numerical problems and determination of chemical oxygen demand - numerical problems

Text Books:

1. A text Book of Engineering Chemistry, 1st edition, Dara. S. S, S. Chand & Co. Ltd., 2009, New Delhi.
2. A text Book of Engineering Chemistry, 16th edition, Jain P.C and Jain M, Dhanpat Rai Publications, 2006, New Delhi.

Reference Books:

1. An introduction to Thermodynamics, Y V C Rao, Revised Edition, University Press, 2009 Hyderabad.
2. Hand book of batteries, David Linden, Thomas B Reddy, 3rd edition McGraw Hill publications, 2001.
3. Puri B. R., Sharma L.R. and Pathania M. S., Principles of Physical Chemistry, 33rd Edition, S Nagin Chand & Co.,1992.
4. Fontana M G, Corrosion Engineering, 3rd Edition, McGraw Hill Publications, 1986.
5. Billmeyer F W, Text Book of Polymer Science, John Wiley &Son's, 1994.
6. Principles of Polymer Chemistry- A. Ravve Plelum Press, New York and London.
7. Callister William D, Materials Science and Engineering: An introduction, John Wiley and Sons 2007: 721 pages.

Back

Program: Automation & Robotics Engineering		Semester: I
Course Title: Engineering Exploration		Course Code: 15ECRP101
L-T-P: 0-0-3	Credits: 3	Contact Hours: 6 hrs/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching Hours: 78hrs	Examination Duration: 3 hrs	

No	Content	Sessions
1	Introduction to Engineering and Engineering Study	1
2	Role of Analysis in Engineering, Analysis Methodology	2
3	Data Analysis Graphing	2
4	Basics of Engineering Design, Multidisciplinary Nature of Engineering Design	5
5	Project Management	1
6	Sustainability in Engineering	2
7	Ethics	1
8	Modeling, Simulation and Data Acquisition using Software Tool	1
9	Platform-based development: Arduino	3

Reference Books:

1. Engineering Fundamentals & Problem Solving by Arvid Eide, Roland Jenison, Larry Northup, Steven, Mc GrawHill Higher Education, 6th Edition (2011)
2. Engineering Exploration (Edited Book, 2008) by Pearson Publication
3. B.A. Forouzan, R.F. Gilberg, A Structured Program Approach Using C, 3ed, CENGAGE Learning, 2008

Back

Program: Automation & Robotics Engineering		Semester: I
Course Title: C Programming for Problem Solving		Course Code: 18ECSP101
L-T-P: 0-0-3	Credits: 3	Contact Hours: 6 hrs/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching Hours: 78 hrs	Examination Duration: 3 hrs	

1	**Introduction to Problem solving** Introduction to algorithms / flowcharts and its notations, top down design, elementary problems.
2	**Basics of C programming language** Characteristics and uses of C, Structure of C program, C Tokens: Keywords, Identifiers, Variables, Constants, Operators, Data-types, Input and Output statements.
3	**Decision control statements** Conditional branching statements: if statement, if else statement, else if ladder, switch statement, unconditional branching statements**:** break, continue. Introduction to Debugging Skills Introduction to Test Driven Programming.
4	**Iterative statements** while, do while, for, nested statements
5	**Functions** Introduction, Function declaration, definition, call, returns statement, passing parameters to functions, introduction to macros.Introduction to Coding Standards
6	**Arrays and Strings** Introduction, Declaration, Accessing elements, Storing values in arrays, Operations on one dimensional array, Operations on two dimensional arrays, Introduction to Code Optimization and refactoring
7	**Pointers** Introduction, declaring pointer, pointer variables, pointer expression and arithmetic, passing arguments to functions using pointers, pointers and arrays, passing an array to a function.
8	**Structures and Unions** Introduction, passing structures to functions, Array of structures, Unions

Text Books:

1. R.G.Dromey, How to Solve it by Computer, 1ed, PHI, 2008.
2. Yashvant Kanetkar, Let us C,15th ed, BPS Publication, 2016

Reference Books:

1. B W Kernighan, D M Ritchie, The Programming language C, 2ed, PHI, 2004.
2. B S Gottfried, Programming with C, 2ed, TMH, 2006.
3. B.A. Forouzan, R.F. Gilberg, A Structured Program Approach Using C, 3ed, CENGAGE Learning, 2008

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Program: Automation & Robotics Engineering		Semester: II
Course Title: Multivariable Calculus		Course Code: 18EMAB102
L-T-P: 4-1-0	Credits: 5	Contact Hours: 6 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50 hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Partial differentiation

Function of several variables, Partial derivatives, Level curves, Chain rule, Errors and Approximations. Extreme value problems. Lagrange's multipliers.

Chapter 2: Double integrals

Double integrals- Rectangular and polar coordinates, Change the order of integration. Change of variables, Jacobian. Application of double integrals

Unit II

Chapter 3: Triple integrals

Triple integrals, Cartesian, change to Cylindrical and Spherical coordinates Application of Triple integrals

Chapter 4: Calculus of Vector Fields

fields, Gradient and directional derivatives. Line and Surface integrals. Independence of path and potential functions. Green's theorem, Divergence of vector field, Divergence theorem, Curl of vector field. Stokes theorem.

MATLAB: application of Triple integrals, Vector calculus problems

Unit III

Differential equations of higher orders

a. Linear differential equations of second and higher order with constant coefficients. The method of Variation of parameters. Initial and boundary value problems
b. (b) Applications of second order differential equations-Newton's 2nd law, electrical circuits, Simple Harmonic motion. Series solution of differential equations. Validity of Series solution of Differential equations.

MATLAB: application of differential equations

Text Books

1. Early Transcendental Calculus- James Stewart, Thomson Books, 7ed 2010

Reference Books:

1. Calculus Single and Multivariable, Hughues-Hallett Gleason, Wiley India Ed, 4ed, 2009.
2. Thomas Calculus, George B Thomas, Pearson India, 12ed, 2010

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Program: Automation & Robotics Engineering		Semester: II
Course Title: Basic Electrical Engineering		Course Code: 18EEEF102
L-T-P: 3-0-0	Credits: 3	Contact Hours: 3 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Overview of Electrical Engineering

Specialization, scope & role, impact of Electrical Engineering on national economy, environment, Sources of generation, sustainability, challenges and opportunities for electrical engineers, electrical engineering marvels, future challenges.

Chapter 2: DC Circuits

Voltage and current sources, Kirchoff's current and voltage laws, loop and nodal analysis of simple circuits with dc excitation. Time-domain analysis of first-order RL and RC circuits

Chapter 3: .AC Circuits

Representation of sinusoidal waveforms, peak and rms values, phasor representation, real power, reactive power, apparent power, power factor. Analysis of single-phase series and parallel R-L-C ac circuits. Three-phase balanced circuits, voltage and current relations in star and delta connections. power measurement using two watt meters

Unit II

. **Chapter 4: Electrical Actuators**

Electromagnetic principles, Solenoid, Relays, classification of Electric motors, DC motors-shunt, series, compound, separately excited, PMDC motors – Speed Control, Stepper Motors, BLDC motors, three phase induction motor, Characteristics and applications, selection of motors for various applications.

Chapter 5: Power Electronics (Text1, chapter 45)

Introductory, Thyristor, Some thyristor circuits, Limitations to thyristor operation, The thyristor in practice, The fully controlled AC/DC converter, AC/DC inversion, Switching devices in inverters, Three-phase rectifier networks, The three-phase fully controlled converter, Inverter-fed induction motors, Soft-starting induction motors, DC to DC conversion switched-mode power

Unit III

Chapter 6: Electrical Wiring, Safety and protection(ref: Text3-page 1 to 10)

Types of wires and cables for internal wiring, Types of switches and Circuits, Types of wiring, Safety precautions and rules in handling electrical appliances, Electric shock, first aid for electrical shocks, Importance of grounding and earthing, Methods for earthing, Fuses, MCB, ELCB and Relays, Lockout and Tagout, Electrical Codes and Standards

Chapter 7: Batteries

Basics of lead acid batteries, Lithium Ion Battery, Battery storage capacity, Coulomb effiISAncy,

Numerical of high and low charging rates, Battery sizing. Numericals
Text Books 1. Hughes, Electrical & Electronic Technology, 8th, Pearson Education, 2001 2. P C Sen, Principals of Electrical Machines and Power Electronics, 2nd, Wiley Publications 3. Gilbert M Masters, Renewable and effiISAnt Electrical Power systems, Published by John Wiley & Sons 2004 edition 4. Frank D. Petruzella, Electric Motors and Control Systems, McGraw Hill Education Private Limited 2009 Edition
Reference Books: 1. D C Kulshreshtha, Basic Electrical Engineering, Mc Graw Hill Publications 2. David G Alciatore and Michel B Histand, Introduction to Mechatronics and Measurement Systems, 3rd, Tata McGraw Hill Education Private Limited, New Delhi., 2005 3. Vincent Del Toro, Electrical Engineering Fundamentals, 2nd edition Prentice Hall India

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Program: Automation & Robotics Engineering		Semester: II
Course Title: Engineering Physics		Course Code: 15EPHB102
L-T-P: 3-0-0	Credits: 3	Contact Hours: 3 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40 hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Concept of Motion - Kinematics in One Dimension

Introduction, Motion Diagrams, The Particle Model, Position Model, Linear Velocity and Acceleration, Uniform Motion, Instantaneous Velocity, Finding Position from Velocity, Motion with Constant Acceleration, Free Fall Motion on an Inclined Plan, Instantaneous Acceleration, Numericals

Chapter 2: Kinematics in Two Dimensions

Introduction to Vectors, Properties of vectors, Coordinate Systems and Vector Components, Vector Algebra. Position, velocity and Acceleration vectors, Projectile Motion, Relative Motion, Uniform Circular Motion, Velocity and Acceleration in Uniform Circular Motion, Nonuniform Circular Motion and Angular Acceleration, Numericals. Force and Motion

Chapter 3: Force and Motion

Concept of Force, Identifying Forces, A Virtual Experiment, Newton's First Law, Newton's Second Law, Free-Body Diagrams, Applications.

Unit II

Chapter 4: Dynamics I

Equilibrium using Newton's second Law, Friction, Drag,
Newton's Third Law, Analyzing Interacting Objects, Newton's Third Law, Applications.

Chapter 5: Dynamics II

Motion in a plane, Dynamics in Two Dimension, Velocity and Acceleration in Uniform Circular Motion, Dynamics of Uniform Circular Motion, Fictitious Forces, Non-uniform Circular Motion, Numerical

Chapter 6: Impulse and Momentum

Momentum and Impulse, Problems, Conservation of Momentum, Inelastic Collisions, Explosion, Momentum in Two Dimension, Numericals.

Unit III

Chapter 6: Energy and Work

Energy: Kinetic Energy and Gravitational Potential Energy, Restoring Forces, Hooke's Law, Elastic Potential Energy, Elastic Collisions, Energy Diagrams.
Work: Work and Kinetic Energy, Force, Work and Potential energy, Conservation of Energy, Power, Numericals

Text Books:

1. John W Jewett and Raymond A Serway, Physics for SISAntists and Engineers with modern physics, Cengage publication, India Edition, 8th Edition.

Reference Books:

1. Randall D Knight, Physics for SISAntists and Engineers, Pearson publication, 2ndEdition.
2. Hans C Ohanian and John T Markert, Physics for Engineers and SISAntists, W W Norton and Company, Volume 1, 3rd Edition

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Program: Automation & Robotics Engineering		Semester: II
Course Title: Engineering Mechanics		Course Code: 15ECVF102
L-T-P: 4-0-0	Credits: 4	Contact Hours: 3 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50 hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Overview of Civil Engineering

Evolution of Civil Engineering Specialization, scope and role. Impact of Civil Engineering on National economy, environment and social & cultural fabric. Challenges and Opportunities for Civil Engineers, Civil Engineering Marvels, Future challenges, Higher education and Research.

Chapter 2: Coplanar concurrent force system

Introduction to Engineering Mechanics: Basic idealizations – Particle, Continuum, Body, Rigid body, Deformable body, Definition of force and its elements; Laws of Mechanics – Parallelogram law of forces, Principle of transmissibility, Law of Superposition, Newton's laws of motion.

Classification of force systems Resultant of coplanar concurrent force system: Definitions – Resultant, composition & Resolution of a force, Equilibrium, Equilibrant, Formulae for resultant of forces and resolution of a force. Numerical problems on resultant of forces.

Equilibrium of coplanar concurrent force system: Conditions of equilibrium, Action & Reaction, Free body diagram, Lamis' theorem. Numerical problems on equilibrium of forces.

Chapter 3: Coplanar non-concurrent force system

Resultant of a force system: Moment, moment of a force, couple, moment of a couple, Characteristics of couple, Equivalent force-couple system, Numerical problems on moment of forces and couples, on equivalent force-couple system. Varignons principle of moments, Resultant of coplanar- non-concurrent force systems and numerical problems.

Unit II

Chapter 4: Equilibrium of a force system (Chapter 3 contd.)
Conditions of equilibrium, types of support and loading for a statically determinate beam, Reactions at support connections, Numerical problems on equilibrium of force systems and support reactions for a statically determinate beam.

Chapter 5: Static Friction
Introduction, types of friction, definition, limiting friction, coefficient of friction, laws of Coulomb friction, angle of friction and angle of repose, cone of friction. Wedge and belt friction theory. Derivation of belt friction formula. Numerical problems on, impending motion on horizontal and inclined planes (including connected bodies); wedge friction; Ladder friction and Belt friction

Chapter 6: Centroid of Plane Figures
Introduction, Definition, Methods of determining the centroid, axis of reference, axis of symmetry, Locating the centroid of simple plane figures (triangle, semicircle, quarter of a circle and sector of a circle, etc.) using method of integration, Numerical problems on Centroid of simple built up sections

Unit III

Chapter 7: Second moment of area (Plane figures)
Introduction, Definition, Method of determining the second moment of area, Section Modulus, Radius of gyration, perpendicular and Parallel axis theorems, Polar second moment of area, second moment of area of simple plane figures (triangle, rectangle, semicircle, circle etc.) using method of integration, Numerical problems on MI of simple built up sections

Chapter 8: Kinetics of a particle- Work, Power, Energy
Introduction – Kinematics and Kinetics, Definitions – work, power and energy. Work done by a force (constant, gravitational and spring forces) in rectilinear motion. Numerical problems, Kinetic energy of a particle, principle of work and energy. .

Text Books:

1. Beer, F.P. and Johnston, R., Mechanics for Engineers: Statics, McGraw Hill Company, New York, 1988.
2. Bhavikatti, S.S., and Rajasshekarappa K.G., Engineering Mechanics, 3Ed., New Age International Pub. Pvt. Ltd., New Delhi, 2008.
3. Kumar, K.L., Engineering Mechanics, 3ed., Tata McGraw Hill Publishing Company, New Delhi, 2003.
4. Punmia, B.C., Jain, A. and Jain, A., Mechanics of Materials, Lakshmi Publications, New Delhi, 2006

Reference Books:

1. Jagadeesh, T.R. and Jayaram, Elements of Civil Engineering, Sapna Book House, Bangalore, 2006.
2. Ramamrutham, S., Engineering Mechanics, Dhanpat Rai Publishing Co., New Delhi, 1998.
3. Singer, F.L., Engineering Mechanics, 3rd edition Harper Collins, 1994.
4. Timoshenko, S.P. and Young, D.H., Engineering Mechanics, 4th edition, McGraw Hill

Publishing Company, New Delhi, 1956.
5. Irving H Shames, Engineering Mechanics, 3rd edition, Prentice-Hall of India Pvt. Ltd, New Delhi- 110 001, 1995

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Program: Automation & Robotics Engineering			**Semester: II**
Course Title: Social Innovation			**Course Code: 15EHSP101**
L-T-P: 0-1-1	**Credits: 2**		**Contact Hours: 4 hrs/week**
ISA Marks: 80	**ESA Marks: 20**		**Total Marks: 100**
Teaching Hours: 24 hrs	**Examination Duration: 3 hrs**		

Module		Topics	Assignments	Support activities / Tools
		1. Introduction to Social Innovation: • Awakening social consciousness **(www.yourstory.com)** • Social Innovation and Leadership • Engineering& Social innovation (EPICS) **(Connecting SI Course to Mini Project, Capstone Project, Campus Placements)** • Course Overview • **Students' Self Introduction Activity** • Group formation **Activity**	**Reading assignments** • Read the handout on "The Process of Social Innovation" by Geoff Mulgan • Design thinking for Social Innovation **Written Assignments** • **Writing about Akshaya Patra in class.** **(Background information about Akshaya patra and the Social Cuase it is addressing)** • **Brainstorming Session on Social Innovators in Class**	• Class activity on Behavioral Blocks to Innovation **Discussion on the behavioural blocks.** • **Introducing oneself with three Adjectives- Appreciating diversity and discovering self** • **Group Formation Activity** **(Forming square)** **(Making four equilateral triangles out of popsicle sticks to enhance group cohesiveness amongst the group mates)**
	Create Mindsets	**Seven Mindsets:** 1. Empathy **(Example of The Boy and the Puppies)** 2. Optimism **(Person Paralyzed waist down / Glass Halh full Half Empty)** 3. Iteration **(Thomas Alva Edison)** 4. Creative Confidence **(Origamy – Josef Albers)** 5. Making it 6. Embracing Ambiguity **(Confusion is the Welcome doormat at the door of Creativity)** 7. Learning from Failure **(Designing Website first and then asking the stakeholders about the website)** **(Spending one lakh for the business which is never launched)**	**Reading assignments** • Handout on " Create Mindsets"	• **(How to train the Dragon? Common Video for all the mindsets)** • **Watching in Class TED Talk on "How to build youir Creative Confidence by David Kelley – IDEO Founder)**

	Process of Social Innovation	**Engage** Community study and Issue Identification	**Reading assignments** • Handout on Community Study and Issue Identification • Case Study on "EGramSeva" • Case Study on "Janani Agri Serve" **Class Presentations** • Initial observations being made by the group **(Literature Survey of Places of Hubli- Dharwad)** **www.readwhere.com** • Detailed interaction / engagements with the society and finalize the social issue for intervention **Use template 1: Frame your Design Challenge**	• Activity on Observation skills To know how to use one's observation skills in understanding the social conditions • Experience sharing by senior students • Brainstorming Deliberations on the initial observations and arrive at the "Social Issue" • Familiarization of the respective templates with the help of sample case study
		PEER REVIEW		
		2. Inspiration • Plan for the Research • Development of Interview guide • Capture your Learnings	**Reading assignments** • Handout on Overview of Inspiration **Class Presentations** • Entirety of the Social Issue • Identification of the Stake Holders **(Examples on Fluoroscent Curtain and Students' Punctuality for Class)** • Interview Questions **(Role Play on Interview with Stakeholders)** • Category wise Learnings capture **Use template 2: Plan your Research** **Template 3. Development of Interview Guide** **Template 4. Capture your Learning**	Familiarization of the respective templates with the help of sample case study

		3. Ideation **3.1 Synthesis** • Search for meaning Create "How might we" question	**Reading assignments** • Handout on Overview of Ideation-Synthesis **Class Presentations** • Create insights • "How might we" questions **Use template 5: Create Insights** **Template 6: Create "How Might We' Questions**	Familiarization of the respective templates with the help of sample case study
		3.0 Ideation **3.2 Prototyping** • Generate Ideas • Select Promising Ideas • Determine what to prototype • Make your prototype Test and get feedback	**Reading assignments** • Handout on Overview of Ideation-Prototyping **Class Presentations** • Story board-demonstrating the possible solutions **Use template 7: Select your best ideas** **Template 8: Determine what to prototype**	• Brain storming • Familiarization of the respective templates with the help of sample case study • Activity on Risk management • Activity on Resource management Structure building games
		PEER REVIEW		
		4.0 Implementation • Create an action plan • Community Partners (if any) • Budgeting & Fundraising 1. **Peer to Peer** 2. **Crowd Funding** 3. **Giving Kiosks** 4. **Donation** 5. **Envelop Funding** 6. **Marathons/ Walkathons** 7. **Conducting Yoga Classes** **(www.causevox.com / www.blog.fundly.com)** • Duration • Ethical concerns • Launch your solution • Feedback (Impact)	**Reading assignments** • Handout on Overview of Implementation **Class Presentations** Pilot implementation plan with required resources and Budget indicating stake holders & their enagement	• Familiarization of the respective templates with the help of sample case study
		5.0 Reflect Reflection of the overall learning	**Reading assignments** • Handout on Overview of	• Familiarization of the respective templates with the help of

		by the students	students Reflection **Use template 9: Reflection on the Process** **Class Presentations** Final Presentation- After Implementation	sample case study

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Program: Automation & Robotics Engineering		Semester: II
Course Title: Computer-Aided Engineering Drawing		Course Code: 15EMEP101
L-T-P: 0-0-3	Credits: 3	Contact Hours: 6 hrs/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching Hours: 72 hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Introduction to engineering drawing and orthographic projections (Manual Drafting)

1. Introduction to engineering drawing – BIS conventions.
2. Orthographic projections: first angle projection and third angle projection – symbolic representation.
3. Projections of points.
4. Projections of lines inclined to both the planes and determination of true length by rotating the view method (Problems on traces of a line and mid-point problems are not included). However, application problems are included.
5. Projection of planes: Planes parallel to one plane and perpendicular to other plane or perpendicular to one plane and inclined to other plane (Two stage problems).
6. Projection of simple solids such as prisms, pyramids, cylinders, cones and sphere and their frustums in simple positions (Base parallel to or in one of the three planes).

