ANNA UNIVERSITY, CHENNAI

UNDERGRADUATE CURRICULUM (UNIVERSITY DEPARTMENTS)

Campus: Madras Institute of Technology

Department: Production Technology

Programme: Robotics and Automation

Regulations: 2023 (Revised 2024), with effect from the AY 2024 – 25 to all the students of UG Programme.

OVERVIEW OF CREDITS

Sem	PCC	PEC	ESC	HSMC	ETC	OEC	SDC	UC	SLC	Total
I			4	11			7	1		**23**
II			7	15				1		**23**
III	16		4	4						**24**
IV	20						2	2		**24**
V	18				3		2	3		**26**
VI		18				3			1	**22**
VII	13				3	3	2	4		**25**
VIII							8			**8**
Total	**67**	**18**	**15**	**30**	**6**	**6**	**21**	**11**	**1**	**175**
% of Category	**38**	**10**	**9**	**17**	**3**	**3**	**12**	**6**	**1**	**100**

CATEGORY OF COURSES

PCC – Professional Core Course;

PEC – Professional Elective Course;

ETC – Emerging Technology Course;

OEC – Open Elective Course;

SLC – Self Learning Course

ESC – Engineering Science Course

HSMC – Humanities Science and Management Course

SDC – Skill Development Course

UC – University Course

For Honours & Minor Degree, please refer the Regulations 2023 (Revised 2024).

Semester – I							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1	EN23C01	Foundation English	LIT	2-0-2	4	3	HSMC
2	MA23C01	Matrices and Calculus	T	3-1-0	4	4	HSMC
3	PH23C01	Engineering Physics	LIT	3-0-2	5	4	HSMC
4	ME23C01	Engineering Drawing and 3D Modelling	LIT	2-0-4	6	4	SDC
5	ME23C03	Engineering Mechanics	T	3-1-0	4	4	ESC
6	ME23C04	Makerspace	LIT	1-0-4	5	3	SDC
7	UC23H01	தமிழர்மரபு/Heritage of Tamils	T	1-0-0	1	1	UC
8		NCC/NSS/NSO/YRC	L	0-0-2	2	-	UC
					Total Credits	**23**	

*** TCP** – Total Contact Period(s)

TYPE OF COURSE

LIT –Laboratory Integrated Theory, **T**– Theory
L – Laboratory Course, **IPW**– Internship cum Project Work
PW – Project Work,**CDP**– Capstone Design Project

Semester– II							
S. No.	**Course Code**	**Course Name**	**Course Type**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP**		
1	EN23C02	Professional Communication	LIT	2-0-2	4	3	HSMC
2	MA23C02	Ordinary Differential Equations and Transform Techniques	T	3-1-0	4	4	HSMC
3	PH23201	Applied Material Science	LIT	3-0-0	3	3	HSMC
4	CY23C01	Engineering Chemistry	LIT	3-0-2	5	4	HSMC
5	CS23C04	Programming in C	LIT	2-0-4	6	4	ESC
6	EE23C04	Electrical, Electronics and Measurements Engineering	LIT	3-0-2	5	4	ESC
7	UC23H02	தமிழரும்தொழில்நுட்பமும் / Tamils and Technology	T	1-0-0	1	1	UC
8		Audit Course – I	-	-	-	-	UC
					Total Credits	**23**	

SEMESTER– III							
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE	PERIODS / WEEK		CREDITS	CATE GORY
				L-T-P	TCP		
1.	MA23C03	Linear Algebra and Numerical Methods	T	3-1-0	4	4	HSMC
2.	AU23C02	Mechanics of Solids	LIT	3-0-2	5	4	ESC
3.	PR23C01	Theory of Machines	LIT	3-0-2	5	4	PCC
4.	RA23301	Digital Electronics and Microprocessor	T	3-0-0	3	3	PCC
5.	RA23302	Electrical Drives and Actuators	LIT	3-0-4	7	5	PCC
6.	RA23303	Kinematics of Robotics	LIT	3-0-2	5	4	PCC
TOTAL CREDITS						24	

SEMESTER– IV							
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE	PERIODS / WEEK		CREDITS	CATE GORY
				L-T-P	TCP		
1	RA23401	Sensors and Signal Conditioning	LIT	3-0-2	5	4	PCC
2	RA23402	Embedded Systems and Programming	LIT	3-0-4	7	5	PCC
3	RA23403	Motion Control Systems	LIT	3-0-2	5	4	PCC
4	RA23404	Design of Robot Elements	LIT	3-0-2	5	4	PCC
5	RA23405	Thermal and Fluid Systems	LIT	2-0-2	4	3	PCC
6		Audit Course – II	T	2-0-0	2	-	UC
7		Skill Development Courses - I$ (Naan Mudhalvan /Siemens Centre for Excellence (SCOE)	L	0-0-2	2	1	SDC
8		Industry Oriented Course I	-	-	-	1	SDC
9	UC23U01	Universal Human Values	LIT	1-0-2	3	2	UC
TOTAL CREDITS						24	