Chapter 2: Development of lateral surfaces of solids. (MANUAL)

1. Development of lateral surface of prisms and cylinders (Either full or truncated using parallel line development method)
2. Development of lateral surface of pyramids and cones (Either full or truncated or of their frustums using radial line development method)
3. Development of lateral surfaces of spheres using both the methods and development of transition pieces

Chapter 3: Conversion of pictorial views into orthographic projections using CAD software.

Drawing orthographic projection of objects shown in pictorial views by first angle method of projection using CAD software. (2D drafting only)

Chapter 4: Isometric projection or view using CAD software.

Drawing isometric projections or views of objects shown in orthographic projections using CAD software

Text Books:

1. Text Book of Engineering Drawing by K R Gopalakrishna
2. Text Book of Engineering Drawing by N D Bhatt and V M Panchal

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Program: Automation & Robotics Engineering		Semester: II
Course Title: Engineering Physics Lab		Course Code: 16EPHP102
L-T-P: 0-0-1	Credits: 1	Contact Hours: 2 hrs/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching Hours: 20 hrs	Examination Duration: 3 hrs	

Experiments	
1	Experimental Data Error Analysis
2	Coefficient of Friction
3	Centripetal Force
4	Young's Modulus by Searle's method
5	The Law of Forces by three wire suspension table
6	Force Table and Vector addition of forces
7	Moment of inertia and rotational motion
8	Projectile motion
9	Variable g pendulum
10	Study of one dimension motion by linear air track

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Program: Automation & Robotics Engineering		Semester: III
Course Title: Calculus And Integral Transforms		Course Code: 15EMAB231
L-T-P: 4-0-0	Credits: 4	Contact Hours: 4 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Differential Calculus

Differentiation of standard functions of first and higher orders, Taylor's and Maclaurin's series expansion of simple functions for single variable.

Chapter 2: Integral Calculus

Evaluation of integrals, properties, Beta and Gamma functions, relation between Beta and Gamma functions simple problems, Approximate integration- Trapezoidal rule, Simpson's 1/3 rule.

Chapter 3: Fourier Series

Fourier series, Evaluation of Fourier coefficients, Waveform symmetries as related to Fourier co-efficient, Exponential form of the Fourier series, half range Fourier series. Practical Harmonic Analysis.

Unit II

Chapter 4: Fourier Transform

Exponential Representation of non-periodic signals, Existence of Fourier transforms properties of Fourier Transform: symmetry, scaling, shifting, Fourier transform of Sine and Cosine Convolution theorem

Chapter 5: Laplace Transforms

Definition, transforms of elementary functions- transforms of derivatives and integrals- Properties. Periodic functions, Unit step functions and Unit impulse functions. Inverse Transforms- properties- Initial and final value theorems and examples; Convolution Theorem. Applications to differential equations.

Unit III

Chapter 6: Ordinary Differential Equations of First Order

Introduction, order and degree of equation, Solution of first order first-degree differential equations –variable separable methods, Linear differential equations, Bernoulli's equations, Initial value problems.

Chapter 7: Complex Analysis

Function of complex variables. Limits, continuity and differentiability. Analytic functions, C-R equations in Cartesian and polar forms, construction of Analytic functions (Cartesian and polar forms).

Text Books:

1. Grewal B S, Higher Engineering Mathematics, 38, Khanna Pub, 2001
2. Bali and Iyengar, A text book of Engineering Mathematics, 6, Laxmi Publ, 2003

Reference Books:

1. James Stewart, Early Transcendental Calculus, 5, Cengage Le, 2007.

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Program: Automation & Robotics Engineering		Semester: III
Course Title: Statistics And Integral Transforms		Course Code: 15EMAB201
L-T-P: 4-0-0	Credits: 4	Contact Hours: 4 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50 hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Laplace Transforms

Definition, transforms of elementary functions- transforms of derivatives and integrals- Properties. Periodic functions, Unit step functions and Unit impulse functions.

Inverse Transforms- properties- Initial and Final value theorems, examples, Convolution Theorem. Applications to differential equations.

Chapter 2: Curve Fitting and Regression

Introduction to method of least squares, fitting of curves $\boldsymbol{y = a + bx}, \boldsymbol{y = ab^x}$, $\boldsymbol{y = a + bx + cx^2}$ Correlation and regression. Applications to Engineering problems: fluid flow through a pipe problem-using curve.

Chapter 3: Probability

Definition of probability, addition rule, conditional probability, multiplication rule, Baye's rule. (no proof)

Unit II

Chapter 4: Random variable and Probability Distributions

Discrete and continuous random variables- PDF-CDF- Binomial, Poisson and Normal distributions (Problems only).

Chapter 5: Tests of Hypothesis

Sampling, Sampling distribution, Standard error, Null and alternate hypothesis, Type -I and Type- II errors, Level of significance. Confidence limits, testing of hypothesis for single mean and difference of means (large samples). t-test (test for single mean, paired t-test), Chi Squared distribution, analysis of variance (one-way and two-way classifications). Case studies of designs of experiments (CRD, RBD). Applications to civil Engineering problems

Unit III

Chapter 6: Fourier Series

Fourier series representation of a function, Derivation of Complex coefficients of Exponential Fourier Series and its relationship with coefficients of trigonometric Fourier series, examples. Convergence of Fourier Series, properties. Even and odd functions and examples. Fourier half range series and examples

Chapter 7: Fourier Transform

Exponential Representation of non-periodic functions and Existence of Fourier transforms and simple examples

Text Books:

1. Gupta S C and Kapoor V K, Fundamentals of Mathematical Statistics, 9th edition, Sultan Chand and sons, 2002
2. J. Susan Milton, Jesse C. Arnold, Introduction to Probability and Statistics: Principles and Applications for Engineering and the Comp, 4th edition, TATA McGraw, 2007
3. Kreyszig. E, Advanced Engineering Mathematics, 8th edition, John Wiley, 2003

Reference Books:

1. Kishor S Trivedi, Probability and statistics with reliability queuing and computer science applications, 1st edition, PHI, 2000
2. Miller, Freud and Johnson, Probability and Statistics for Engineering, 5th edition, PHI, 2000
3. Potter.M.C, Jack Goldberg and Aboufadel.E. F, Advanced Engineering Mathematics, 3rd edition, Oxford Ind, 2005

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Program: Automation & Robotics Engineering		**Semester: III**
Course Title: Analog & Digital Electronic Circuit		**Course Code: 18EARC201**
L-T-P: 4-0-0	**Credits: 4**	**Contact Hours: 4 hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 50 hrs	**Examination Duration: 3 hrs**	

Unit I

Chapter 1: Introduction of PN junctions and analog electronics

Diode theory, forward and reverse biased junctions, reverse- bias breakdown, load line analysis, diode applications – limiters, clippers, clampers, voltage multipliers, half wave and full wave rectification, voltage regulators, voltage dividers, pull up, pull down, optocoupler, special purpose diodes – Zener diode, varactor, light emitting diodes, photodiodes. Network theorems and applications: KVL, KCL, Node Method, Loop Method, Superposition, Thevenin's Theorem and Norton's Theorem.

Chapter 2: Transistors

Bipolar Junction Transistors and introduction to MOSFET:
Operating point, Fixed bias circuits, Emitter stabilized biased circuits, Voltage divider biased, Bias stabilization, BJT transistor modeling, Emitter follower, CB configuration, Collector feedback configuration, analysis of CE configuration using h- h-parameter model; Relationship between h-parameter model of CE, CC and CB configuration, Introduction to MOSFETs, MOSFET as a switch.

Chapter 3: Operational Amplifiers

Op-Amp Basics, practical Op-Amp circuits, differential and Common mode operation, Inverting & Non-Inverting Amplifier, differential and cascade amplifier, Op-Amp applications: Voltage follower, Comparator, summing, integrator, differentiator, instrumentation amplifiers, Schmitt trigger, Op-amp based oscillators.

Unit II

Chapter 4: Number system and digital logic gates

Decimal, binary, octal, hexadecimal number system and conversion, binary weighted codes, signednumbers, 1s and 2s complement codes, Binary arithmetic.Logical Operators, Logic Gates-Basic Gates, Other gates, Active high and Active low concepts,
Universal Gates and realization of other gates using universal gates, Gate Performance Characteristics
and Parameters.

Chapter 5: Boolean algebra and combinational logic circuits

Binary logic functions, Boolean laws, truth tables, half adder, full adder, subtractor, associative and
distributive properties, DE Morgan's theorems, realization of switching functions using logic gates.
Switching equations, canonical logic forms, sum of product & product of sums, Karnaugh maps, two,
three and four variable Karnaugh maps, simplification of expressions.

Chapter 6: Design of combinational logic circuits and sequential logic

Introduction to combinational circuits, code conversions, decoder, encoder, priority encoder, multiplexersas function generators, binary adder, subtractor, BCD adder, Binary comparator, arithmetic logic units.Sequential circuits, flip-flops, clocked and edge triggered flipflops, timing specifications, asynchronousand synchronous counters, counter design with state equations, Registers, serial in serial out shift
registers, tristate register, timing considerations.

Unit III

Chapter 7: Data conversions

Introduction to data conversions, R/2 n R DAC, R/2R, Flash, Digital ramp ADC, Successive approximationADC, Slope (integrating) ADC, Delta-Sigma (ΔΣ) ADC, Practical considerations of ADC circuits.

Chapter 8: Digital integrated circuits

Logic levels, propagation delay time, power dissipation fan-out and fan-in, noise margin, logic families
and their characteristics TTL, LSTTL CMOS and ECL integrated circuits and their performance comparison, open collector and tristate gates and buffers.

Text Books:

1. Anant Agarwal, Foundations of Analog and Digital Electronic Circuits, 1, Morgan Kau, 2005
2. Thomas L. Floyd, Digital fundamentals, 9, Pearson Ed, 2006
3. Robert L. Boylestad, Electronic Devices and Circuit Theory, 10, Pearson Ed, 2008

Back

Program: Automation & Robotics Engineering		Semester: III
Course Title: Kinematics of Machinery		Course Code: 19EARC202
L-T-P: 4-0-0	Credits: 4	Contact Hours: 4 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50 hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Introduction to Kinematics

The subject of Kinematics and Dynamics of Machines, Kinematics and Dynamics as Part of the Design Process, Is It a Machine, a Mechanism, or a Structure? Examples of Mechanisms; Terminology, Mobility of Mechanisms, Kinematic Inversion, Grashof's Law for a Four-Bar Linkage.

Chapter 2: Position Analysis

Kinematic Requirements in Design, The Process of Kinematic Analysis, Kinematic Analysis of the Slider-Crank Mechanism, Solutions of Loop-Closure Equations, Applications to Simple Mechanisms, Applications to Compound Mechanisms, Trajectory of a Point on a Mechanism.

Chapter 3: Velocity & Acceleration Analysis

Velocity Vector, Equations for Velocities, Applications to Simple Mechanisms, Applications to Compound Mechanisms. Acceleration Vector, Equations for Accelerations, Applications to Simple Mechanisms, Applications to Compound Mechanisms.

Unit II

Chapter 4: Static Force Analysis

Forces, Moments and Torques, Laws of Motion, Free-Body Diagrams, Drawing a Free-Body Diagram, Characterizing Contact Forces, Static Equilibrium, Analysis of a Two-Force Member, Sliding Friction Force

Chapter 5: CAMS: Design and Kinematic Analysis

Types of Cam, Types of Followers, Prescribed follower motion, Follower motion schemes, Graphical disk cam profile design, Pressure angle, Design Limitations, Analytical disk cam profile design.

Chapter 6: Gears: Kinematic Analysis and Selection

Types of gears, spur gear terminology, involute tooth profiles, spur gear kinematics, rack and pinion kinematics, gear trains, idler gears, planetary gear trains.

Unit III

Chapter 6: Screw Mechanisms

Thread features, Thread forms, Ball screws, Lead Screw kinematics, Screw forces and torques, Differential screws, Auger screws.

Text Books:

1. Fundamentals of Kinematics and Dynamics of Machines and Mechanism, Oleg Vinogradov,

CRC Press-2000.
2. Machines and Mechanisms-Applied Kinematic Analysis, David H. Myszka, Fourth Edition, Pearson Education.

Reference Books:

1. Kinematics, Dynamics and Design of Machinery, Kenneth J. Waldron, Wiley India Pvt Ltd; Second edition.

Back

Program: Automation & Robotics Engineering		**Semester: III**
Course Title: Data Structure Algorithm Design and Analysis		**Course Code: 18EARC203**
L-T-P: 4-0-0	**Credits: 4**	**Contact Hours: 6 hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 50 hrs	**Examination Duration: 3 hrs**	

Unit I

Chapter 1: General Problem Solving Concepts

Problem Solving in Everyday Life, Types of Problems, Problem Solving with Computers - Problem Definition, Solution Design & Refinement, Testing Strategy Development, Program Coding and Testing, Using the Problem Solving Method, Break-Out Diagrams, Difficulties with Problem Solving. How the Computer Stores Data, Functions-function prototypes, Operators, Expressions and Equations.

Chapter 2: Design and Analysis of Algorithms

Algorithms and Their Representations, Modifying Algorithms, Review of Asymptotic Notations, Mathematical Analysis of Non-Recursive and Recursive Algorithms, Brute Force Approaches: Introduction, Selection Sort and Bubble Sort, Sequential Search and Brute Force String Matching, Divide and Conquer: General Method, Defective Chess Board, Binary Search, Merge Sort, Quick Sort and its performance.

Chapter 3: Arrays, Stacks & Queues

Arrays, Dynamically Allocated Arrays, Polynomials, Sparse Matrices, Representation of Multidimensional Arrays, Structures and Unions, Stacks, Stacks Using Dynamic Arrays, Queues, Circular Queues, Evaluation of Expressions, Queues, Single- and Double-Ended Priority Queues.

Unit II

Chapter 4: LINKED LISTS, TREES &GRAPHS

Singly Linked lists and Chains, Representing Chains in C, Linked Stacks and Queues, Polynomials, Additional List operations, Sparse Matrices, Doubly Linked Lists. Introduction, Binary Trees, Binary Tree Traversals, Graph representation, Adjacency matrix, Adjancey list, Application of graphs

Chapter 5: DYNAMIC PROGRAMMING & GREEDY METHOD

Depth First Search and Breadth First Search, The General Method, Warshall's Algorithm, Floyd's Algorithm for the All-Pairs Shortest Paths Problem, Single-Source Shortest Paths, The Traveling Salesperson problem, Kruskal's algorithm, Huffman trees.

Unit III

Chapter 6: Introduction To C++

Overview of C++, Sample C++ program. Different data types, operators, expressions, and statements, arrays and strings, pointers & user defined types. Class Specification, Class Objects, Scope resolution operator, Access members, Defining member functions, Data hiding, Constructors, Destructors, Parameterized constructors

Chapter 7: Basic OOP Concepts

Base Class, Inheritance and protected members, Protected base class inheritance, Inheriting multiple base classes, Virtual function, Calling a Virtual function through a base class reference, Virtual attribute is inherited, and Virtual functions are hierarchical, Pure virtual functions, Abstract classes, Using virtual functions.

Text Books:

1. Maureen Sprankle, Jim Hubbard: "PROBLEM SOLVING & PROGRAMMING CONCEPTS", Pearson Publications, 9th edition, 2012.
2. AnanyLevitin: Introduction to The Design & Analysis of Algorithms, 2nd Edition, Pearson Education, 2007.
3. Horowitz, Sahni, Anderson-Freed: Fundamentals of Data Structures in C, 2nd Edition, Universities Press, 2007.
4. Herbert Schildt: The Complete Reference C++, 4th Edition, Tata McGraw Hill, 2003

Reference Books:

1. Yedidyah, Rubenstein, Tannenbaum: Data Structures Using C and C++, 2nd Edition, Pearson Education, 2003.
2. Thomas H. Cormen, Charles E. Leiserson, Ronal L. Rivest, Cliffor Stein: Introduction to Algorithms, 3rd Edition, PHI, 2010.

Back

Program: Automation & Robotics Engineering		Semester: III
Course Title: Mechanics of Materials		Course Code: 18EARC204
L-T-P: 3-0-0	Credits: 3	Contact Hours: 3 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40 hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Stress & Strain

Introduction, Normal Stress Under Axial Loading, Direct Shear Stress, Bearing Stress, Stresses on Inclined Sections, Equality of Shear Stresses on Perpendicular Planes, Strain, Displacement, Deformation, and the Concept of Strain, Normal Strain, Shear Strain

Chapter 2: Mechanical Properties of Materials

The Tension Test, The Stress-Strain Diagram, Hooke's Law, Poisson's Ratio, Design Concepts, Types of Loads, Safety, Allowable Stress Design, Load and Resistance Factor Design

Chapter 3: Axial Deformation

Introduction, Saint-Venant's Principle, Deformations in Axially Loaded Bars, Deformations in a System of Axially Loaded Bars, Statically Indeterminate Axially Loaded Members

Unit II

Chapter 4: Torsion

Introduction, Torsional Shear Strain, Torsional Shear Stress, Stresses on Oblique Planes, Torsional Deformations, Torsion Sign Conventions, Power Transmission, Statically Indeterminate Torsion Members.

Chapter 5: Equilibrium of Beams

Introduction, Shear and Moment in Beams, Graphical Method for Constructing Shear and Moment Diagrams, Discontinuity Functions to Represent Load, Shear, and Moment

Chapter 6: Bending

Introduction, Flexural Strains, Normal Stresses in Beams, Analysis of Bending Stresses in Beams, Introductory Beam Design for Strength, Flexural Stresses in Beams of Two Materials, Bending Due to Eccentric Axial Load, Un symmetric Bending

Unit III

Chapter 7. Shear Stress in Beams

Introduction, Resultant Forces Produced by Bending Stresses, The Shear Stress Formula, The First Moment of Area Q, Shear Stresses in Beams of Rectangular Cross Section, Shear Stresses in Beams of Circular Cross Section

Chapter 8: Beam Deflections

Introduction, Moment-Curvature Relationship, The Differential Equation of the Elastic Curve,

Deflections by Integration of a Moment Equation, Deflections by Integration of Shear-Force or Load Equations, Deflections Using Discontinuity Functions
Text Books: 1. Timothy .A. Philpot, Mechanics of Materials, An Integrated Learning System, Third edition, Wiley
Reference Books: 1. Roy R., Craig, JR. Mechanics of Materials, Third edition, JOHN WILEY & SONS.