SEMESTER– V							
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE	PERIODS / WEEK		CREDITS	CATE GORY
				L-T-P	TCP		
1.	RA23501	Manufacturing Systems and Process	LIT	2-0-2	4	3	PCC
2.	RA23C02	Industrial Automation	LIT	3-0-2	5	4	PCC
3.	RA23502	Autonomous Mobile Robots&&	LIP	2-0-2	4	3	PCC
4.	RA23503	Robot Dynamics and Control	LIT	3-0-2	5	4	PCC
5.	RA23504	Fluid Power Automation	LIT	3-0-2	5	4	PCC
6.		Emerging Technology Course– I	LIT	-	-	3	ETC
7.		Skill Development Courses – II	L	0-0-2	2	1	SDC

SEMESTER– V							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE**	**PERIODS / WEEK**		**CREDITS**	**CATE GORY**
				L-T-P	**TCP**		
		(Naan Mudhalvan /Siemens Centre for Excellence (SCOE)					
8.		Industry Oriented Course II	-	-	1	1	SDC
9.	UC23E01	Engineering Entrepreneurship Development Course	T	2-0-2	4	3	UC
TOTAL CREDITS						**26**	
COURSES FOR HONOURS DEGREE							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE**	**PERIODS / WEEK**		**CREDITS**	**CATEG ORY**
				L-T-P	**TCP**		
1.	RA23D01	Capstone Design Project – Level I	CDP	0-0-12	12	6	SDC
(OR)							
1.		Honours Elective – I	T	3-0-0	3	3	
2.		Honours Elective – II	T	3-0-0	3	3	
COURSES FOR MINOR DEGREE							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE**	**PERIODS / WEEK**		**CREDITS**	**CATE GORY**
				L-T-P	**TCP***		
1.		Minor Elective – I	T	3-0-0	3	3	
2.		Minor Elective – II	T	3-0-0	3	3	

&&- Theory with project

SEMESTER– VI (Preference for Foreign Exchange)							
S. No.	**Course Code**	**Course Name**	**Course Type**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP**		
1.		Professional Elective – I	T	3-0-0	3	3	PEC
2.		Professional Elective – II	T	3-0-0	3	3	PEC
3.		Professional Elective – III	T	3-0-0	3	3	PEC
4.		Professional Elective – IV	T	3-0-0	3	3	PEC
5.		Professional Elective – V	T	3-0-0	3	3	PEC
6.		Professional Elective – VI	T	3-0-0	3	3	PEC
7.		Open Elective – I	T	3-0-0	3	3	OEC
8.	RA23L01	Self-Learning Course	T	-	0	1	SLC
Total Credits						**22**	
Courses for Honours Degree							
				L-T-P	**TCP**		
1.	RA23D02	Capstone Design Project – Level II	CDP	0-0-12	12	6	SDC
(OR)							
1.		Honours Elective – III				3	
2.		Honours Elective – IV				3	
Courses for Minor Degree							
1.		Minor Elective – III				3	
2.		Minor Elective – IV				3	

SEMESTER– VII							
S. No.	**Course Code**	**Course Name**	**Course Type**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP**		
1.	RA23701	Robot Trajectory and Path Planning	LIT	3-0-2	5	4	PCC
2.	RA23702	Robot Vision	LIT	3-0-2	5	4	PCC
3.	RA23703	Machine Learning for Intelligent Systems	LIT	3-0-2	5	4	PCC
4.		Emerging Technology Course-II	LIT	-	-	3	ETC
5.	RA23U02	Sustainability for Automation	LIT	2-0-2	4	3	UC
6.		Open Elective – II	T	3-0-0	3	3	OEC
7.	RA23704	Comprehension	L	0-0-1	1	1	PCC
8.		Industry Oriented Course – III	T	1-0-0	1	1	SDC
9.		Skill Based Courses - III[$] (Naan Mudhalvan/SCOE)	L	0-0-2	2	1	SDC
10	RA23U01	Standards for Robotics and Automation	T	1-0-0	1	1	UC
					Total Credits	**25**	
Courses for Honours Degree							
S. No.	**Course Code**	**Course Name**	**Course Type**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP**		
1.	RA23D03	Capstone Design Project – Level III	CDP	0-0-12	12	6	SDC
(OR)							
1.		Honours Elective – V				3	
2.		Honours Elective – VI				3	
Courses for Minor Degree							
S. No.	**Course Code**	**Course Name**	**Course Type**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP**		
1.		Minor Elective – V				3	
2.		Minor Elective – VI				3	