Back

Program: Automation & Robotics Engineering		Semester: III
Course Title: Manufacturing Technology		Course Code: 18EARC205
L-T-P: 3-0-0	Credits: 3	Contact Hours: 3 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40 hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Lathe Machining

Classification of Machining, construction of lathe, driving mechanisms of lathe, different operations on lathe, nomenclature of cutting tools, parameters. Numerical related to machining operations. Material Properties, Selection of materials based on properties, grain size, bonding process. (Tutorial: Simulation of the cutting process using any CAM software, refining parameters through literature study, Process sheets).

Chapter 2: Milling Machining

Need, constructional features of milling machines, types of milling cutters, operations & milling cutter profiles. Milling processes, up milling and down milling concepts, indexing- Simple, compound, differential and angular indexing concepts. Numericals

Chapter 3: Drilling & Abrasive processes

Classification, constructional features of drilling machine & related operations. Types of drill & drill bit nomenclature, drill materials. Numericals. Classification, constructional features of grinding machines (Center less, cylindrical and surface grinding). Selection of grinding wheel grade and structure of grinding wheels, grinding wheel types.(Tutorial: Simulation of the drilling process using any CAM software, selection and application of materials, develop operation process sheet)

Unit II

Chapter 4: Non-Traditional Machining

Need for non-traditional machining, principles, utilization of Abrasive Jet Machining, Water Jet Machining, Electro-Chemical Machining, Electrical Discharge Machining, Wire EDM, Electron Beam Machining, Laser Beam Machining & Plasma Arc Machining

Chapter 5: Welding and Joining Processes

Welding Technology, methods of welding, Gas Welding, Electric Arc Welding, Welding designs, Resistance Welding and Friction welding. Brazing, soldering and fastening technique.(Tutorial: Illustration of the welding process and GD&T terminologies, Welding process

Chapter 6: Advanced Manufacturing

Introduction to CNC machines- Principles of operation, coordinate systems of CNC machine, construction and elements of a CNC system, manual part programming methods, G & M codes, Selection of CNC machine tool. CNC programming (Tutorials: Building and simulation of CNC codes for various machining operations)

Unit III

Chapter 7: Additive Manufacturing

Basics of Additive Manufacturing, classifications, principles, Material and binder, Powder Bed Fusion, Extrusion based systems, Stereolithography, Design for Additive Manufacturing (DFAM) concepts & Applications. (Tutorials: Developing a model using DFAM concept)

Chapter 8: Dimensional Metrology

Definition, need for inspection, standards of measurement-line standards, end standards & wavelength standards, terminologies, methods of measurement. Limits & Fits- Introduction, tolerances, limits of size, fit and tolerances, Limit gauges classification, Co-ordinate Measuring Machine, important features of CMM, Precision instruments based on laser.

Text Books:

1. Manufacturing Technology- Foundry, Forming and Welding, 5e (Volume 1), PN RAO (Call No.- 669 Rao)
2. Manufacturing Technology- Metal Cutting and Machine Tools, PN RAO. (Call No.- 669 Rao, D68-)
3. CNC Machines, ADITHAN (M) AND PABLA (BS), (Call No.- 629.892 ADI)

Reference Books:

1. Rapid prototyping, 3D printing and additive manufacturing principles and applications, CHUA (CK) AND LEONG (KF). (Call No. - 629.892 ADI)
2. Engineering Dimensional Metrology, MILLER. (Call No. - 669 MIL)

Back

Program: Automation & Robotics Engineering		Semester: III
Course Title: Analog & Digital Electronic Circuits Lab		Course Code: 18EARP201
L-T-P: 0-0-1	Credits: 1	Contact Hours: 2 hrs/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching Hours: 28 hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Demonstration of lab equipment and components
CRO, Multimeter, Function Generator, Power supply- Active/Passive Components & Bread Board.
Demonstration of Software – Matlab.
Learning Objectives:
The students should be able to:

1. Identify and demo knowledge of functioning and purposes of different components like Resistors, Inductors, capacitors, transistors etc.

Chapter 2: Demonstration of Lab Equipments and Components
While this experiment may not be directly simulated in MATLAB, MATLAB can be used for educational simulations or virtual labs to introduce students to the functioning of lab equipment and components before they work with physical equipment
Learning Objectives:
The students should be able to:

1. Simulate circuits using Matlab software

Chapter 3: Design and Implementation of Rectifiers with and without Filters: MATLAB can simulate the output waveform of rectifiers and help students understand the effects of filtering on the output signal
Learning Objectives:
The students should be able to:

1. Draw and understand the use of diodes in half wave and fullwave rectifiers without filter and with filter
2. Calculate the ripple and efficiency
3. Calculate the peak value of the output voltage of the rectifiers given the rms input value
4. The process of AC to DC conversion

Chapter 4: Network Theoresm:
Verification of Superposition, Thevenin's. MATLAB can assist in verifying these network theorems using circuit simulations and comparing the results with theoretical calculations
Learning Objectives:
The students should be able to:

1. Explain and Learn circuit analysis using these theorems
2. How to solve linear circuit problems and short circuit current
3. Verifification of Network theorems using Matlab software

Unit II

Structured Enquiry

Design and Implementation of Code Converters, Encoder, and Decoder using Logic Gates: MATLAB can simulate logic gates and code converters, enabling students to analyze their functioning.

Learning Objectives:

The students should be able to:

1. Design and implementation of converters using logic gates
2. Learn how to design and implementation of encoders and decoders
3. Learn how and where to use encoders and decoders

Design an 8-bit ADC Circuit that Utilizes LEDs to Indicate its Binary Output Value: MATLAB/Multisim can simulate the ADC circuit's performance and help students understand its behavior with varying input signals

Learning Objectives:

The students should be able to:

1. Learn how to design and implement 8 bit ADC circuit that to indicate its binary output values
2. Understands why to use Analog to Digital converter

Chapter 6: Demonstrate the Characterization of Ultrasonic Sensor: MATLAB/Multisim can assist in the analysis of ultrasonic sensor data and calibration

Learning Objectives:

The students should be able to:

1. Learn how to measure distance from ultrasonic sensor
2. Understands how to calibrate data from ultrasonic sensor.

Viva, Journal and Attendance Learning Outcomes:

The students should be able to:

1. Command of appropriate communication skills such as technical reports, viva and presentations through the lab.
2. Maintaining the punctuality to all the lab sessions.

Project Learning Outcomes :

The students should be able to:

1. Carryout a project in a team.
2. Come up with PCB design using Eagle software

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Program: Automation & Robotics Engineering		**Semester: III**
Course Title: Kinematics of Machinery lab		**Course Code: 18EARP202**
L-T-P: 0-0-1	**Credits: 1**	**Contact Hours: 2 hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 28 hrs	**Examination Duration: 3 hrs**	

Experiments	
1	Introduction to Matlab
2	Introduction to Multibody Simulation
3	Visualizing Co-ordinate frames
4	Simple Pendulum
5	Double Pendulum
6	Pendulum on cart
7	Crane Base
8	Pendulum waves
9	Four bar linkage
10	Inline –Three Engine
11	Crank & Flywheel
12	Importing CAD model in Mat lab
13	Project

Back

Program: Automation & Robotics Engineering		**Semester: III**
Course Title: Machine Drawing Lab		**Course Code: 18EARP203**
L-T-P: 0-0-1	**Credits: 1**	**Contact Hours: 2 hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 28 hrs	**Examination Duration: 3 hrs**	

Sr. No	Exercise Details	No. of Lab Session(s) per batch (estimate)
1	Explain the importance of information on blueprints .	1
2	Introduction to Solid Works® Interface	1
3	Exercises using Solid Works® 2019 to execute 20 problems using various commands.	3
4	Exercises using Solid Works® 2018 to use different mating commands in assembly module.	2
5	Demonstration of drawing conventions used in GD&T for ANSI and ISO applications.	1
6	Introduction to Protection provided by enclosures for electrical equipment indicated by the IP codes.	1
7	Exercises using Solid Works® Routing to create a special type of subassembly that builds a path of pipes, tubes, electrical cables or ducts between components.	1
8	Exercises using Solid Works® Sustainability to demonstrate basic concepts of sustainable design. Measure the environmental impacts of various design choices, including material, manufacture location, and more on the various parts and assemblies	1

Back

Program: Automation & Robotics Engineering		Semester: IV
Course Title: Vector Calculus and Differential Equations		Course Code: 15EMAB241
L-T-P: 4-0-0	Credits: 4	Contact Hours: 4 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50 hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Partial Differentiation

Function of several variables, Partial derivatives, Chain rule, Errors and approximations

Chapter 2: Multiple Integrals

Double integral, Evaluation by change of order, change of variables, simple problems, Triple integrals simple problems.

Chapter 3: Vector Algebra and Calculus

Vector addition, multiplication (Dot and Cross products), Triple products, Vector functions, Vector differentiation, Velocity and Acceleration of a vector point function, Vector fields, Gradient and directional derivatives.

Unit II

Chapter 4: Vector Calculus-continued

Line and Surface integrals. Independence of path and potential functions. Green's theorem, Divergence of vector field, Divergence theorem, Curl of vector field. Stokes theorem

Chapter 5: Differential equations of second order

Differential equations of second and higher orders with constant coefficients, method of variation of parameters.

Unit III

Chapter 6: Partial differential equations

Introduction, classification of PDE, Formation of PDE, Solution of equation of the type Pp + Qq = R. Solution of partial differential equation by direct integration methods, method of separation of variables

Text Books:

1. Grewal B S, Higher Engineering Mathematics, 38ed, Khanna Publication, New Delhi, 2001.
2. Bali and Iyengar: A text book of Engineering Mathematics, 6ed, Laxmi Publications (p) Ltd, New Delhi, 2003

Reference Books:

1. Early Transcendental Calculus by James Stewart, Thomson Books, 5ed, 2007

Back

Program: Automation & Robotics Engineering		Semester: IV
Course Title: Numerical Methods and Partial Differential Equations		Course Code: 15EMAB206
L-T-P: 4-0-0	Credits: 4	Contact Hours: 4hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50 hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Interpolation techniques

Finite differences, Forward, Backward and central difference operators. Newton Gregory forward and backward interpolation formulae. Sterling's and Bessel's formulae for central difference, Newton's divided difference formula for un equal intervals. Heat transfer problem, gas law problem-shear stress problem-using interpolation.

Chapter 2: Matrices and System of linear equations

Introduction to system of linear equations, Rank of a matrix by elementary row transformations. Consistency of system of linear equations, solution of system by (i) Direct methods-Gauss elimination, Gauss Jordon method (ii) Iterative methods: Guass-Seidal method. Eigen values and Eigenvectors of a matrix. Largest Eigen value and the corresponding Eigenvector by power method. Spring mass system Falling parachutist using system of equations.

Unit II-

Chapter 3: Partial Differenal Equationsti

Introduction, classification of PDE, Formation of PDE, Solution of equation of the type Pp + Qq = R, Solution of partial differential equation by direct integration methods, method of separation of variables. Modeling: Vibration of one-dimensional string-wave equation and heat equation. Laplace equation. Solution by method of separation of variables

Chapter 4: Finite Difference Method

Finite difference approximations to derivatives, finite difference solution of parabolic PDE explicit and implicit methods, hyperbolic PDE-explicit method, Elliptic PDE-initial-boundary value problems. Engineering Problems: Temperature distribution in a heated plate, vibration of a stretched string, steady-state heat flow

Unit III –

Chapter 5: Complex Analysis

Function of complex variables. Limits, continuity and differentiability. Analytic functions, C-R equations in Cartesian and polar forms, construction of Analytic functions (Cartesian and polar forms).

Chapter 6: Complex Integration

Line integral, Cauchy's theorem-- corollaries, Cauchy's integral formula. Laurent's Series, Singularities, Poles, Residue theorem – problems.

Text Books:

1. Kreyszig E., Advanced Engineering Mathematics, 8ed, John Wiley & sons, 2003.
2. Potter M C, Jack Goldberg and Aboufadel E F, Advanced Engineering Mathematics, 3ed,

Oxford Indian Edition, 2005.
3. Grewal B S, Higher Engineering Mathematics, 38ed, TATA McGraw-Hill, 2001
4. Chapra S C and Canale R P, Numerical methods for Engineers, 5ed, TATA McGraw-Hill, 2007

Reference Books:

1. Burden R L and Douglas Faires J, Numerical Analysis, 7ed, Thomson publishers, 2006.
2. Simmons G F and Krantz S G, Differential Equations, TATA McGraw-Hill, 2007.
3. Sastry S S, Introductory method for numerical analysis, 3ed, PHI, 2003

Back

Program: Automation & Robotics Engineering		Semester: IV
Course Title: Machine Design		Course Code: 18EARC206
L-T-P: 3-0-0	Credits: 3	Contact Hours: 3 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40 hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: The Design Process

Introduction, Materials in Design, The Evolution of Engineering Materials, The Evolution of Materials in Products, the Design Process, Types of Design, Design Tools and Materials Data, Function, Material, Shape, and Process.

Chapter 2: Material Property Charts

Exploring Material Properties, Modulus–density chart Strength–density chart, Modulus–strength chart, Maximum service temperature chart, Cost bar charts, The modulus–relative cost chart, and The strength–relative cost chart.

ENGINEERING MATERIALS, THEIR PROPERTIES AND MATERIAL SELECTION

The Families of Engineering Materials, Materials Information for Design, Material Properties and Units

Chapter 3: Kinematics Of Gears and Gear Design

Spur Gear Geometry: Involute-Tooth Form, Interference Between Mating Spur Gear Teeth, Devising Gear Trains, Forces, Torque And Power In Gearing, Gear Manufacture, Gear Quality, Allowable Stress Numbers, Stresses In Gear Teeth, Selection Of Gear Material Based On Bending Stress, Design Of Spur Gears, Power-Transmitting Capacity, Practical Considerations For Gears And Interfaces With Other Elements. Forces and stresses on helical gear teeth, design of helical gears, bearing forces on shafts carrying bevel gears, bending moments on shafts carrying bevel gears, design of bevel gears for pitting resistance, forces, friction, and efficiency in worm gear sets, stress in worm gear teeth, surface durability of worm gear drives.

Unit II

Chapter 4: Keys, Couplings, Seals and Shaft Designs

Materials for keys, stress analysis to determine key length, other methods of fastening elements to shafts, couplings, universal joints, retaining rings and other means of axial location, types of seals, seal materials, shaft design procedure, forces exerted on shafts by machine elements, stress concentrations in shafts, design stresses for shafts, shafts in bending and torsion only, shaft design example, recommended basic sizes for shafts, shaft rigidity and dynamic considerations, flexible shafts

Chapter No. 5. Linear Motion Elements, Springs, Fasteners

Power screws, ball screws, application considerations for power screws and ball screws, bolt materials and strength, externally applied force on a bolted joint, thread stripping strength, other means of fastening and joining. Kinds of springs, helical compression springs, stresses and deflection for helical compression springs, analysis of spring characteristics, design of helical compression springs, helical torsion springs, improving spring performance by shot

peening, spring manufacturing.

Chapter 6: Clutches and Brakes

Descriptions of clutches and brakes, types of friction clutches and brakes, performance parameters, time required accelerating a load, inertia of a system referred to the clutch shaft speed, effective inertia for bodies moving linearly, energy absorption: heat-dissipation requirements, response time, friction materials and coefficient of friction, plate-type clutch or brake.

Unit III

Chapter.7: Bearings: Rolling Contact & Surface Contact

Types of rolling contact bearings, thrust bearings, mounted bearings, bearing materials, load/life relationship, design life, bearing selection: radial loads only, bearing selection: radial and thrust loads combined, mourning of bearings, tapered roller bearings, practical considerations in the application of bearings, importance of oil film thickness in bearings, life prediction under varying loads.

Chapter 8: Machine Frames, Bolted Connections and Welded Joints

Machine frames and structures, recommended deflection limits, design to resist bending, design of members to resist torsion, eccentrically loaded bolted joints, types of joints, types of welds, size of weld, method of treating weld as a line, welded joints.

Text Books:

1. Robert L. Norton, Machine Design, Pearson Education edition, Prentice Hall, 2005
2. Robert L. Mott, Machine Elements in Mechanical Design, Fourth edition, PEARSON Prentice Hall, 2004.

Reference Books:

1. Shigley J.E. and Mischke C.R, Mechanical Engineering Design, McGraw Hill Publication Co. Ltd
2. Michael F. Ashby, Materials Selection in Mechanical Design, Fourth Edition, 2014, 2014

Back

Program: Automation & Robotics Engineering		Semester: IV
Course Title: Control Systems		Course Code: 19EARC207
L-T-P: 4-0-0	Credits: 4	Contact Hours: 4hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50 hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Introduction to Control System and System Modeling in Frequency Domain
System Configurations (open-loop & closed loop systems), Analysis and Design Objectives, The Design Process. Mathematical modeling of physical Systems: Electrical networks, Mechanical systems, Electro mechanical systems, Analogous systems.

Chapter 2: Topological Models
Transfer function, Block diagram representation and reduction, signal flow graph representation and reduction using Mason's Gain formula, Transfer functions of control components – dc servomotor.

Chapter 3: Time –Domain Analysis
Standard test signals, Unit step response of First and second order systems, Time response specifications of first and second order systems, steady – state errors and error constants.

Unit II

Chapter 4: Stability Analysis
Concepts of stability, Necessary conditions for Stability, Routh- stability criterion, Relative stability analysis; More on the Routh stability criterion.

Chapter 5: Root Locus Techniques
Introduction, The root locus concepts, Construction of root loci.

Chapter 6: Design Via Frequency Response
Control System Design via Frequency Response – Lead, Lag and Lag-Lead Compensation

Unit III

Chapter 7: Design Via Frequency Response
Transient Response via Gain Adjustment, Lag Compensation, Lead Compensation, Lag-Lead Compensation, tuning of PID controllers.

Chapter 8: Design Via Root Locus
Improving Transient Response and Steady-State Error via Cascade Compensation, Feedback Compensation, Physical Realization of Compensation

Text Books:

1. Norman S. Nise, "Control Systems Engineering", John Wiley & Sons, Inc, Sixth edition, 2011.

Reference Books:

1. Benjamin C. Kuo, Automatic Control Systems by,PHI/ 7th edition.

2. https: //ocw.mit.edu/courses/2-04a-systems-and-controls-spring-2013.
3. K.Ogata “Modern Control Engineering”, Pearson Education Asia/ PHI, 4th Edition, 2002.

Back

Program: Automation & Robotics Engineering		Semester: IV
Course Title: Microcontrollers Programming & Interfacing		Course Code: 18EARC208
L-T-P: 4-0-0-	Credits: 4	Contact Hours: 4hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50 hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Introduction to Microcontroller

Introduction To Microprocessor and Microcontroller: History and Evolution, types of microprocessors, Difference between Microprocessors and Microcontrollers. CPU architectures: RISC/CIS, Overview of PIC Microcontroller family, Introduction to different microcontroller families (8051, ATMEL/AVR, and ARM).

Chapter 2: Microcontroller Architectures and System Design

The architecture of microcontrollers (Harvard vs von Neumann), STM 32 ARM Architecture, ESP Microcontroller Architecture, Memory organization (ROM, RAM, EEPROM, Flash), Input/output ports (GPIO, ADC, DAC, PWM), System design considerations (power, timing, interfacing)

Chapter 3: Introduction to the STMicroelectronics Line of Microcontrollers

Overview of STMicroelectronics microcontroller families (STM32, STM8), Features and specifications of STM32 microcontrollers, Advantages of using STMicroelectronics microcontrollers, Comparison with other microcontroller brands.