SEMESTER– VIII							
S. No.	**Course Code**	**Course Name**	**Course Type**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP**		
1.	RA23801	Project Work / Internship cum Project Work	PW/IPW	0-0-16	16	8	SDC
					Total Credits	**8**	

PROFESSIONAL ELECTIVE COURSES

Sl. No.	VERTICAL 1	VERTICAL 2	VERTICAL 3	VERTICAL 4	VERTICAL 5
	ADVANCED ROBOTICS	**INDUSTRIAL AUTOMATION TECHNOLOGIES**	**INTELLIGENT SYSTEMS**	**SMART MOBILITY**	**PRODUCTION ENGINEERING AND SYSTEMS**
1.	Robots and Systems in Manufacturing	Virtual Instrumentation	Programming for Robotics	Architecture of Electric and Hybrid Vehicles	CNC Machines and Automated Production Systems
2.	Multi-agent Robotics	Industrial Network Protocols	Medical Mechatronics	Automotive Mechatronics	Material Handling and Storage Systems
3.	Micro robotics	Factory Integrated Automation	Cloud Point Data Processing	Automotive System Modelling and Simulation	Unconventional Machining Processes
4.	Medical Robotics	Building Automation	Wearable Devices	Advanced Driver Assistance Systems	Additive Manufacturing
5.	Humanoid Robotics	Advanced topics in PID Control	Computational Method and Algorithms	Special Purpose Vehicles	Engineering Metrology
6.	Agricultural Robotics and Automation	Engineering Data Analytics	Computer Vision and Deep Learning	Aircraft Mechatronics	Total Productive Maintenance

Sl. No.	VERTICAL 6	VERTICAL 7	VERTICAL 8	VERTICAL9
	AVIONICS AND DRONE TECHNOLOGY	**INDUSTRIAL MANAGEMENT**	**DIVERSIFIED GROUP 1**	**DIVERSIFIED GROUP 2**
1.	Avionics Systems	Quantitative Techniques in Management	Integrated Product Development	Biologically Inspired Robotics
2.	Aircraft Navigations Systems	Design of Experiments	Composite Materials	Linear Integrated Circuits
3.	Aircraft System Modeling and Simulation	Engineering management	Process Planning and Cost Estimation	Data Structures and Object Oriented Programming in C++
4.	Aircraft Guidance and Control	Supply Chain Management	Finite Element Analysis	Human Factors and Work Design
5.	Air Traffic Control and Planning	Fundamentals of Lean Six Sigma	Statistical Quality Control and Reliability	Product Life Cycle Management
6.	Vibration Analysis and Control	Engineering Economics and Costing	Advanced controllers and FPGA	GD&T in Design and Manufacturing

VERTICAL I: ADVANCED ROBOTICS						
S. No.	Course Code	Course Name	Course Type#	Periods / Week		Credits
				L-T-P	TCP*	
1	RA23001	Robots and Systems in Manufacturing	T	3-0-0	3	3
2	RA23002	Multi-agent Robotics	T	3-0-0	3	3
3	RA23003	Micro robotics	T	3-0-0	3	3
4	RA23004	Medical Robotics	T	3-0-0	3	3
5	RA23005	Humanoid Robotics	T	3-0-0	3	3
6	RA23006	Agricultural Robotics and Automation	T	3-0-0	3	3

VERTICAL II: INDUSTRIAL AUTOMATION TECHNOLOGIES						
S. No.	Course Code	Course Name	Course Type#	Periods / Week		Credits
				L-T-P	TCP*	
1	RA23007	Virtual Instrumentation	T	3-0-0	3	3
2	RA23008	Industrial Network Protocols	T	3-0-0	3	3
3	RA23009	Factory Integrated Automation	T	3-0-0	3	3
4	RA23010	Building Automation	T	3-0-0	3	3
5	EI23C01	Advanced topics in PID Control	T	3-0-0	3	3
6	RA23C01	Engineering Data Analytics	T	3-0-0	3	3