Unit II

Chapter 4: HAL, GPIO and Interrupt Management, A/D Conversions

STM32 peripherals mapping and HAL handlers, GPIO configuration, GPIO Modes. GPIO Alternate functions, GPIO Speeds, Driving a GPIO and De-initializing GPIOs. NVIC Controller, Vector table in STM32, Enabling Interrupts, Interrupt lifecycle, Interrupt priority levels, Interrupt re-entrancy, masking Interrupts. HAL_ADC Module, Conversion modes, HAL_DAC Module and DAC peripherals.

Chapter 5: Communication with STM32

Universal Asynchronous serial communication – UART ad USARTs, URAT communication in polling mode, URAT in Interrupt mode, Error Management and I/O retargeting, I2C- Specs and Protocols, Start Stop Conditions, I2C peripherals in STM32 MCUs, HAL_I2C Module. SPI Interface, HAL_SPI Module.

Chapter 6: Clock Tree and Timers

Clock distribution in STM32, Overview of HAL_RCC module, Introduction to Timers, Timers

Unit III –

Chapter 7: Application Development and Setting Up the Tool Chain

Embedded systems design and development, Real-time operating systems (RTOS), sensor and actuator interfacing, Robotics and automation applications, Tool chain in different environments, STM32 Cube IDE, Eclipse, GCC ARM, ST Tools and drivers.

Chapter 8: Case studies: Microcontrollers in robotics and automation. Microcontroller-based robot control systems, Microcontroller-based automation systems, Design and implementation of microcontroller-based control systems for various applications, Integration of microcontrollers with other hardware and software platforms.
Text Books: 1. Carmine Noviello, “Mastering STM32”, Lean Pub publications, 2018 Edition. 2. Donald Norris, “Programming with STM32 getting started with Nucleo board and C/C++”, McGraw-Hill Education
Reference Books: 1. Ramesh Gaonkar, Fundamentals of microcontrollers and Applications in Embedded Systems. Penram International Publishing(India) Pvt. Ltd. 2. Ajay V Deshmukh, “Microcontroller: Theory and Applications” 3. M Krishnakumar, “Microprocessors and Microcontrollers”.

Back

Program: Automation & Robotics Engineering		Semester: IV
Course Title: Object Oriented Programming & DBMS		Course Code: 19EARC209
L-T-P: 4-0-0	Credits: 4	Contact Hours: 4hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1. Fundamental Concepts of Object Oriented
programming: Introduction to the principles of object-oriented programming, classes, objects, messages, encapsulation, inheritance, polymorphism, exception handling, and object-oriented containers, Access Specifiers, Member Functions, Instance of a Class, Default Constructors, Destructors, Accessing Data Fields, Constructors with Parameters, Static Class Members, - Data Members and Member Functions.

Chapter 2. Object-Oriented Programming - I
Inheritance, Derived Class, Calling the Base Class Constructor, Overriding Member Functions, Polymorphism, Class Inheritance Hierarchies, Revisiting Class Diagrams, Abstract Classes, Run-Time Information, Early vs. Late Binding, Virtual Base Classes, Multiple Inheritance, Interfaces, Scope Resolution Operator, Nested Classes, Local Classes, Passing Objects to Functions, Return Objects, Object Assignment, Friend Function, Operator Overloading, Function Overloading, Copy Constructors.

Chapter 3: Object-Oriented Programming-II
Data types, program control, Functions, Numerical Computations in Python - NumPy arrays, SciPy for numerical methods, Data plotting with Matplotlib, Statistical modelling in Python - Pandas for Data Frame, SciPy and stats models for basic statistical data analysis, Image Processing in Python scikit-image, filtering, edge detection.

Unit II

Chapter 4: SDLC Models, Object Oriented Analysis and Structural Modeling
SDLC Models-waterfall model, v-model, spiral model and agile model, Requirement Engineering, System Modelling, UML and SysML Walkthrough, Class Diagram, Use Case Diagram, State Chart Diagram, Activity Diagram, Sequence Diagram.

Chapter 5 Introduction to Database Management System
Introduction to DBMS and an example, Characteristics of Database approach; Actors on and Behind the Scene; Advantages and Disadvantages of using DBMS; Data models, schema and instances; Three-schema architecture and data independence; Database languages and interfaces; The database system environment.

Chapter 6: Data Models
Using High-Level Conceptual Data Models for Database Design; An Example

Unit III:

Chapter 7: Relational Database Design and Structured Query Language

Relational Model Concepts; Relational Model Constraints and Relational Database Schemas; Update Operations, SQL Data Definition and Data Types; Specifying basic constraints in SQL, Insert, Delete and Update statements in SQL; Specifying constraints as Assertion and Trigger; Views in SQL; Basic queries in SQL

Chapter 8: Normalization

Informal Design Guidelines for Relation Schemas; Functional Dependencies; Normal Forms Based on Primary Keys; General Definitions of Second and Third Normal Forms; Boyce-Codd Normal Form.

Text Books:

1. Herbert Schildt, “C++: The Complete Reference”, Tata McGraw-Hill, 2003.
2. Allen B. Downey “Think Python” First Edition, Green Tea Press,2011
3. Ian Sommerville, “Software Engineering,” Pearson Publication, 9th edition, 2010.
4. Grady Booch, James Rumbaugh and Ivar Jacobson, “Unified Modeling Language User Guide,” Addison-Wesley, 1999.
5. Ramez Elmasri and Shamkant B. Navathe, “Fundamentals of Database Systems,” Pearson Education, 5th edition, 2008.

Reference Books:

1. Ramakrishnan S. and Gehrke J: “Database Management Systems”, 3rd edition, McGraw Hill, 2007
2. R. S. Pressman, “Software Engineering – A practitioner’s approach”, 3rd ed., McGraw Hill Int. Ed
3. Mark Lutz Programming Python, 4th Edition, O'Reilly Media, Inc., December 2010

Back

Program: Automation & Robotics Engineering		Semester: IV
Course Title: Object Oriented Programming & DBMS Lab		Course Code: 19EARP209
L-T-P: 0-0-1	Credits: 1	Contact Hours: 2hrs/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching Hours: 24 hrs	Examination Duration: 3 hrs	

Experiment Number	Experiments
01	Getting used to tool, and creating use case, class diagram, and sequence diagram.
02	Write programs in .NET using the concept of OOP like class, objects, functions, inheritance, encapsulation and Polymorphism.
03	Write programs in python using the concepts of constructs, data structures, functions, modules, packages and regular expressions.
04	Write programs in python using the concept of generic classes, inheritance, encapsulation and Polymorphism.
05	Creating ER models considering different relationship and attributes.
06	Execute SQL queries on - group by, having clauses and aggregate functions on a given database to retrieve the required data.
07	Design a database for the given schema using normalization concept and write and execute the SQL statements for given queries.
08	Develop a class diagram concerning sensor, actuators and controls, implement these classes, and build DLL files.
09	Develop an ER model and construct a database schema for sensor, actuators and controls.
10	Implement an application that utilizes previously generated DLL files and database schema to store data from sensors and control the actuators.
11	Implement any project using C++/ Python/DBMS concepts, for automation and robotics applications.

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Program: Automation & Robotics Engineering		Semester: IV
Course Title: Robot Analysis & Design		Course Code: 18EARC210
L-T-P: 4-0-0	Credits: 4	Contact Hours: 4 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Introduction to Robotics and Applications

Introduction, Classifications of Robots, Robot Components, Robot Degrees of Freedom, Robot Joints, Robot Coordinates, Robot Reference Frames, Programming Modes, Robot Characteristics, Robot Workspace, Robot Languages, and Robot Applications.
Representing Position and Orientation Coordinate frames, representing Pose in 2-Dimensions, representing Pose in 3-Dimensions, representing Orientation in 3-Dimensions, orthonormal Rotation Matrix, three-Angle Representations, combining Translation and Orientation.

Chapter 2: Position Analysis of Serial Manipulators

Describing a Robot Arm, Link Parameters and Link Coordinate systems, Homogeneous transformation Matrices, Denavit-Hartenberg, Product of Exponential formula in space frame, Forward Kinematics, Inverse Kinematics, A 2-Link Robot, A 6-Axis Robot.

Chapter 3: Introduction to Robotics and Applications

Introduction, Classifications of Robots, Robot Components, Robot Degrees of Freedom, Robot Joints, Robot Coordinates, Robot Reference Frames, Programming Modes, Robot Characteristics, Robot Workspace, Robot Languages, and Robot Applications.
Representing Position and Orientation Coordinate frames, representing Pose in 2-Dimensions, representing Pose in 3-Dimensions, representing Orientation in 3-Dimensions, orthonormal Rotation Matrix, three-Angle Representations, combining Translation and Orientation.

Chapter 4: Jacobian Analysis of Serial Manipulators

Different Kinematics of rigid body, Different Kinematics of serial manipulators, screw coordinates and screw systems, Manipulator Jacobian Matrix, conventional Jacobian, Screw-Based Jacobian, and Transformations of screw coordinates. Relationship Between Two Methods, condition number, singularity analysis.

Unit II-

Chapter 5: Statics and Dynamics of Serial Manipulators

Types of gears/ motor/ drives/ encoders, Motion controller (Motion control software),Statics of Serial Manipulators, Transformations of Forces and Moments, mass properties, momentum, transformation of inertia matrix, kinetic energy. Newton-Euler Laws, Recursive Newton-Euler Formulation

Chapter 6: Trajectory planning

Path versus Trajectory, Joint-Space versus Cartesian-Space Descriptions, Basics of Trajectory Planning, Joint-Space Trajectory Planning, Third-Order Polynomial Trajectory Planning, Fifth-Order Polynomial Trajectory Planning, Linear Segments with Parabolic Blends, Linear Segments with Parabolic Blends and Via Points, Higher-Order Trajectories, Other Trajectories, Cartesian-Space Trajectories, Continuous Trajectory Recording.

Unit III

Chapter 8: Tendon-Driven Manipulators

Introduction, classification of Tendon-Driven Manipulators, Planar Schematic Representation, Kinematics of Tendon-Driven Manipulators, Static Force Analysis, Feasible Structure Matrices, Redundant forces resolution.

Text Books:

1. Saeed B. Niku, "Introduction to Robotics, Analysis, Systems, Applications, PHI Learning private limited. 2009.
2. Lung-Wen Tsai, “Robot Analysis”, A Wiley-Interscience Publications, John Wiley & Sons, Inc., 1999.
3. S.K. Saha, “Introduction to Robotics”, Tata McGraw Hill Education Private Limited, 2008.

Reference Books:

1. Fu K.S., Gonzalez R.C., and Lee C.S.G., "Robotics control, Sensing, Vision and Intelligence”, McGraw-Hill Book Co.
2. Groover M.P., “Industrial Robotics, programming and applications ", McGraw-Hill Book Co., 1995.
3. AshitaviaGhoshal, “Robotics Fundamental Concepts & Analysis”, Oxford University Press.
4. John J. Craig, “Introduction to Robotics-Mechanics & Control”, Pearson Education, Inc., 2005.
5. T. Bajd, M. Mihelj, J. Lenarcic, A. Stanovnik, M. Munih., “Robotics”, Springer, Vol 43.
6. Peter Corke, “Robotics, Vision and Control: Fundamental Algorithms In MATLAB, Second, Completely Revised, Extended and Updated Edition: 118 (Springer Tracts in Advanced Robotic

Back

Program: Automation & Robotics Engineering		**Semester: IV**
Course Title: Manufacturing & Metrology Lab		**Course Code: 16EARP205**
L-T-P: 0-0-1	**Credits: 1**	**Contact Hours: 2 hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 24 hrs	**Examination Duration: 3 hrs**	
Experiment 1- Material Removal Operation		
Experiment 2- Metrology		
Experiment 3- Additive Manufacturing		
Experiment 4- Measurement for linear and angular dimensions		
Experiment 5- Fabrication of XY positioning table		

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Program: Automation & Robotics		Semester: **IV**
Course Title: Microcontrollers Programming & Interfacing Lab		**Course Code: 18EARP208**
L-T-P: 0-0-1	**Credits: 1**	**Contact Hours: 2hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 24 hrs	**Examination Duration: 3 hrs**	

Exp. No.	List of Experiments
1	Write a program to demonstrate the working with I/O ports by initializing pins and blinking of LED in PIC16F877A and Arduino board using Assembly and Embedded C language
2	Write a program to demonstrate a counting machine which count from 0000 to 9999 and display on 7 segment LED display using Timers of PIC16F877A in Assembly and Embedded C language.
3	Write a program to read the values from the temperature sensor (LM35) and display the temperature in degree Celsius on LCD display.
4	In bank lockers, there is a requirement of password protection to open the locker. Develop an application Using a 4*3 keypad and LCD to secure the lockers by providing password protection
5	Write a program to measure an object's distance using ultrasonic sensors and display the distance in terms of centimeters and inches. Make the connections as per the schematic and develop the flowchart and code to perform the required operation.
6	Design and develop an interconnected connection of controllers to communicate and transfer data between them use Bluetooth module and controller.
7	Write a program using Analog to Digital Converter where in read the speed of a motor from a user interface and convert them to digital values to control the speed of the DC, stepper, and servo motors.
8	Design and develop an IOT (Internet of Things) system to collect data from a load sensor and store the data in the cloud. Use Wi-Fi-module and controller.
9	Develop an application using Node MCU to predict the data using the existing trained module.
10	The Open Ended Project is based on understanding, modeling and developmentof solution for a real time problem.

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Program: Automation & Robotics Engineering		Semester: V
Course Title: Numerical Methods and Statistics		Course Code: 15EMAB301
L-T-P: 3-0-0	Credits: 3	Contact Hours: 3hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Numerical Methods

Introduction to numerical methods. Roots of equations using Bisection Method, Newton-Raphson Method, Finite differences, Forward, Backward Operators. Newton Gregory forward and backward interpolation formulae. Newton's divided difference formula for unequal intervals. Numerical solution of first order ODE, Euler's and Modified Euler's method, Runge-Kutta 4^{th} order method.

Python: Interpolation problems related to Mechanical engineering/Civil/AR

Chapter 2: Matrices and System of Linear Equations

Introduction to the system of linear equations, Rank of a matrix by elementary row transformations. Consistency of system of linear equation solution of system by (i) Direct methods-Gauss elimination, Gauss Jordon method (ii) Iterative methods- Gauss-Seidel method. Eigenvalues and Eigenvectors of a matrix. Largest Eigen value and the corresponding Eigenvector by power method.

Python: Matrices, system of linear equations by Gauss elimination, Gauss Jordon and eigenvalue problems

Unit II

Chapter 3: Curve Fitting and Regression

Introduction to method of least squares, fitting of curves $\boldsymbol{y = a + bx}$, $\boldsymbol{y = ab^x}$, $\boldsymbol{y = a + bx + cx^2}$, correlation and regression.

Python: Fitting of curves, correlation and regression

Chapter 4: Probability

Definition of probability, addition rule, conditional probability, multiplication rule, Baye's rule. (no proof) Discrete and continuous random variables- PDF-CDF- Binomial, Poisson and Normal distributions (Problems only).

Python: Probability distributions

Unit III –

Chapter No. 5. Sampling Distribution-I

Sampling, Sampling distribution, Standard error, Null and alternate hypothesis, Type-I and Type- II errors, Level of significance. Confidence limits for means (large sample).

Chapter No. 6. Sampling Distribution-II

Testing of hypothesis for means. Large and small samples and student's t- distribution and Confidence limits for means (small sample).

Python: Sampling distributions

Text Books:

1. Bali and Iyengar, A text book of Engineering Mathematics, 6ed, Laxmi Publications(p) Ltd, New Delhi,2003.
2. Chapra S C and Canale R P, Numerical methods for Engineers, 5ed, TATA McGraw-Hill, 2007.
3. Gupta and Kapoor V K, Fundamentals of Mathematical Statistics, 9, Sultan and Chand, 2002

Reference Books:

1. Sastry S S, Introductory method for numerical analysis, 3ed, PHI, 2003.
2. J. Susan Milton, Jesse C. Arnold, Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences, 4th Ed, TATA McGraw-Hill Edition 2007

Back

Program: Automation & Robotics Engineering		Semester: V
Course Title: Machine Learning & ROS		Course Code: 18EARC301
L-T-P: 3-0-0	Credits: 3	Contact Hours: 3 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: The Machine Learning Landscape

Introduction to machine learning and its applications, Types of machine learning: supervised, unsupervised, reinforcement learning.The main challenges of machine learning: data quality, overfitting, underfitting, bias, etc.The machine learning workflow: data preparation, model training, model evaluation, deployment.

The Python ecosystem for machine learning: NumPy, Pandas, Matplotlib, Scikit-Learn, Keras, TensorFlow. Setting up your machine learning environment: Anaconda, Jupyter Notebook, virtual environments.

Chapter 2: End-to-End Machine Learning

Understanding and analyzing the problem, Gathering and exploring the data, Preparing the data for machine learning: data cleaning, feature engineering, feature scaling, handling missing values. Selecting a model and training it, Fine-tuning the model: hyperparameter tuning, cross-validation, Evaluating the model and making predictions, Documenting the project and presenting the results.

Chapter 3: Classification

The classification task and its applications, Binary classification and multiclass classification, Evaluating classification models: accuracy, precision, recall, F1 score, confusion matrix, Common algorithms for classification: Logistic Regression, k-Nearest Neighbors, Decision Trees, Random Forests, Support Vector Machines. Using Scikit-Learn for classification.

Unit II-

Chapter 4: Training Models

The linear regression model and its assumptions, Training linear regression models with Scikit-Learn, Gradient descent and its variants, Polynomial regression and other nonlinear models, Regularization techniques (L1, L2, Elastic Net), Logistic regression and softmax regression, Using Keras and TensorFlow for deep learning.

Chapter 5: Support Vector Machines

Introducing SVMs and their applications, Linear SVM classification and regression, Nonlinear SVM classification and regression, SVM optimization and the dual problem, Kernel tricks for SVMs.

Chapter 6: Decision Trees and Random Forests

The decision tree model and its advantages and disadvantages, Training decision trees with Scikit-Learn, Regularization techniques for decision trees (max_depth, min_samples_split, etc.), The random forest model and its advantages over decision trees, Training random forests with Scikit-Learn.

Unit III

Chapter 6: Ensemble Learning and Gradient Boosting

Introducing ensemble learning and its advantages, Combining weak learners into strong learners (bagging, boosting, stacking), The AdaBoost algorithm for boosting
Gradient boosting and its variants (XGBoost, LightGBM), Using ensemble methods with Scikit-

Chapter 7: Neural Networks and Deep Learning

The basics of neural networks and their architecture, Activation functions and loss functions, Training neural networks with backpropagation and stochastic gradient descent, Convolutional neural networks (CNNs) for image recognition, Recurrent neural networks (RNNs) for sequence prediction, Generative models (GANs, VAEs) for image and text generation, Using Keras and TensorFlow for deep learning.

Text Books:

1. Aurélien Géron " Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems" O'Reilly Media, October 2019, 2nd edition. ISBN-13: 978-1492032649
2. Kevin P. Murphy "Machine Learning: A Probabilistic Perspective" The MIT Press, August 2012, ISBN-13: 978-0262018029

Reference Books:

1. Shai shalev-scwartz and Shai Ben David "Understanding Machine Learning" First Edition, Cambridge Press, USA, 2014.
2. Tom Mitchell "Machine Learning" McGraw-Hill Science/Engineering/Math (March 1, 1997).

Back

Program: Automation & Robotics Engineering		Semester: V
Course Title: Real-time Embedded Systems		Course Code: 18EARC303
L-T-P: 4-0-0	Credits: 4	Contact Hours: 4 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Introduction to System Structures and Real-time Embedded System

System Structures types, Real-time systems & basics, Classification, Example case studies, namely, Process control system, Avionics system, Multimedia systems, Intensive Care Computing, Modern car, Digital Flight control system, Embedded system purpose, Quality attributes, Challenges and characteristics of Embedded Computing System Design, Embedded System Design Process, Core and Supporting components of the embedded system, Embedded firmware, discussion on real-time case studies and block diagram representation of systems, Embedded design cycle-case study- Engine Control Unit, GPS Moving Map, Automatic Chocolate Vending Machine (ACVM) using Finite State machine(FSM), Unified Modeling Language(UML), state charts etc.