VERTICAL III: INTELLIGENT SYSTEMS						
S. No.	Course Code	Course Name	Course Type#	Periods / Week		Credits
				L-T-P	TCP*	
1	RA23011	Programming for Robotics	T	3-0-0	3	3
2	RA23012	Medical Mechatronics	T	3-0-0	3	3
3	RA23013	Cloud Point Data Processing	T	3-0-0	3	3
4	RA23014	Wearable Devices	T	3-0-0	3	3
5	RA23015	Computational Method and Algorithms	T	3-0-0	3	3
6	RA23016	Computer Vision and Deep Learning	T	3-0-0	3	3

VERTICAL IV: SMART MOBILITY						
S. No.	Course Code	Course Name	Course Type#	Periods / Week		Credits
				L-T-P	TCP*	
1	RA23017	Architecture of Electric and Hybrid Vehicles	T	3-0-0	3	3
2	RA23018	Automotive Mechatronics	T	3-0-0	3	3
3	RA23019	Automotive System Modelling and Simulation	T	3-0-0	3	3
4	RA23020	Advanced Driver Assistance Systems	T	3-0-0	3	3
5	AU23C03	Special Purpose Vehicles	T	3-0-0	3	3
6	RA23021	Aircraft Mechatronics	T	3-0-0	3	3

VERTICAL V: PRODUCTION ENGINEERING AND SYSTEMS						
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**
				L-T-P	**TCP***	
1	RA23022	CNC Machines and Automated Production Systems	T	3-0-0	3	3
2	PR23C06	Material Handling and Storage Systems	T	3-0-0	3	3
3	RA23023	Unconventional Machining Processes	T	3-0-0	3	3
4	MF23C01	Additive Manufacturing	T	3-0-0	3	3
5	RA23024	Engineering Metrology	T	3-0-0	3	3
6	MF23C04	Total Productive Maintenance	T	3-0-0	3	3

VERTICAL VI: AVIONICS AND DRONE TECHNOLOGY						
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**
				L-T-P	**TCP***	
1	AE23C06	Avionics Systems	T	3-0-0	3	3
2	AE23C04	Aircraft Navigations Systems	T	3-0-0	3	3
3	AE23C05	Aircraft System Modeling and Simulation	T	3-0-0	3	3
4	AE23C03	Aircraft Guidance and Control	T	3-0-0	3	3
5	AE23C02	Air Traffic Control and Planning	T	3-0-0	3	3
6	RA23C03	Vibration Analysis and Control	T	3-0-0	3	3

VERTICAL VII: INDUSTRIAL MANAGEMENT						
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**
				L-T-P	**TCP***	
1	RA23026	Quantitative Techniques in Management	T	3-0-0	3	3
2	RA23027	Design of Experiments	T	3-0-0	3	3
3	RA23028	Engineering management	T	3-0-0	3	3
4	RA23029	Supply Chain Management	T	3-0-0	3	3
5	IE23C02	Fundamentals of Lean Six Sigma	T	3-0-0	3	3
6	IE23C05	Engineering Economics and Costing	T	3-0-0	3	3

VERTICAL VIII: DIVERSIFIED GROUP 1						
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**
				L-T-P	**TCP***	
1	RA23030	Integrated Product Development	T	3-0-0	3	3
2	PR23C02	Composite Materials	T	3-0-0	3	3
3	PR23C08	Process Planning and Cost Estimation	T	3-0-0	3	3
4	ME23C09	Finite Element Analysis	T	3-0-0	3	3
5	RA23031	Statistical Quality Control and Reliability	T	3-0-0	3	3
6	RA23032	Advanced controllers and FPGA	T	3-0-0	3	3

VERTICAL IX: DIVERSIFIED GROUP 2						
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**
				L-T-P	**TCP***	
1	RA23033	Biologically Inspired Robotics	T	3-0-0	3	3
2	RA23034	Linear Integrated Circuits	T	3-0-0	3	3
3	RA23035	Data Structures and Object Oriented Programming in C++	T	3-0-0	3	3
4	PR23C07	Human Factors and Work Design	T	3-0-0	3	3
5	IE23C04	Product Life Cycle Management	T	3-0-0	3	3
6	PR23C04	GD&T in Design and Manufacturing	T	3-0-0	3	3

Courses for Honors Degree							
S. No.	**Course Code**	**Course Name**	**Course Type**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP**		
1.	RA23036	Multibody Dynamics	T	3-0-0	3	3	PEC
2.	RA23037	Modern Control Theory	T	3-0-0	3	3	PEC
3.	RA23038	Digital Signal Processing	T	3-0-0	3	3	PEC
4.	RA23039	Condition Monitoring	T	3-0-0	3	3	PEC
5.	RA23040	Immersive Technologies and Haptics	T	3-0-0	3	3	PEC
6.	RA23041	Brain Computer Interface and Applications	T	3-0-0	3	3	PEC
7.	RA23042	Bio-Mechatronics	T	3-0-0	3	3	PEC
8.	AE23C07	Drone Technology	T	3-0-0	3	3	PEC