Chapter 2: Target Architectures: ARM Cortex M3 processors & its Programming

Introduction to embedded computing with examples and arm processors, The architecture of ARM Cortex M3, Nested Vector Interrupt Controller. Interrupt behavior of ARM Cortex M3. Exceptions Programming. Advanced Programming Features. Memory Protection. Debug Architecture. Digital Signal Processor (DSP), Field Programmable Generic Array (FPGA).Examples to demonstrate each of its architectural and programmable features. A case study on the Antilock Brake System(ABS) and stability control system

Chapter 3: Real-Time Kernels and Operating Systems

Introduction to Real-Time Kernels, Tasks, process and threads, Introduction to RTOS, key characteristics of RTOS, its kernel, components in RTOS kernel, objects, scheduler, services, context switch, Task scheduling, Task communication and synchronization, Multiprocessing and multitasking, Multi-Threading, Hyper-threading, State diagrams, timing diagrams, examples for each, Scheduling types: Preemptive priority-based scheduling, Round-robin and preemptive scheduling. First come first served scheduling, shortest job first scheduling, Device drivers and selection of an RTOS. Examples for each of the scheduling technique, objects, context switching, synchronization, and device drivers, Case study on Mars Pathfinder mission

Unit II

Chapter 4: Inter-task Communication in RTOS

Tasks, Semaphores and Message Queues: A task, its structure, A typical finite state machine, Steps showing the how FSM works. A semaphore, its structure, binary semaphore, mutual exclusion (MUTEX) semaphore, Synchronization between two tasks and multiple tasks, Single shared-resource-access synchronization, Recursive shared- resource-access synchronization. A message queue, its structure, Message copying and memory use for sending and receiving messages, Sending messages in FIFO or LIFO order, broadcasting messages., Demonstration of each of the objects of Inter-process communication, namely, semaphore, Message Queue,

MUTEX, Mailbox, etc. Case-study on Magnetic Resonance Imaging (MRI)

Chapter 5: Tasks and Task Management

RTOS - task creation and Management, task scheduling, kernel services, inter-task-communication, Micro C/OS-II- task creation and Management, task scheduling, kernel services, inter-task-communication, Demo on Task creation and management functions. Case studies on Industrial Robot, Weapons Defence System, Adaptive Cruise control

Chapter 6: Handling Deadlocks

Sharing Resources, Deadlock Model- Necessary Conditions, A Graph-Theoretic Tool—The Resource Allocation Graph, Handling Deadlocks, Deadlock Prevention, Deadlock Avoidance, Deadlock Detection, Demonstration on Handling of deadlocks, identification through a case study, The Dynamic Dining Philosopher problem

Unit III

Chapter 7: Performance Analysis and Optimization

Performance or Efficiency Measures, Complexity Analysis—A High-Level Measure, The Methodology, Analyzing Code, algorithms, Response Time, Time Loading, Memory Loading, Evaluating Performance, Performance Optimization, optimizing for Power Consumption. Demonstration of concepts of Performance Analysis and Optimization through a case-study.

Chapter 8: Wired and Wireless Protocols used in Real-Time Embedded System

Bus communication protocol (USB, I2C, SPI), Wireless and mobile system protocol (Bluetooth, 802.11 and its variants, ZigBee), Examples of block diagrams to explain the working of each protocol for a specified application.

Text Books:

1. James K. Peckol, " Embedded Systems A Contemporary Design Tool," Wiley student edition
2. Joseph Yiu " The Definitive Guide to the ARM Cortex–M3"
3. Silberschatz, Galvin, and Gagne, "Operating system concepts," 8th edition, WILEY Publication.

Reference Books:

1. Shibu K V, "Introduction to Embedded Systems Tata McGraw Hill, New Delhi, 6th reprint 2012.
2. Raj Kamal," Embedded Systems," McGraw-Hill Education
3. Steve Furber, "ARM System-on-Chip Architecture" LPE, Second Edition

Back

Program: Automation & Robotics Engineering		Semester: V
Course Title: Mechatronics System Design		Course Code: 18EARC304
L-T-P: 4-0-0	Credits: 4	Contact Hours: 4 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50hrs	Examination Duration: 3 hrs	

Chapter 1: Introduction to Mechatronics

Introduction to Mechatronics, Evolution of Mechatronics systems, Key elements of Mechatronics, Role of Mechatronics in Industrial Automation, Design methodology for Mechatronics systems-VDI2206.

Chapter 2: Requirements Collection

What is requirement, types of requirements, Steps and techniques of requirement gathering, importance requirement gathering, Mind map.

Chapter 3: Writing Specifications

What is specification, Tips for writing technical specification, what are product Specifications, Steps to write product specifications.

Chapter 4: System Design

Partitioning modules, synergies, function behavior system.

Chapter 5: Modelling and Simulation

Models of components, Behavior analysis, Requirements for components design.

Chapter 6: Prototype

Introduction to virtual Prototyping, Action Plan, MATLAB simulation of the proposed prototype

Chapter 7: Testing

Test plan, User-experience feedback, and iteration process, Identify limitations and scope for further improvement.

Text Books:

1. Mechatronics system design by Devdas Shetty, Richard A. Kolk, Second edition.
2. Practical Model-Based Systems Engineering by Jose L. Fernandez, Carlos Hernandez (z-lib.org) (1).

Reference Books:

1. Mechatronics system fundamentals by Rolf Isermann.

Back

Program: Automation & Robotics Engineering		Semester: V
Course Title: Measurement Systems		Course Code: 18EARC305
L-T-P: 3-0-0	Credits: 3	Contact Hours: 4 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Introduction to Measurement Systems

Need for study of Measurement Systems, Classification of Types of Measurement Applications, Computer-Aided Machines and Processes, Functional Elements of an Instrument, Active and Passive Transducers, Analog and Digital Modes of Operation, Null and Deflection Methods, Input-Output Configuration of Instruments and Measurement Systems, Static Characteristics and Static Calibration, Dynamic Characteristics.

Chapter 2: Sensors and Signal conditioning

Sensor characterization, Relations between physical quantities, Sensor Classification, Specifications, Error reduction techniques, Loading errors, Signal conditioning processes, The operational amplifier, Filtering, Wheatstone bridge, Pulse modulation.

Chapter 3: Motion Measurement

Fundamental Standards, Relative Displacement: Translation and Rotational, Relative Velocity: Translation and Rotational, Relative-Acceleration Measurements, Displacement Pickups, Velocity Pickups, Acceleration Pickups, Calibration and Vibration Pickups, Jerk Pickups

Unit II

Chapter 4: Force, Torque, and Shaft Power Measurement

Standards and Calibration, Basic Methods of Force Measurement, Characteristics of Elastic Force Transducers, Torque measurement on Rotating shaft, Shaft Power Measurement (Dynamometers), Vibrating Wire Force Transducers.

Chapter 5: Pressure & Sound Measurement

Standards and Calibration, Basic Methods of Pressure Measurement, Deadweight Gages and Manometers, Elastic Transducers, Vibrating-Cylinder and Other Resonant Transducers, Dynamic Testing of Pressure-Measuring Systems, High-Pressure Measurement, Low-Pressure Measurement, Sound Measurement.

Chapter 6: Flow and Temperature Measurement

Local Flow Velocity, Magnitude and Direction, Gross Volume Flow Rate, Standards and Calibration of Temperature Measurement, Thermal-Expansion methods, Thermoelectric Sensors, Electrical-Resistance Sensors, Junction Semiconductor Sensors, Digital Thermometers, Radiation Methods.

Unit III

Chapter No.7. Data Acquisition Systems

Data conversion devices, Signal sampling and aliasing, Sampling theorem, Quantization,

Encoding, Digital to analog conversion methods, Analog to digital conversion methods, Sample & Hold circuit, Flash ADC, Successive approximation ADC, Dual slope ADC, Sigma Delta ADC, Multiplexers.

Chapter 8: Transmission and Recording of Data

Cable Transmission of Analog Voltage and Current Signals, Cable Transmission of Digital Data, Fiber-Optic Data Transmission, Analog Voltmeters and Potentiometers, Electrical Instruments, Digital Voltmeters and Multimeters, Signal Generation, Electromechanical XT and XY Recorders, Fiber Optic Sensors.

Text Books:

1. Ernest O. Doebelin and Dhanesh N. Manik, “Measurement Systems”, Sixth Edition, McGraw Hill Education Pvt Ltd, 2011.
2. W. Bolton, “Mechatronics – Electronic Control Systems in Mechanical and Electrical Engineering”, Fourth Edition, PEARSON, 2010.

References:

1. Sabri Cetinkunt “Mechatronics with Experiments”, WILEY, Second Edition, 2015.
2. J. P. Holman, “Experimental Methods for Engineers”, Eighth Edition, McGraw Hill Education Pvt Ltd, 2012

Back

Program: Automation & Robotics Engineering		Semester: V
Course Title: Programming Industrial Automation Systems		Course Code: 18EARC302
L-T-P: 4-0-0	Credits: 4	Contact Hours: 8hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 24 hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Programmable logic controllers (PLC) and its building blocks

Internal architecture of Programmable Logic Controllers systems, Input/ Output devices, Memory Organization, I/O processing, Signal conditioning, Remote connections, Networks, Processor Scan cycle, Error Checking and Diagnostics.

Chapter 2: The IEC 61131, IEC61499 standards and Ladder, FB, IL, SFC and ST programming

IEC 61131-3: Building Blocks, Goals, benefits, Programming Languages of IEC 61131-3, Ladder diagrams, Analogy with Boolean Algebra and Binary Logic, Function blocks, Instruction lists, Sequential function charts, State chart modelling, Structured text programming with example programs for each, IEC 61499 models: models, concepts and industrial examples like Temperature control system, Conveyor test station

Chapter No. 03. Advanced PLC functions

PLC Sequencer, Shift registers, Program / Flow Control Instructions, Arithmetic Instructions, Data handling Instructions like FIFO, FAL, ONS, Data Transfer Instructions PLC MOVE, PLC Matrix functions, Network Communication Instructions, Analog PLC operation, PID control of continuous processes.

Unit II

Chapter No. 04. Designing systems, PLC Start-up & Maintenance

PLC Core application development, Development Cycle, Safe systems, Commissioning, Fault finding, PLC System Layout, Power Requirements and Safety Circuitry, Noise, Heat, and Voltage Considerations, I/O Installation, System wiring strategies, and Precautions, Safety Standards like NEMA & NEC, Electrical wiring diagrams PLC Start-Up and Checking Procedures, PLC System Maintenance & Troubleshooting

Chapter No. 05. PC based Automation, SCADA

Technologies and advantages of PC based Automation, Programmable Automation Controller systems (PACs) for Industrial control, Comparison of PLC with PAC Supervisory Digital Control and Data Acquisition (SCADA) system & Distributed Control Systems (DCS): SCADA Hardware and software, Open SCADA protocols like DNP3 and IEC60870

Unit III

Chapter No. 06. DCS & Field Bus

Overview of DCS, Network Standards: Device net, CAN bus, Control Net, Profibus, SERCOS, EtherCAT, Ethernet Powerlink, Comparison of each of them with other network standards

Chapter No. 07. System Selection Guidelines & Commissioning

PLC Selection process, estimation of program memory and time requirements, PLC Sizes and

Scope of applications, Special I/O modules, Electrical relay diagram symbols, Fail Safe Design, IEC 61508/61511 safety standards, Process modeling, Programming for large systems, Control system documentation & Commissioning
Text Books: 1. John W. Webb & Ronald A Reis, "Programmable Logic Controllers: Principles and Applications ", Fifth Edition, PHI, 2012 2. W. Bolton, Programmable Logic Controllers, Fourth Edition, ELSEVIER, 2009
Reference Books: 1. Frank D. Petruzella, Programmable Logic Controllers, McGraw- Hi, 1989 2. Siemens, PLC Handbook

Back

Program: Automation & Robotics		Semester: V
Course Title: Machine Learning & ROS Lab		Course Code: 18EARP301
L-T-P: 0-0-1	Credits: 1	Contact Hours: 2 hrs/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching Hours: 24 hrs	Examination Duration: 3 hrs	

Exp. No.	List of Experiments
1	Set up ROS on the system and create a ROS package. Write a minimal ROS publisher and subscriber. Compile and run the nodes, examining the output.
2	Define custom messages and services in ROS. Implement ROS service nodes and interact with them manually. Create a custom action server and client for more complex tasks.
3	Demonstrate obstacle detection, avoidance, and navigation on a simulation environment using python programming in your controller.
4	Explore a machine learning dataset and handle missing values. Perform data cleaning, feature engineering, and feature scaling.
5	Implement binary and multiclass classification models. Evaluate models using metrics like accuracy, precision, and recall.
6	Train a linear regression model using Scikit-Learn. Explore different variants of gradient descent.
7	Implement polynomial regression and other nonlinear models. Apply L1, L2, and Elastic Net regularization techniques.
8	Implement Linear SVM for classification and regression tasks. Explore Nonlinear SVM using kernel tricks.
9	Train decision trees using Scikit-Learn and examine their advantages and disadvantages. Implement Random Forests and compare their performance.
10	Implement ensemble learning techniques like bagging and stacking. Apply the AdaBoost algorithm and explore its impact on model performance.
11	Implement neural networks for image recognition using CNNs. OR Explore RNNs for sequence prediction tasks. Implement GANs OR VAEs for image or text generation.

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Program: Automation & Robotics		Semester: **V**
Course Title: Industrial Robotics Lab		**Course Code: 18EARP303**
L-T-P: 0-0-1	**Credits: 1**	**Contact Hours: 2 hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 28 hrs	**Examination Duration: 3 hrs**	

Unit I

Chapter 1: Matlab Introduction

Millions of engineers and scientists worldwide use MATLAB to analyze and design the systems and products transforming our world. The matrix-based MATLAB language is the world's most natural way to express computational mathematics. Built-in graphics make it easy to visualize and gain insights from data. The desktop environment invites experimentation, exploration, and discovery. These MATLAB tools and capabilities are all rigorously tested and designed to work together.

MATLAB helps you take your ideas beyond the desktop. You can run your analyses on larger data sets, and scale up to clusters and clouds. MATLAB code can be integrated with other languages, enabling you to deploy algorithms and applications within web, enterprise, and production systems.

Topics:

Basic commands

Vectors and Matrices

Importing Data

Plotting Data

Technically speaking, MATLAB is not a programming language but it is a tool with which you can find engineering solutions based on mathematics. Robotic developers need to learn MATLAB if they want to analyze data, produce advanced graphs or implement control systems. MATLAB, and its open source relatives, such as Octave, is very popular with some robotic engineers for analyzing data and developing control systems.

Programming for a robot requires designing the controller that governs robot behavior. Modeling and simulation became vital to understand how the controller interacts with the robot's environment perception, mobility, and interaction.

Chapter 2: Robotics Toolbox

The Toolbox has always provided many functions that are useful for the study and simulation of classical arm-type robotics, for example such things as kinematics, dynamics, and trajectory

. **Chapter 3: RoboAnalyzer**

Explaining the concepts in a course on Robotics typically requires a 3D model of a serial-robot/manipulator, either in the form of a physical robot or a virtual robot in software environment, for a better understanding. With the experience of handling Robotics courses and the feedback received so far, we have come up with a list of Virtual Experiments using RoboAnalyzer.

List of Virtual Experiments using RoboAnalyzer

Sl No.	Practical Assignments using RoboAnalyzer	Topics Covered
1	Introduction to RoboAnalyzer	Usage of RoboAnalyzer
2	Virtual Models of Industrial Robots	Industrial Robots
3	Understanding coordinate frames and transformations	DH Parameters, Robot Geometry
4	Forward kinematics of robots	Robot Kinematic Analysis
5	Inverse kinematics of robots	Robot Kinematic Analysis
6	Case Study: Kinematics of MTAB Mini Robot	Robot Kinematic Analysis
7	Case Study: Workspace Analysis of a 6-axis robot	Workspace Analysis
8	Inverse and Forward dynamics of robots	Robot Dynamics
9	Creating robot joint trajectories	Trajectory Planning

Chapter 4: Simulation/Offline Programming (Robotstudio)

Topics to be covered:

1.Create mechanism

2.AutoPath

3.Set Task Frame

4.Collision control

5.Reachability

6.Create MultiMove System from Layout

Chapter 5: Online Programming

To perform a particular action, robots are programmed either by guiding or by off-line programming. Most of the industrial robots are programmed by guiding a robot from point to point through the phases of an operation, with each point stored in the robotic control system. Robots receive instructions through computer commands and this is referred to as manipulator level off-line programming. Usage of off-line programming involves higher-level languages, in which robotic actions are defined by tasks or objectives.

Robotic programmers must have knowledge on different types of programming languages as switching from computers to robots is not the smooth transition that many developers/programmers may think.

Chapter 6: Simulation/Offline Programming (Robotstudio)

Topics to be covered:

1.Create mechanism

2.AutoPath

3.Set Task Frame

4.Collision control

5.Reachability

6.Create MultiMove System from Layout

Online Programming

To perform a particular action, robots are programmed either by guiding or by off-line programming. Most of the industrial robots are programmed by guiding a robot from point to point through the phases of an operation, with each point stored in the robotic control system. Robots receive instructions through computer commands and this is referred to as manipulator level off-line programming. Usage of off-line programming involves higher-level languages, in which robotic actions are defined by tasks or objectives.
Robotic programmers must have knowledge on different types of programming languages as switching from computers to robots is not the smooth transition that many developers/programmers may think.

Chapter 7: Introduction to ABB Robotstudio

Offline programming is the best way to maximize return on investment for robot systems. ABB's simulation and offline programming software, RobotStudio, allows robot programming to be done on a PC in the office without shutting down production.
RobotStudio provides the tools to increase the profitability of your robot system by letting you perform tasks such as training, programming, and optimization without disturbing production. This provides numerous benefits including:
Risk reduction
Quicker start-up
Shorter change-over
Increased productivity
RobotStudio is built on the ABB VirtualController, an exact copy of the real software that runs your robots in production. This allows very realistic simulations to be performed, using real robot programs and configuration files identical to those used on the shop floor.

Unit III

Chapter 8: Structured Enquiry

Project
Students should form a team of 4 in numbers and select a problem or need statement in industrial robotics area.
The project should consists of following requirements:
Minimum 3 to 6 DOF robot arm
DH Parameters
Students are free to choose the software to complete the project

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Program: Automation & Robotics Engineering		Semester: V
Course Title: Programming Industrial Automation Systems Lab		Course Code: 18EARP302
L-T-P: 0-0-1	Credits: 1	Contact Hours: 4hrs/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching Hours: 24 hrs	Examination Duration: 3 hrs	

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Category: Demonstration		Total Weightage: 20.00		No. of lab sessions: 4.00
Expt./ Job No.	**Experiment / Job Details**	**No. of Lab Session(s) per batch (estimate)**	**Marks / Experiment**	**Correlation of Experiment with the theory**
1	Introduction to Safety guidelines & PLC and system wiring	1.00	5.00	
	Learning Outcomes: The students should be able to: 1. *appreciate the guidelines to be followed while working with PLC and I/O devices and follow the procedures involved in wiring the PLC system elements*			UNIT I
2	Introduction to Panasonic PLC Hardware and FPWinPro software , Instruction set, Demo Programs	1.00	5.00	
	Learning Outcomes: The students should be able to: 1. *Identify the different input and output devices and their configuration for interfacing with Panasonic PLC* system elements 2. *Solve the problems on interfacing by using Panasonic PLC, sensors and different types of actuators through ladder logic, Function block and Structured Text programming*			UNIT I
3	Introduction to Bosch Rexroth PLC Hardware, Indra Works, Instruction set and Demo Programs	1.00	5.00	
	Learning Outcomes: The students should be able to: 1. *Simulate PLC logic using Indra logic Software by solving problems on ON - OFF control strategy , Counting Items coming on a conveyor with planned intervals*			UNIT I
4	Demo on Electro Pneumatics : A. Time-dependent control of a double-acting cylinder with switch-on delay B. Sequential control of 2	1.00	5.00	

	double-acting cylinders with impulse valves			
	Learning Outcomes: The students should be able to: 1. *Implement PLC logic solution to drive electro-pneumatic elements based on stated case study problems* ems on ON - OFF control strategy , Counting Items coming on a conveyor with planned intervals			UNIT I
Category: Exercise		**Total Weightage: 20.00**		**No. of lab sessions: 5.00**
Expt./ Job No.	**Experiment / Job Details**	**No. of Lab Session(s) per batch (estimate)**	**Marks / Experiment**	**Correlation of Experiment with the theory**
5	Simulation Exercises on FPWINPro Software & Panasonic PLC a. Car safety system b. Solving Boolean Expressions c. Sequential Logic Control	1.00	4.00	
	Learning Outcomes: The students should be able to: 1. *Solve problems based on given case studies using ladder logic and function blocks*			UNIT II and III
6	Exercises using Panasonic PLC hardware interfaced with sensors and actuators & FPWinPro software	1.00	4.00	
	Learning Outcomes: The students should be able to: 1. *Implement PLC control logic by interfacing sensors for control of DC motor/stepper motor using timers , counters and process indicators*			
7	simulate exercises using Rexroth PLC software using ladder diagram, function block and structured text programming for the given case studies	1.00	4.00	
	Learning Outcomes: The students should be able to: 1. *simulate exercises using Rexroth PLC software using ladder diagram, function block and structured text programming for the given case studies*			
8	Solve case study problems using Rexroth PLC hardware interfaced with	1.00	4.00	

	sensors, actuators and process indicators			
	Learning Outcomes: The students should be able to: 1.			
9	Exercises using Rexroth PLC software and hardware Building ALU , Timer and Counter b. Motor Control c.Burglar Alarm . d. Conveyor Control e. To explore PID control	1.00	4.00	
	Learning Outcomes: The students should be able to: 1. *Solve case study problems using Rexroth PLC hardware interfaced with sensors, actuators and process indicators.* indent:-.25in;mso-list:l0 level1 lfo1'>*1. simulate exercises using Rexroth PLC software using ladder diagram, function block and structured text programming for the given case studies*			
Category: Structured Enquiry		**Total Weightage: 10.00**		**No. of lab sessions: 2.00**
Expt./ Job No.	**Experiment / Job Details**	**No. of Lab Session(s) per batch (estimate)**	**Marks / Experiment**	**Correlation of Experiment with the theory**
10	Case studies on Automatic stamp B. Vehicle control system C. Process control system	2.00	10.00	
	Learning Outcomes: The students should be able to: 1.			UNIT III
Category: Open Ended		**Total Weightage: 10.00**		**No. of lab sessions: 2.00**
Expt./ Job No.	**Experiment / Job Details**	**No. of Lab Session(s) per batch (estimate)**	**Marks / Experiment**	**Correlation of Experiment with the theory**
11	Exploring PLC Serial communication using Ethernet	2.00	10.00	
	Learning Outcomes:			UNIT III

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Program: Automation & Robotics		Semester: **V**
Course Title: Mini Project - (Engineering Design)		**Course Code: 18EARW301**
L-T-P: 0-0-3	**Credits: 3**	**Contact Hours: 6 hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 30 hrs	**Examination Duration: 3 hrs**	

Theme: Product development through Engineering Design and Rapid Prototyping

Course Objective: To apply engineering design process to develop a simple product and build it using rapid prototyping.

Task Details:

The project should include usage of engineering design principles, agile methodology and rapid prototyping. The product should be used to automate a process or perform a set of useful tasks.

Course Outcomes - CO

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

1. Carry out need analysis and identify suitable problems.
2. Apply the principles of engineering design to scope, plan and implement the project, continuously evaluate progress, navigate uncertainty and adversity, and iterate as needed.
3. Think critically while analyzing, evaluating, synthesizing, and applying diverse information and experiences to support decision-making during the design process.
4. Develop and apply creativity to generate novel ideas taking into account real constraints that lead to innovative outcomes.
5. Develop schematics and select appropriate components.
6. Prototype the product using rapid prototyping and test it.
7. Collaborate successfully with other team members to achieve the desired outcome.
8. Consider the individual, social and environmental impacts of their decisions to produce positive transformations while minimizing unintended consequences.
9. Communicate effectively through oral, written, and visual media and listen actively to

Experiment wise plan

List of activities planned to meet the requirements of the syllabus

Week No	Activities	Deliverables
1&2	Need analysis, Identification of problem	Problem statement, Project plan,
3&4	Product development	Component designs & Integration,
5,6,7&8	Rapid prototyping, Testing and validation	Prototype (hardware and software)
9&10	Reporting	Test reports and Conclusion

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Program: Automation & Robotics Engineering		Semester: VI
Course Title: Hydraulics & Pneumatics		Course Code: 18EARC308
L-T-P: 4-0-0	Credits: 4	Contact Hours: 4 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Introduction to Hydraulic Power and Hydraulic Pumps

Pascal's law, Structure of Hydraulic Control System. The Source of Hydraulic Power: Pumps Pumping theory, pump classification, gear pumps, vane pumps, piston pumps, Variable displacement pumps, pump performance, pump selection. Problems on determining the pump flow rate, pump efficiency and pump power.

Chapter 2: Hydraulic Actuators: Cylinders and Motors

Linear Hydraulic Actuators (cylinders), Mechanics of Hydraulic Cylinder loading, Hydraulic Rotary Actuators, Gear motors, vane motors, piston motors, Hydraulic Motor Performance. Problems on determining motor speed, torque, power, motor efficiency

Chapter No. 3. Hydraulic Valves

Hydraulic Valves: Directional Control Valves- classification of directional control valves, direction control valves actuating devices, Symbolic representation as per ISO 1219 and ISO 5599, pressure control valves, flow control valves- classification of flow control valves, proportional control valves, and servo valves.

Unit II

Chapter 4: Hydraulic Circuit Design and Analysis

Control of single acting and double acting Hydraulic Cylinder, regenerative circuit, pump unloading circuit, Double pump Hydraulic system, Counter Balance Valve application, Hydraulic cylinder sequencing circuits. Locked cylinder using pilot check valve, cylinder synchronizing circuits, Speed control of hydraulic cylinder: Meter-in circuit, Meter-out circuit and Bleed-off circuit, speed control of hydraulic motors. Ancillary Hydraulic Devices: Reservoirs, Accumulators, Pressure Intensifiers, Sealing Devices.

Chapter No. 5. Pneumatic Systems

Structure of Pneumatic control system, Choice of working medium, characteristics of compressed air, Pneumatic Actuators: Types of Linear Actuators or Pneumatic cylinders, Cylinder mountings, Cylinder seals, End cushioning in pneumatic cylinders. Pneumatic Control Valves: Direction control valve- types of direction control valves, ISO designation of direction control valves, Non return valves, methods of actuation of pneumatic directional control valves, Flow control valves, and Pressure control valves.

Chapter No. 6. Pneumatic Circuit Design and Hydraulic Control Systems

Pneumatic Circuit Design: Direct and indirect control of single acting cylinder, control of single acting cylinder using “or”, “and”, “not” valve. Direct control of a double acting cylinder, Indirect control of double acting cylinder using memory valve, Supply air throttling and exhaust air throttling, Various methods of checking end position of a cylinder, Pressure dependent controls and Time dependent controls.

Hydraulic Control Systems: Servo Control, Valve servo systems: Valve lap, mechanical feedback, systems response, electro hydraulic servo valves, Proportional valves: Force control, force position control, spool position control, proportional pressure control, proportional flow control, electrical control of proportional valve, Applications of proportional control valves.

Unit III

Chapter No. 7. Electro Pneumatics

Basic electrical devices- Manually actuated push button switches, Limit switches, Pressure switches, Solenoids, Relays, Timers, Temperature switches, Direct and indirect control of single acting cylinders using electro pneumatics, Direct and indirect control of double acting cylinders using electro- pneumatics, Control of double acting cylinder OR logic (Parallel circuit), Control of double acting cylinder AND logic.

Chapter No. 8. Hydraulic System Maintenance

Common faults in a hydraulic systems, contamination, Filter and filter maintenance, pump maintenance, Hydraulic system maintenance, fault diagnosis of Hydraulic system**.**

Text Books:

1. Anthony Esposito, Fluid Power with Applications, 6th Edition, Pearson, 2003.
2. Michael J. Pinches and John G. Ashby, Power Hydraulics, Prentice-Hall, 1989

Reference Books:

1. Herbert E. Merritt, Hydraulic Control Systems, John Wiley & Sons, 1967.
2. Peter J Chapple, Principles of Hydraulic System Design, 1st Edition,Coxmoor Publishing Company, 2003.
3. S. R. Majumdar, Oil Hydraulic Systems, Tata McGraw Hill publishing Company Ltd, 2001

Back

Program: Automation & Robotics Engineering		Semester: VI
Course Title: AI for Autonomous Robots		Course Code: 17EARE301
L-T-P: 3-0-0	Credits: 3	Contact Hours: 3 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Introduction to Artificial Intelligence and Autonomous Systems Foundation of artificial intelligence, robotics and the AI approach, Semi-autonomous control, Seven areas of AI, The Concept of Rationality The Nature of Environments, The Structure of Agents, Problem-Solving Agents, Searching for Solutions, Uninformed Search Strategies, Informed Search Strategies, Knowledge representation in AI, knowledge based agents, propositional logic, predicate calculus, inference rules

Chapter 2: Robotic Software Architectures
Subsumption architecture, Three-layer architecture, Pipeline architecture, Hierarchical Paradigm- Attributes of the Hierarchical Paradigm, Reactive Paradigm- Attributes of Reactive Paradigm, Hybrid Deliberative/Reactive Paradigm-Attributes of Hybrid Paradigm, Architectural Aspects, Managerial Architectures-Autonomous Robot Architecture (AuRA), Sensor Fusion Effects (SFX), State-Hierarchy Architectures, Model-Oriented Architectures, Interleaving Deliberation and Reactive Control.

Chapter 3: Biological Foundations of the Reactive Paradigm
Agency and computational theory, Animal Behaviors, Reflexive behaviors, Coordination and Control of Behaviors, Innate releasing mechanisms, Concurrent behaviors, Perception in Behaviors, Action-perception cycle, Two functions of perception Gibson: Ecological approach, Neisser: Two perceptual systems, Schema Theory, Behaviors and schema theory, Principles and Issues in Transferring Insights to Robots

Unit II

Chapter 4: Capturing Intelligence - Designing a Reactive Implementation with Common Sensing Techniques for Robotics Perception
Behaviors as Objects in OOP, Steps in Designing a Reactive Behavioral System, Case Study: Unmanned Ground Robotics Competition, Assemblages of Behaviors, Logical sensors, Behavioral Sensor Fusion, Designing a Sensor Suite, Proprioceptive Sensors, Proximity Sensors, Computer Vision, Range from Vision, Case Study: Hors d'Oeuvres, Anyone?

Chapter 5: Multi-Agents and Navigation in Robotics
Heterogeneity, Control, Cooperation, Emergent Social Behavior, Topological Path Planning, Relational Methods, Associative Methods, Case Study of Topological Navigation with a Hybrid Architecture

Unit III

Chapter 6: Localization and Map Making
Sonar Sensor Model, Bayesian, Conditional probabilities, Conditional probabilities, Updating

with Bayes' rule, Dempster-Shafer Theory, Shafer belief functions Belief function for sonar Dempster's rule of combination Weight of conflict metric, HIMM sonar model and Comparison of Methods, Example computations, Performance Errors due to observations from stationary robot, Tuning, Localization, Continuous localization and mapping, Feature-based localization Exploration, Frontier-based exploration, Generalized Voronoi graph methods .

Chapter 7: Deep Learning and Natural Language Processing

Deep Learning Improvement of the Deep Neural Network Vanishing Gradient Over fitting Computational Load. Language models, text classification, information retrieval

Text Books:

1. Stuart J. Russell and Peter Norvig, "Artificial Intelligence,A Modern Approach" Third Edition, Pearson Education, Inc.2010
2. R. Murphy "Introduction to AI Robotics", Second edition, The MIT Press Cambridge, Massachusetts,2000

Reference Books:

1. Elaine Rich, Kevin Knight: "Artificial Intelligence", 3rd Edition, Tata McGraw Hill, 2009, ISBN-10: 0070087709
2. Sebastian Thrun, Wolfram Burgard, Dieter Fox, "Probabilistic Robotics" MIT Press; Intelligent Robotics and Autonomous Agents series edition,2005

Back

Program: Automation & Robotics Engineering		**Semester: VI**
Course Title: Power Electronics, Motors & Drives		**Course Code: 16EARE301**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40hrs	**Examination Duration: 3 hrs**	

Unit I

Chapter 1: Introduction to PE and Electric Drive Systems

Power Electronics, Applications of Power Electronics, Types of Power Electronic Circuits, Peripheral Effects, Characteristics and Specifications of Switches. Basic components of an Electric drive system: Mechanical loads, electric motors, power sources, converters and controllers.

Chapter 2: Power Diodes, BJT, MOSFET and Rectifiers

Introduction, Diode Characteristics, Reverse Recovery Characteristics, Power Diode Types, Freewheeling Diodes with Switched RL Load. Power BJT, structure of BJT, MOSFET and IGBT, characteristics of BJT, MOSFET and IGBT, comparison of power devices. Introduction, Single-Phase Full-Wave Rectifiers, Single-Phase Full-Wave Rectifier with RL Load, Single-Phase Full-Wave Rectifier with a Highly Inductive Load.

Chapter 3: Thyristors and Commutation Theory

Introduction, Principle of Operation of SCR, Static Anode-Cathode Characteristics of SCR, two transistor model of SCR, Gate Characteristics of SCR, Firing circuits for SCRs, Turn-On Methods, Turn-Off Mechanism, Turn-Off. Natural and Forced Commutation – Class A and Class B types, Gate Trigger Circuit: Resistance Firing Circuit, Resistance capacitance firing circuit.

Unit II

Chapter 4: Static Switches and Power Supplies

Single phase ac static switches, three phase ac static switches, three phase reversing switches, Solid state relays, Design of static switches, DC power supplies, DC Switched Mode DC power supplies, bidirectional power supplies, Switched Mode AC power supplies.

Chapter 5: DC-DC Converters

Introduction, principle of step-down operation and its analysis with RL load, principle of step-up operation, Step-up converter with a resistive load, Performance parameters, Converter classification, Switching mode regulators: Buck regulator, Boost regulator, Buck-Boost Regulators.

Chapter 6: Power Electronics for Motor and Drive Applications

DC and AC motor control, Single phase SCR drive, Three phase SCR drive, Reversible SCR drive, Speed control of DC motor, chopper-controlled DC drives, Microprocessor-Controlled DC drives, AC motor characteristics, speed control methods of induction motor, commutator less DC motor and Electronic commutation.

Unit III

Chapter 7: Stepper Motor

Principle of Stepper motor, Classification of Stepper motor, Principle of variable reluctant stepper motor, Principle of Permanent magnet stepper motor, Principle of hybrid stepper motor, driver for stepper motor, Applications of Stepper motor

Chapter 8: Drives for Industrial Applications

Rolling mill drives, cement mill drives, electric traction drives, textile mill drives and machine tool drives.

Text Books:

1. Gopal K Dubey, Fundamental of electric drives, Second, Narosa publication, 2005
2. P.S Bhimbhra, Power Electronics, Fourth, Khanna, 2007
3. Mohammed A Sharkawi, Fundamental of electric drives, Fourth, Brooks/Cole, 2000
4. Robert Boylestead and Louis Nashelsky “Electronic Devices and Circuit Theory, Eleventh edition, Pearson Publications
5. Rashid M H, Power Electronics Circuits,devices and applications, Second, PHI, 2000
6. P.C Sen, Power Electronics, Tata McGraw Hill, Ninth Edition

Reference Books:

1. P.S Bhimbhra, Power Electronics, Fourth, Khanna, 2007
2. Mohammed A Sharkawi, Fundamental of electric drives, Fourth, Brooks/Cole, 2000

Back

Program: Automation & Robotics Engineering		Semester: VI
Course Title: Computer Vision & Digital Image Processing		Course Code: 15EARE302
L-T-P: 3-0-0	Credits: 3	Contact Hours: 3 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40hrs	Examination Duration: 3 hrs	

Unit I

Chapter 1: Fundamentals of Computer Vision and Digital Image Processing

Introduction to computer vision system, Geometric Camera Models- Pinhole Perspective, Cameras with Lenses, the Human Eye, Intrinsic and Extrinsic Parameters, Geometric Camera Calibration. Digital image processing system, application of computer vision and digital image processing. Design of machine vision system.

Chapter 2: Light and Shading, Color

Modeling Pixel Brightness, Reflection at Surfaces, Sources and Their Effects, the Lambertian+SpecularModel, Inference from Shading, Radiometric Calibration and High Dynamic Range Images, the Shape of specularities, Inferring Lightness and Illumination, Color-Human Color Perception, The Physics of color, representing Color, Inference from Color Finding specularities Using Color Shadow removal, using Color Constancy: Surface Color from Image Color.

Chapter 3: Image Formation and Processing

Image Acquisition – Sampling and Quantization- Pixel Relationships, image enhancement Spatial Domain Gray level Transformations Histogram Processing Spatial Filtering – Smoothing and Sharpening, Introduction to the Fourier Transform and the Frequency Domain, DFT, FFT

Unit II

Chapter 4: Image Segmentation and Feature Analysi

Detection of Discontinuities – Edge Operators – Edge Linking and Boundary Detection – Thresholding – Region Based Segmentation, A Model of the Image Degradation/Restoration Process, Noise Models, Restoration in the Presence of Noise Only–Spatial Filtering, Periodic Noise Reduction by Frequency Domain Filtering.

Chapter 5: Color Image Processing and Image Compression

Color Fundamentals, Color Models, Pseudo color Image Processing, Basics of Full-Color Image Processing Color Transformations, Smoothing and Sharpening, Color Segmentation, Noise in Color Images Color Image Compression, Image Compression-Fundamentals, Image Compression Models, Elements of Information Theory, Error-Free Compression, Lossy Compression.

Unit III

Chapter 6: Morphological Processing

Dilation and Erosion, Opening and Closing, The Hit-or-Miss Transformation, Some Basic Morphological Algorithms.

Chapter 7: Recognition and Bayesian Modeling Object detection, Face recognition. Instance recognition, Category recognition, Context and scene understanding, Recognition databases and test sets, Prior models and Bayesian inference. Gradient descent and simulated annealing, Graph cuts, Markov random fields.
Text Books: 1. David A. Forsyth and Jean Ponce- Computer vision A modern approach, 2nd Edition, Pearson publication, 2003. 2. Rafael C. Gonzalez and Richard E. Woods- Digital Image Processing-2nd Edition, Prentice Hall publication,2002
Reference Books: 1. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer publication,2010

Back

Program: Automation & Robotics		Semester: **VI**
Course Title: Robot Dynamics & Control		**Course Code: 17EARE302**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40 hrs	**Examination Duration: 3 hrs**	

Unit I

Chapter 1: Dynamics of Open Chains

Introduction to robot dynamics, Lagrangian Formulation, Basic Concepts and examples, General Formulation, Mass Matrix, Gravity terms, Inertia Matrix, Coriolis Matrix, Friction, Effect of Payload.

Chapter 2: Actuation, Gearing, & Friction

Introduction, Characteristics of actuating systems robot, Comparison of actuating systems dynamics, Motors and Gearing, Apparent Inertia, Independent joint control, Motor Inertias, Friction, Joint and Link Flexibility, Robot Dynamics in the URDF format.

Unit II

Chapter 3: Motion Control

Introduction to robot motion control, trends in robotic research, motion control, types of manipulator control, robust & adaptive control, motion and model-based control, kinematic and dynamic control schemes, Feedforward and feedback control.

Chapter 4: Trajectory Planning

Introduction to trajectory generation, Cubic polynomial schemes, Higher-order polynomial function, cycloidal function, parabolic blends, joint-space, and task-space schemes.

Unit III

Chapter 5: Motion Planning

Overview of Motion Planning, Types of Motion Planning Problems, Motion planning- arms vs. mobile robots, Motion Planning Schemes – Graph-based methods, Motion Planning Schemes – Analytical approaches**.**

Chapter 6: Manipulator-Mechanism Design

Introduction, Basing the design on task requirements, Kinematic configuration, Quantitative measures of workspace Attributes, Stiffness and deflections, Position sensing, Force sensing**.**

Text Books

1. Modern Robotics: Mechanics, Planning, and Control, K. M. Lynch and F. C. Park, Cambridge University Press, 2017
2. Introduction to Robotics: Mechanics and Control, John J. Craig, Pearson; 3rd edition (27 July 2004)
3. Robotics, Vision and Control Fundamental Algorithms in MATLAB, Peter Corke, Springer Berlin Heidelberg, Springer, Cham, 978-3-319-54413-7

Reference Books:

1. Robot Modeling and Control, M. W. Spong, S. Hutchinson, and M. Vidyasagar, Wiley, 2020**.**

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Program: Automation & Robotics		Semester: **VI**
Course Title: Digital System Design & FPGA Programming		**Course Code: 17EARE304**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40 hrs	**Examination Duration: 3 hrs**	

Unit I

Chapter 1.: Review of Logic Design Fundamentals

Combinational logic, Boolean algebra and algebraic Simplification Karnaugh maps, designing with NAND and NOR gates, hazards in combinational circuits, flip-flops and latches, Mealy sequential circuit design, design of a Moore sequential circuit, equivalent states and reduction of state tables, sequential circuit timing, tristate logic and busses. Advanced Design Issues: Meta-stability, Noise Margins, Power, Fan-out, Timing Considerations, Brief overview of programmable logic devices, simple programmable logic devices (SPLDs), complex programmable logic devices (CPLDs), field-programmable gate arrays (FPGAs)

Chapter 2: Introduction to State Machine Charts and Microprogramming

State machine(SM) charts, derivation of SM charts, realization of SM charts, implementation of the dice game, microprogramming, Design Examples

Unit II

Chapter No. 3. Designing with Field Programmable Gate Arrays

Implementing functions in FPGAs, implementing functions using Shannon's decomposition, carry chains in FPGAs, cascade chains in FPGAs, examples of logic blocks in commercial FPGAs, dedicated memory in FPGAs, dedicated multipliers in FPGAs, cost of programmability, FPGAs and One-Hot state assignment

Chapter No. 4. Modeling and design with HDL

Basic Concepts, Dataflow Descriptions, Behavioral Descriptions, Structural Descriptions, Design examples, Timing and Delays, BCD to 7 Segment Display Decoder, BCD Adder, 32-Bit Adders, Traffic Light Controller, Shift- and-Add Multiplier, Array Multiplier. Introduction to Verilog and VHDL: Data Types, Modeling Concepts, Task and Functions, Specify Block and Timing Checks, Architecture study of popular FPGA families

Unit III

Chapter No. 5. Testing and Verification

What is Verification, what is a Test bench, The Importance of Verification, Convergence Model, What Is Being Verified, Functional Verification Approaches, Testing Versus Verification, Design and Verification Reuse, Cost of Verification

Chapter No. 6 Case Studies on FPGA Technologies in Automation and Robotics Applications

Case studies on I) Robotic Car from Georgia Institute of Technology, II)Robotic Controller: ASIC versus FPGA, III) Expanding a robot's life: Low power object recognition via FPGA-based DCNN deployment IV) FPGA-powered parallel, pipelined vision algorithms

Text Books

1. Charles Roth, Digital Systems Design using VHDL, 2/e, Cengage Learning, 2012
2. Samir Palnitkar, Verilog HDL, 2/e, Pearson Education, 2013.
3. Charles Roth, Digital Systems Design using Verilog, Cengage Learning, 2014

Reference Books:

1. John F. Wakerly, Digital Design Principles and Practices, 4/e, Pearson Education, 2013.
2. Michael Ciletti, Advanced Digital Design using Verilog HDL, 2/e, Prentice Hall Publications, 2012.
3. J. Bhasker, System Verilog HDL Primer, B.S. Publications, 2012.
4. J. Bhasker, Verilog Synthesis Primer, B. S. Publications, 2011.

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Program: Automation & Robotics		Semester: **VI**
Course Title: Hydraulics and Pneumatics Lab		**Course Code: 16EARP302**
L-T-P: 0-0-1	**Credits: 1**	**Contact Hours: 2hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 24 hrs	**Examination Duration: 3 hrs**	

Expt. No.	Types of laboratory work	Name of the Experiment
1	Demonstration (20 Marks)	To study hydraulic pump, its characteristics and calculate the hydraulic power
2		Study of direct and indirect control of a double-acting cylinder with a pneumatically operated 5/2 directional control valve.
3		A. Study of speed control of Single Acting Cylinder - Slow Speed Extension and Rapid Retraction. B. Stop control, double-acting cylinder with 5/3 directional control valve, tensile load
4		To study position dependent control of a double acting cylinder using mechanical limit switches.
5	Exercise (30 Marks)	To study concepts of Meter-in and Meter-out circuits using Single-rod cylinder and 4/2 DCV.
6		To study pressure intensification of a single rod cylinder.
7		Study of Hydraulic Motor with 4/3 DCV.
8		To study the application of different center configuration of 4/3 DCV. (Tandem and closed center)
9		To study the application of Regenerative Circuit.
10		Experiments on AND, OR, Latch and Electric limit Switch
11	Structured Enquiry (20 Marks)	Several stations on a rotary machining station are driven by a hydraulic power pack. As individual stations are Switched on and off, they produce pressure fluctuations throughout the hydraulic circuit. Practice is obtained in using a flow control valve to control feed rate and pressure relief valve as a counter-holding valve to compensate for the tractive forces
12		The sequential control with two pneumatic drives. The signal overlapping occurring during this exercise is constructively solved by use of rollers with idle return. Practice is obtained in developing sequential diagrams

13	Open Ended Enquiry (10 Marks)	A double-acting cylinder is used to press together glued components. Upon pressing a push-button, the clamping cylinder is to extend and trip the roller valve. Once the fully extended position of the cylinder has been reached and sufficient clamping force has been developed, the cylinder is to retract to the initial position. Develop a control circuit using a pressure sequence valve.

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Program: Automation & Robotics		Semester: **VI**
Course Title: Mechatronics & Measurements Lab		**Course Code: 18EARP304**
L-T-P: 0-0-1	**Credits: 1**	**Contact Hours: 2 hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 22 hrs	**Examination Duration: 3 hrs**	

Expt. No.	Category	List of Experiments
1	Demonstration	Demo of Quanser Mechatronics Sensor kit, DAQ card, DC Motor Control Trainer module, Inverted Pendulum Trainer module with NI ELVIS Platform.
2		Investigation of time-response and frequency-response. i. Time-Response Identification of Resistor Capacitor (RC) Circuit. ii. Frequency-Response Identification of Resistor Capacitor (RC) Circuit iii. Control of a Resistor Capacitor (RC) Circuit iv. Investigation of time response of LRC Circuit v. Investigation of loading in circuits in series.
3	Exercise	Sensor characterization using sensor modules, namely, Accelerometer, Ultrasonic sensor, Temperature sensor, Strain gauge
4		Sensor fusion of IMU and compass
5		Model Based Design Experiments: i. Modeling Systems using Simulink. (Hydroplane) ii. System Identification of Disk Head Assembly. iii. Estimating Simulink model parameters from measured data.
6	Structured Enquiry	System identification of DC motor
7		Control of an Inverted Pendulum on a Cart.
8	Open Ended	Control of a Linear Electric Actuator

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Program: Automation & Robotics		Semester: VI
Course Title: Real-Time Embedded Systems Lab		Course Code: 16EARP307
L-T-P: 0-0-1	Credits: 1	Contact Hours: 2 hrs/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching Hours: 28 hrs	Examination Duration: 3 hrs	

Expt. No.	List of Experiments
1	TIVA C Series Microcontroller Board Introduction and Advanced Features Learning Objectives: The students should be able to work with Energia IDE and TM4c1294NCPDT, TIVA C series microcontroller • Gain familiarity with TIVA C series microcontroller board architecture and features. • Understand the development environment setup for TIVA C series microcontroller boards. • Learn advanced functionalities and capabilities offered by TIVA C series microcontrollers.
2	MSP430 LED and Switch Interfacing with Energia & CCS IDE Learning Objectives: The students should be able to work with Code Composer Studio(CCS) and TIVA C series TM4C1294NCPDT microcontroller: • Develop proficiency in interfacing LEDs and switches with MSP430 microcontrollers using Energia and Code Composer Studio IDEs. • Understand GPIO configuration and control techniques. • Learn to write firmware for controlling LEDs based on switch input
3	STM32 LED and Switch Interfacing with Cube IDE Learning Objectives: • Develop expertise in interfacing LEDs and switches with STM32 microcontrollers using Cube IDE. • Explore advanced GPIO configuration options available in STM32 microcontrollers. • Master firmware development for controlling LEDs based on switch input.
4	MSP430 Analog Sensor Interfacing with Signal Conditioning Techniques Learning Objectives: • Learn analog sensor interfacing principles with MSP430 microcontrollers. • Understand signal conditioning techniques for accurate analog sensor data acquisition. • Develop skills in calibrating and processing analog sensor data for various applications.

5	MSP430Sensor Data Acquisition and Processing Techniques Learning Objectives: • Implement advanced techniques for sensor data acquisition and processing with MSP430 microcontrollers. • Explore multiple sensor integration and multiplexing methods. • Learn firmware development for real-time sensor data processing and analysis.
6	Advanced MSP430 Communication Protocols: Serial and I2C Learning Objectives: • Master serial communication protocols (UART) and I2C protocol implementation on MSP430 microcontrollers. • Develop skills in establishing communication with external devices using serial and I2C interfaces. • Learn firmware development for data transmission and reception via serial and I2C protocols.
7	STM32 Advanced Pulse Width Modulation (PWM) Implementation Learning Objectives: • Understand pulse width modulation (PWM) principles and applications. • Learn advanced PWM configuration and control techniques on STM32 microcontrollers. • Develop skills in using PWM for motor control, LED dimming, and other applications.
8	Real-Time Clock (RTC) Implementation with Advanced Features Learning Objectives: • Gain proficiency in real-time clock (RTC) implementation on MSP430 and STM32 microcontrollers. • Explore advanced RTC features and functionalities. • Learn firmware development for timekeeping, scheduling, and alarm functionalities using RTC.
9	Raspberry Pi Advanced OS Installation and GPIO Control with Python Programming Learning Objectives: • Master advanced techniques for Raspberry Pi OS installation and configuration. • Develop expertise in GPIO control using Python programming on Raspberry Pi. • Learn to interface external devices and sensors with Raspberry Pi GPIO pins for various applications.
10	Advanced IoT Application Development with Raspberry Pi Learning Objectives: • Gain comprehensive understanding of IoT application development principles. • Develop skills in designing and deploying advanced IoT applications using Raspberry Pi. • Learn to integrate sensors, actuators, and communication modules for real-world IoT solutions.

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Program: Automation & Robotics		Semester: **VI**
Course Title: Minor Project		**Course Code: 17EARW302**
L-T-P: 0-0-6	**Credits: 6**	**Contact Hours: 12 hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 30 hrs	**Examination Duration: 3 hrs**	

Task Details:

The project should include mechatronics system design (hardware and software co-design), modeling and co-simulation using MATLAB tools, Machine components design, Logic development, selection of controller, interfacing devices like robots, CNC machine tools with sensors and actuators.

Course Learning Objectives-CLO

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

1. Apply the principles of engineering design to plan and manage the project.
2. Gather the requirements, do functional analysis and develop specifications for a machine controller from the identified problem statement.
3. Develop alternative designs and choose the most suitable design for implementation.
4. Apply principles of mechatronics system design for hardware and software co-design as per standards (VDI 2206 & VDI 2221).
5. Develop elaborate validation and verification plans for each phase of the process.
6. Design control and signal conditioning circuits including schematics and wiring diagrams as per standards (IEC standards).
7. Build the Virtual prototype and validate using hardware-in-loop simulation and software-in-loop simulation.
8. Prototype the controller, deploy the software & Interface the controller to the machine.
9. Test, evaluate and improve the system.
10. Prepare technical report

Experiment wise plan

List of activities planned to meet the requirements of the syllabus

Week No	Activities	Deliverables	CIE Marks out of 80
1&2	Engineering Design	Problem statement, Project plan	20
3&4	Mechatronics System Design	Component designs & Integration	20
5,6,7&8	Fabrication	Prototype	20

Experiment wise plan

List of activities planned to meet the requirements of the syllabus

Sl. No	Activity	SEE Marks out of 20

1	Project Report & Presentation	10
2	*Demo of Project*	10

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Program: Automation & Robotics		Semester: **VI**
Course Title: Professional Aptitude & Logical Reasoning		**Course Code: 16EHSC301**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40 hrs	**Examination Duration: 3 hrs**	
Unit I **Arithmetical Reasoning and Analytical Thinking** Chapter 1. – Arithmetical Reasoning Chapter 2. – Analytical Thinking Chapter 3. – Syllogistic Logic		
Unit II **Verbal and Non–Verbal Logic** Chapter 1. – Verbal Logic Chapter 2. – Non-Verbal Logic		
Unit III **Lateral Thinking** Chapter 1. - Lateral Thinking		
Text Books: 1. A Modern Approach to Verbal and Non – Verbal Reasoning – R. S. Aggarwal, Sultan Chand and Sons, New Delhi 2. Quantitative Aptitude – R. S. Aggarwal, Sultan Chand and Sons, New Delhi		
Reference Books: 1. Verbal and Non – Verbal Reasoning – Dr. Ravi Chopra, MacMillan India 2. Lateral Thinking – Dr. Edward De Bono, Penguin Books, New Delhi		

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Program: Automation & Robotics Engineering		Semester: VII
Course Title: Industrial Data Networks		Course Code: 16EARC401
L-T-P: 4-0-0	Credits: 4	Contact Hours: 4hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50	Examination Duration: 3hrs	

Unit I

Chapter 1. Data Network Fundamentals and Industrial Ethernet

Modern Instrumentation and Control Systems, Open Systems Interconnection (OSI) Model, Concepts of Parallelization, Sequential, Framing, Bit Encoding, Media Access Control, Error Correction, Time Division, Bit Rate, and Baud Rate, EIA-232, EIA-485, Fiber Optics Overview, Circuit Switching and Packet Switching, Network Topologies, Ethernet, Ethernet Topology, 10 Mbps Ethernet, 1 Gigabit Ethernet, Internetwork Connections Devices (Repeaters, Bridges, Hubs, Switches, Routers and Gateways)

Chapter 2. TCP/IP

IP Version 4 (IPv4), IP Version 6 (IPv6), Address Resolution Protocol (ARP), Internet Control Message Protocol (ICMP), IP Routing, Transmission Control Protocol (TCP), User Datagram Protocol (UDP)

Chapter 3. MODBUS

MODBUS: Protocol Structure, Function Codes

Unit II

Chapter 4. FIELDBUS, PROFIBUS and AS-INTERFACE

FIELDBUS: Physical Layer, Data Link Layer, and Application Layer of FOUNDATION Fieldbus
PROFIBUS: PROFIBUS DP (Decentralized Periphery), PROFIBUS DP Communication Protocol, Application Profiles, PROFIBUS PA (Process Automation)
AS-Interface: AS-Interface, Physical Layer, Data Link, and Application Layer of the AS-Interface

Chapter 5. ETHERCAT, Ethernet POWERLINK and SERCOS III

ETHERCAT: Architecture Model, Protocol, Topology, Distributed Clocks, Device Profiles, EtherCAT Master, EtherCAT Slave
Ethernet POWERLINK: Slot Communication Network Management, Physical Layer, Data Link Layer, Transport and Application Layer of Ethernet POWERLINK, Ethernet POWERLINK Addressing, Frame Structures
SERCOS III: OSI Layers of SERCOS III, Communication Cycle, Protocol Structure, Topology, Communication Network Infrastructure

Chapter 6. HART and OPC

HART: HART Protocol, Physical Layer, Data Link Layer and Application Layer of HART
OPC: Enterprise Integration, Manufacturing Execution Systems (MES), Process Analysis, Process Modeling, Data Modeling, Data Flow Diagrams (DFDs), Communication Patterns, Data Collection Technologies, OPC (OLE for Process Control)

Unit III

Chapter 7. CAN, and CAN FD

CAN: Physical Layer, Data Link Layer and Application Layer of CAN, Protocol, Bus Arbitration, Frames, Bit Stuffing, Bit Synchronization, Bit Timing

CAN FD: Physical Layer, Data Link Layer, and Application Layer of CAN FD, Protocol, Frames

Chapter 8. FLEXRAY and MOST

FLEXRAY: Topologies, Protocol, Media Access Control (Communication Cycle), Frame Format, Clock Synchronization MOST: OSI Layers for MOST, Data Frame, Timing Master, Timing Slave, MOST Devices

Text Books

1. Steve Mackay, Edwin Wright, Deon Reynders, John Park, “Practical Industrial Data Networks: Design, Installation and Troubleshooting,” First edition, Newnes publication, Elsevier, 2004.
2. John Park, Steve Mackay, Edwin Wright, “Practical Data Communications for Instrumentation and Control,” First edition, Newnes publication, Elsevier, 2003

Reference Books:

1. Modbus, http: //www.Modbus.org.
2. FOUNDATION Fieldbus, http: //www.fieldbus.org.
3. FOUNDATION Fieldbus, https: //www.fieldcommgroup.org/technologies/foundation-fieldbus/foundation-technology-overview.
4. ProfiBus, https: //www.profibus.com.
5. AS-Interface, http: //www.as-interface.net.
6. HART, https: //www.fieldcommgroup.org/technologies/hart/hart-technology.
7. EtherCAT, https: //www.ethercat.org.
8. Ethernet POWERLINK, https: //www.ethernet-powerlink.org.
9. SERCOS, https: //www.sercos.org.
10. OPC Foundation, https: //opcfoundation.org.
11. CAN, https: //www.can-cia.org/can-knowledge.
12. CAN FD, https: //www.can-cia.org/can-knowledge/can/can-fd.

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Program: Automation & Robotics Engineering		Semester: VII
Course Title: Mobile Robotics & Perception		Course Code: 17EARE401
L-T-P: 3-0-0	Credits: 3	Contact Hours: 3hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40	Examination Duration: 3hrs	

Unit I

Chapter 1. Introduction to Mobile robots

Intelligence and embodiment, A roboticist's problem, challenges of mobile autonomous robots, Locomotion, static and dynamic stability, degrees of freedom. Coordinate systems and frames of reference, forward kinematics, inverse kinematics, inverse kinematics using feedback control

Chapter 2. Path Planning

Map representations, path planning algorithms, sampling based path planning, path smoothing, planning at different length scales. Uncertainty and error propagation in robotics, probabilistic robotics, basic concepts in probability.

Chapter 3. Recursive State Estimation

Robot environment interaction, Bayes filter, representation and computation. Gaussian filters, Kalman filter, extended kalman filter, information filter, histogram filter, particle filter

Unit II

Chapter 4. Robot Motion

Kinematic configuration, probabilistic kinematics, velocity motion model, odometry motion model.

Chapter 5. Robot Perception

Maps, Beam models of range finders, likelihood fields for range finders, correlation-based sensor models, feature-based sensor models.

Unit III

Chapter 6. Mobile Robot Localization: Markov and Gaussian

Mobile robot localization, Markov localization, EKF localization, Estimating correspondences, multi-hypothesis tracking, grid localization, Monte Carlo localization.

Chapter 7. Occupancy Grid Mapping

Occupancy grid mapping, Simultaneous localization and mapping, RGB-D SLAM.

Text Books:

1. Sebastian Thrun, Wolfram Burgard & Dieter Fox, " Probabilistic Robotics", The MIT Press

Reference Books:

1. Eugene Kagan, Nir Shvalb & Irad Ben-Gal, "Autonomous Mobile Robots and Multi-Robot Systems ", First Edition, John Wiley & Sons Ltd, 2020.

2. Nikolaus Correll, Introduction to Autonomous Robots, 1st edition

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Program: Automation & Robotics Engineering		Semester: VII
Course Title: Design of Automatic Machinery		Course Code: 17EARE402
L-T-P: 3-0-0	Credits: 3	Contact Hours: 3hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40	Examination Duration: 3hrs	

Unit I

Chapter 1: Introduction and Steps to Automation

What is Automation, An Automation design process, examples of automation, problems and project assignments?

Justifying Automation

Traditional Project Cost Justification for a Purchase, Traditional Costing Estimating for Building and Selling Automation, Win–Win Purchasing Philosophy, Maximum Profit Cost Estimating for Building and Selling Automation, Justifying Flexible Automation over Hard Automation, Intellectual Property, Patents, Trade Marks, Copyrights, and Trade Secrets.

Chapter 2: **The Automation Design Process**

System Specifications, Brainstorming, Machine Classification by Function, Machine Classification by Transfer Method, Machine Configuration Trade-offs Mechanisms Toolbox, TBBL Automation Project and Conclusions, Case Study Number 1: Case Opening, Case Study Number 2: Label Insertion and Printing, Case Study Number 3: Crossed Four-Bar BMC Unloader.

Chapter 3: Workstations

Workstation Basics, Drive Mechanisms, Case Study Number 1: TBBL Workstation Design, Case Study Number 2: Automated Screwdriver Workstation Design, Machine Design and Safety.

Feeders

Feeders, Automatic Feeding and Orienting — Vibratory Feeders, Escapement Feeders, Vibratory Bowl Feeder, Centripetal Feeder, Flexible Feeders, Gravity Feed Tracks, Powered Feed Tracks, Escapements, Parts-Placing Mechanisms, Assembly Robots, Case Study Number 1: Dropping Cookies, Case Study Number 2: Feeding of TBBL Cases.

Unit II

Chapter 4: Conveyors

Flat Belt Conveyors, Tabletop Chain Conveyor, Belt Conveyors, Static (Gravity) Conveyors, Powered Conveyors, Heavy Unit Load Handling Conveyors, Case Study Number 3: Donut Loader Machi**ne.**

Chapter 5: Single Station Manufacturing Cells

Single station manned cells, single station automated cells, applications of single station cells, analysis of single station systems. Manual Assembly Lines Fundamentals of manual assembly lines, Analysis of single model assembly lines, Line balancing algorithms, Mixed model assembly lines, Workstation considerations, Other considerations in assembly line design, Alternative assembly systems. Automated Product Lines Fundamentals of automated product lines, applications of automated product lines, Analysis of transfer lines.

Chapter 6: **Automated Assembly Systems**

Fundamentals of automated assembly systems, Quantitative analysis of assembly systems. Cellular Manufacturing Part families, part classification and coding, product flow analysis, cellular manufacturing, applications of group technology, quantitative analysis in cellular manufacturing. Flexible Manufacturing Systems Introduction to flexible manufacturing system, flexible manufacturing systems components, flexible manufacturing systems applications and benefits, flexible manufacturing system planning and implementation issues, quantitative

Unit III

Chapter 7: System Specifications

Expectations, Other Problems Beyond Specifications, Example 1: Bulk Mail Carrier (BMC) Unloader, Specifications, Design Specifications, Comments, Request for Quote, Example 2: BMC Unloader Bid Award Package**.**

Chapter 8: Packaging Machines

Liquid Filling Machines, Cartoning and Boxes, Labeling, Cases, Palletizing, Forming Pouche, Blister Packs and Bags.

Text Books

1. Stephen J. Derby., "Design of Automatic Machinery", 2005
2. Patrick M. McGuire, P.E., "Conveyors", CRC Press, 2010.

Reference Books:

1. Geoffrey Boothroyd, "Assembly Automation and Product Design", Taylor & Francis Group, CRC Press, 2005

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Program: Automation & Robotics Engineering		Semester: VII
Course Title: Advanced Microcontroller		Course Code: 17EARE403
L-T-P: 3-0-0	Credits: 3	Contact Hours: 3hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40	Examination Duration: 3hrs	

Unit I

Chapter 1 Microcontroller Architectures for Low-power behaviour and High-performance capabilities: Requirements of Low-power and High-Performance in autonomous systems built using advanced microcontrollers, Power management, Power-down modes, Case-studies and Examples, Performance of autonomous system, Technologies to enhance the performance of the system, namely, Direct Memory Access, Memory Mapped I/O, Watch Dog Timer, Interrupt mechanisms.

Chapter 2 MSP430 series Microcontroller devices: Unique architectural features, Addressing modes, Instruction set, Power-down modes, MSP430 Interrupts, Digital Input-Output, On-chip peripherals, Timers, Timer Interrupts, Watchdog Timer, Analog to Digital Converters (ADC), Digital to Analog Converters, Hardware Multiplier, Direct Memory Access Controller (DMA).

Unit II

Chapter 3: Advanced Microcontroller for Real-Time Control: Key Architectural features of Real-Time Controller, TI C2000 family MCUs, Floating Point Unit, Control Law accelerator, Trigonometric Math Unit,(TMU), Fast Integer Division Unit (FINTDIV), Complex Math, and CRC Unit (VCU), Example case study on TI C2000 family of MCUs

Chapter 4: DisPIC Controller, PIC 30F series: Introduction to 16-bit microcontrollers, dsPIC 30F – CPU, Data memory, Program Memory, Instruction set, Programming in Assembly and C Interrupt Structure. Peripherals of dsPIC 30F: I/O Ports, Timers, Input Capture, Output Compare, Motor Control PWM, Quadrature Encoder Interface(QEI), A/D Converter, UART, CAN Unit, Application Development.

Chapter 5: Power/ Energy profiling: Profiling ARM Cortex & MSP430 family devices, Low-power operation, Dynamic Voltage and Frequency Scaling, Optimizing for low power in embedded MCU designs, compiler optimization, parallel programming, run-time optimization, performance analysis & tuning, fault tolerance, and power-aware computing techniques.

Chapter 6: Case studies: ARM cortexM3/M4 & MSP430 microcontroller-based real-time solutions for applications like biomedical system design, machine health monitoring, Energy metering applications, etc.

Text Books

1. Peckol, “Embedded system Design”, John Wiley & Sons,2010
2. John Davies “MSP430 Microcontroller Basics” Second Edition (2008)

Reference Books:

1. Shibu.K.V, “Introduction to Embedded Systems”, Tata Mcgraw Hill,2009
2. Steve Furber, ARM System-on-Chip Architecture, 2nd, LPE, 2002
3. Rajkamal, ‘Embedded system-Architecture, Programming, Design’, TMH,2011

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Program: Automation & Robotics Engineering		**Semester: VII**
Course Title: Research Experience for Undergraduates		**Course Code: 17EARE490**
L-T-P: 0-0-6	**Credits: 6**	**Contact Hours: 12hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: ---	**Examination Duration: 3hrs**	

Course Outcomes (COs):

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

1. Identify the scope of the problem based on the literature survey bringing out the contemporary issues in the defined area.
2. Learn and use the tools required for the defined problem.
3. Define process/methodology/steps towards solving the defined problem.
4. Establish flowchart/test bench/block diagram etc towards solving the defined problem.
5. Conduct/simulate, analyze and interpret the data/input for the defined problem.
6. Communicate effectively in written and oral form of the research findings

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Program: Automation & Robotics Engineering		Semester: VII
Course Title: Institutional Research Project		Course Code: 17EARE491
L-T-P: 0-0-6	Credits: 6	Contact Hours: 12hrs/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching Hours: ---	Examination Duration: 3hrs	

Course Outcomes (COs):

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

1. Carry out literature survey and review for the identified statement of work and formulate a research project plan.
2. Identify and follow a systematic design process and design components and processes to build the required platform, generate and collect data and use research-based knowledge and methods to analyze and interpret the data to reach appropriate conclusions.
3. Use various software tools and techniques to create algorithms and analyze conceptual designs through modelling, analysis and simulation and to create detailed designs.
4. Apply engineering and management principles to scope, plan and implement the project, continuously evaluate progress, navigate uncertainty and adversity, and iterate as needed.
5. Function effectively as an individual and collaborate successfully with other members in the team to achieve the desired outcomes.
6. Prepare effective design documentation, project report, and technical paper and make

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Program: Automation & Robotics Engineering		Semester: VII
Course Title: Sponsored Research Project		Course Code: 19EARE493
L-T-P: 0-0-6	Credits: 6	Contact Hours: 12hrs/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching Hours: 70	Examination Duration: 3hrs	

Course Outcomes (COs):

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

1. Carry out literature survey and review for the identified statement of work and formulate a research project plan.
2. Identify and follow a systematic design process and design components and processes to build the required platform, generate and collect data and use research-based knowledge and methods to analyze and interpret the data to reach appropriate conclusions.
3. Use various software tools and techniques to create algorithms and analyze conceptual designs through modelling, analysis and simulation and to create detailed designs.
4. Apply engineering and management principles to scope, plan and implement the project, continuously evaluate progress, navigate uncertainty and adversity, and iterate as needed.
5. Function effectively as an individual and collaborate successfully with other members in the team to achieve the desired outcomes.
6. Prepare effective design documentation, project report, and technical paper and make

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Program: Automation & Robotics Engineering		**Semester: VII**
Course Title: Senior Design Project		**Course Code: 19EARW401**
L-T-P: 0-0-6	**Credits: 6**	**Contact Hours: 12 hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 30	**Examination Duration: 3hrs**	

Prerequisites:
Subjects learnt up to VI semester.

Course Outcomes-CO
At the end of the course student will be able to:

1. Carry out market survey, do need analysis and identify suitable problems.
2. Write a project proposal, which will involve developing a complete solution for the identified problem from the real world.
3. Apply the principles of engineering design to plan and manage the project.
4. Apply suitable design processes and develop the best possible solution.
5. Develop proof of concepts and models for verification.
6. Prepare production drawings, bill of materials and process plans.

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Program: Automation & Robotics Engineering		Semester: **VII**
Course Title: Constitution of India, Professional Ethics and Environmental Studies		**Course Code: 15EHSA401**
L-T-P: 0-0-0	**Credits: 0**	**Contact Hours: hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40 hrs	**Examination Duration: 3 hrs**	

Unit I

Chapter 1: **Features of Indian Constitution**
Features of Indian Constitution, Preamble to the constitution of India, Fundamental rights under Part III – details of Exercise of rights, Limitations & Important cases. Berubari Union and Exchange of Enclaves, Kesavanand Bharati vs. UOI, Maneka Gandhi vs. UOI, Air India Ltd. vs. Nargees Meerza, T.M.A. Pai Foundation v. St. of Karnataka, M.C. Mehta vs. UOI etc.

Chapter 2: **Relevance of Directive principles of State Policy**
Relevance of Directive principles of State Policy under Part IV, Fundamental duties & their significance. Sarla Mudgal v. UOI

Chapter 3: **Union**
Union – President, Vice President, Union Council of Ministers, Prime Minister, Parliament & the Supreme Court of India.

Chapter 4: **State**
State – Governors, State Council of Ministers, Chief Minister, State Legislature and Judiciary.

Chapter 5: Constitutional Provisions for Scheduled Castes & Tribes
Constitutional Provisions for Scheduled Castes & Tribes, Women &Children & Backward classes, Emergency Provisions.

Chapter 6: Electoral process
Electoral process, Amendment procedure, 42nd, 44th and 86th Constitutional amendments**.**

Unit II

Chapter 7: Scope & Aims of Engineering Ethics
Scope & Aims of Engineering Ethics: Meaning and purpose of Engineering Ethics, Responsibility of Engineers, Impediments to responsibility, Honesty, Integrity and reliability, risks, safety & liability in engineering. Bhopal Gas Tragedy, Titanic case.

Chapter 8: Intellectual Property Rights
Intellectual Property Rights (IPRs)- Patents, Copyright and Designs

Chapter 9: Ethical perspectives of professional bodies
Ethical perspectives of professional bodies- IEEE, ASME, NSPE and ABET, ASCE etc

Unit III

Chapter10: Effects of Human Activities on Environment

Effects of human activities on environment - Agriculture, Housing, Industry, Mining, and Transportation activities, Environmental Impact Assessment, Sustainability and Sustainable Development.

Chapter 11: Environmental Protection

Environmental Protection – Constitutional Provisions and Environmental Laws in India

Text Books

1. Dr. J. N. Pandey, “Constitutional Law of India”, Central Law Agency, 2005
2. Dr. M.K. Bhandari, “Law relating to Intellectual Property Rights”, Central Law Publicaitons, Allahabad, 2010.
3. Charles E. Harris and others, “Engineering Ethics: Concepts and Cases”, Thomson Wadsworth, 2003

Reference Books:

1. Durga Das Basu, “Introduction to the Constitution of India”, Prentice-hall EEE, 2001
2. Mike Martin and Ronald Schinzinger, “Ethics in Engineering”, Tata McGraw-Hill Publications.

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Program: Automation & Robotics		Semester: **VIII**
Course Title: Smart Manufacturing		**Course Code: 17EARE404**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40 hrs	**Examination Duration: 3 hrs**	

Unit I

Chapter 1: Introduction to Smart Manufacturing

Introduction to Smart Manufacturing, Smart Manufacturing Ecosystem, Product Development Lifecycle, Production Systems Lifecycle, Business Cycle, Manufacturing Pyramid, Integration, Production Planning and Control, Examples, Standards

Chapter 2: Supply Chain Management (SCM)

Introduction to Supply Chain, SCOR model, Virtual/Extended Enterprise, Delivery Channel, Decision Phases in a Supply Chain, Production Approaches, Supply Chain Process, Push & Pull Production Systems, Push-Pull Boundary, Lack of Coordination and Bullwhip Effect, Order-to-Cash Process, Procure-to-Pay Process, Call-off, Replenishment, Sourcing, Uncertainties, Responsiveness vs Cost, Supply Chain Performance Drivers – Facilities, Inventory, Transportation, Information, Sourcing, and Pricing

Chapter 3: Enterprise Resource Planning (ERP)

Business Processes, Process Modeling and Data Modeling, Business Process Reengineering, Event Process Chains (EPC), ERP Functionalities, Financial Accounting, Cost Accounting and Managerial Accounting, Cost Assignment Techniques, Cost Drivers, Purchasing, Receiving, Inventory Management, Warehouse Management, Shipping and Transportation, Billing, Material Requirement Planning (MRP), Manufacturing Resource Planning (MRP II)

Unit II

Chapter 4: Product Development Lifecycle

Product Development Lifecycle, Digital Thread, PLM Overview, Background for PLM, Scope, PLM Grid, PLM Paradigm - Concepts, Business Process in the PLM Environment, Product Data in the PLM Environment, Information Systems in the PLM Environment, Organization Change Management in the PLM Environment, CAD, CAE, CAM, CAPP, Simulations, NC Programming, CMM Programming, Introduction to Digital Twin, Standards

Chapter 5: Production System Lifecycle

Production System Lifecycle, Revisit Production Planning and Control, Manufacturing Pyramid, Manufacturing Execution Systems (MES), MES Functionalities, MES Models, Functional Control Model, MES in Discrete Industry, MES in Process Industry, Data Collection, Traceability, Performance Measurement and Management, Real-Time Enterprise, Revisit Digital Twin, Standards

Unit III

Chapter 6: Cloud Computing

Introduction to Cloud Computing, Virtualization Concepts, Main Players, Types of Cloud – Public, Private and Hybrid, Cloud Services – CaaS, SaaS, PaaS, and IaaS, Service Level Agreement, Cloud Security, Leveraging Cloud Services for Smart Manufacturing, Cloud Computing at Enterprise Systems Level, Hybrid Cloud Options

Chapter 7: Key Focus Areas

Knowledge Management, Case-Based Reasoning (CBR), Big Data Analytics, Smart Maintenance, Smart Product, Smart Supply Chain, Intelligent Machines, Smart Services, Blockchain

Text Books:

1. Sunil Chopra, and Peter Meindl, “Supply Chain Management – Strategy, Planning, and Operation,” Pearson Education, Sixth Edition, 2016.
2. Ellen Monk, and Bret Wagner, “Concepts in Enterprise Resource Planning,” Fourth Edition, Course Technology CENGAGE Learning, 2009.
3. Stark John, "Product Lifecycle Management: 21st Century Paradigm for Product Realization," Springer, Third Edition, 2015.
4. Sachin Karadgi, “A Reference Architecture for Real-Time Performance Measurement,” Springer, 2014.
5. Anthony T. Velte, Toby J. Velte, and Robert Elsenpeter, “Cloud Computing – A Practical Approach,” McGraw Hill Education, 2010.

Reference Books:

1. Y. Lu, K.C. Morris, S. Frechette, “Current Standards Landscape for Smart Manufacturing Systems,” National Institute of Standards and Technology (NIST), (2016).
2. MESA International, "Three Functional Dimensions Converge on Smart Manufacturing," Whitepaper #59, 2018.
3. MESA International, "Smart Manufacturing and Cloud Computing," Whitepaper #60, 2018.

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Program: Automation & Robotics		Semester: **VIII**
Course Title: Capstone Project		**Course Code: 18EARW402**
L-T-P: 0-0-11	**Credits: 11**	**Contact Hours:** ---
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: ---	**Examination Duration: 3 hrs**	

Prerequisites:
Subjects learnt up to VII semester.

Course Outcomes-CO
At the end of the course student will be able to:

1. Carry out market survey, do need analysis and identify suitable problems.
2. Write a project proposal, which will involve developing a complete solution for the identified problem from the real world.
3. Apply the principles of engineering design to plan and manage the project.
4. Apply suitable design processes and develop the best possible solution.
5. Develop proof of concepts and models for verification.
6. Prepare production drawings, bill of materials and process plans.

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Program: Automation & Robotics		Semester: **VIII**
Course Title: Industry Internship - Training		**Course Code: 17EARI493**
L-T-P: 0-0-6	**Credits: 6**	**Contact Hours:** ---
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: ---	**Examination Duration: 3 hrs**	

Course Outcomes (COs):

Upon completion of an internship, students will be able to demonstrate the following outcomes:

1. Gain knowledge to real-world challenges in an industry environment.
2. Engage in responsible conduct while working as an intern and allow decisions to be informed by a value-centered life.
3. Understanding an organization by proper insight into their structure, processes and functions.
4. Able to assimilate new technical knowledge, and integrate the same with the existing technical knowledge for industrial application.
5. Understanding of lifelong learning processes through critical reflection of internship experiences.

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Program: Automation & Robotics		Semester: **VIII**
Course Title: Industry Internship - Project Work		**Course Code: 17EARW494**
L-T-P: 0-0-6	**Credits: 6**	**Contact Hours:** ---
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: ---	**Examination Duration: 3 hrs**	

Preamble:

The aim of this project work is to enable students to develop their engineering skills and practice by co-working with industry mentors on an industry relevant problem.

Course Outcomes (COs)

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

1. Generate and evaluate different alternative solutions
2. Formulate a detailed solution plan to solve the given problem.
3. Identify and employ tools that help to arrive at solutions
4. Understand and adhere to various standards, legislation and regulations
5. Distribute the work load based on competences among team members and integrate the various components of the solution
6. Adhere to promised deliverable, including bill of material, production drawings, manufacturing of components, assembly, and so forth

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