Courses for Minor Degree in "Automation Technology"							
S. No.	**Course Code**	**Course Name**	**Course Type**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP**		
1.	RA23043	Robotics	T	3-0-0	3	3	PCC
2.	RA23044	Industrial Automation	T	3-0-0	3	3	PCC
3.	RA23045	Mobile Robotics	T	3-0-0	3	3	PCC
4.	RA23046	Robot Dynamics and Control	T	3-0-0	3	3	PCC
5.	RA23047	Fluid Power systems	T	3-0-0	3	3	PCC
6.	RA23048	Vision Technology	T	3-0-0	3	3	PCC
Emerging Technology Courses							
S. No.	**Course Code**	**Course Name**	**Course Type**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP**		
SEMESTER V							
1	RA23E01	Robot Operating Systems&&	LIT	1-0-4	5	3	ETC
2	RA23E02	Robot Process Automation&&	LIT	1-0-4	5	3	ETC
SEMESTER VI							
3	RA23E03	Digital Twin and Industry 5.0	T	3-0-0	3	3	ETC
4	RA23E04	Smart Mobility and Intelligent Vehicles	T	3-0-0	3	3	ETC

&& - Theory with Project

Open Elective Courses							
S. No.	Course Code	Course Name	Course Type	Periods / Week		Credits	Category
				L-T-P	TCP		
1	RA23901	Basics of Fluid Power Automation	T	3-0-0	3	3	OEC
2	RA23902	Robotics	T	3-0-0	3	3	OEC

Bridge Course

Bridge Course For Lateral Entry Students (Diploma) (CIRCUIT BRANCHES)							
S. No.	Course Code	Course Name	Course Type	Periods / Week		Credits	Category
				L-T-P	TCP		
1.	MA23C02	Ordinary Differential Equations and Transform Techniques	T	3-1-0	4	4	HSMC
2.	ME23C03	Engineering Mechanics	T	3-1-0	4	4	ESC
Bridge Course for Lateral Entry Students (Diploma) (NON CIRCUIT BRANCHES)							
1.	MA23C02	Ordinary Differential Equations and Transform Techniques	T	3-1-0	4	4	HSMC
2.	EE23C04	Electrical, Electronics and Measurements Engineering	LIT	3-0-2	5	4	ESC

Bridge Course for Lateral Entry Students (B.Sc.)							
S. No.	Course Code	Course Name	Course Type	Periods / Week		Credits	Category
				L-T-P	TCP		
1.	ME23C03	Engineering Mechanics	T	3-1-0	4	4	ESC
2.	ME23C01	Engineering Drawing & 3D Modelling	LIT	2-0-4	6	4	SDC
3.	EE23C04	Electrical, Electronics and Measurements Engineering	LIT	3-0-2	5	4	ESC

List of Industrial Oriented Courses							
S. No.	Course Code	Course Name	Course Type	Periods / Week		Credits	Category
				L-T-P	TCP		
1.		Inverse Kinematic Solvers for Serial Robots in Python	T	1-0-0	1	1	SDC
2.		Industrial IOT	T	1-0-0	1	1	SDC
3.		Marine Robotics	T	1-0-0	1	1	SDC
4.		Robot Tool Design	T	1-0-0	1	1	SDC
5.		Electro Mechanical Automation	T	1-0-0	1	1	SDC

List of Industrial Oriented Courses							
S. No.	**Course Code**	**Course Name**	**Course Type**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP**		
6.		Integrated Product Development	T	1-0-0	1	1	SDC
7.		GDT	T	1-0-0	1	1	SDC

List of Skill Development Courses							
S. No.	**Course Code**	**Course Name**	**Course Type**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP**		
Level I							
1.	RA23S01	Basic Design Software	L	0-0-2	2	1	SDC
2.	RA23S02	Motion Simulation	L	0-0-2	2	1	SDC
3.	RA23S03	Basics of Software for Robot	L	0-0-2	2	1	SDC
4.	RA23S04	Basics of PLC	L	0-0-2	2	1	SDC
5.	RA23S05	Basics of Low Voltage Switch gear	L	0-0-2	2	1	SDC
Level II							
6.	RA23S06	Basics of Induction Motors	L	0-0-2	2	1	SDC
7.	RA23S07	Basic Course on AC DC Drives	L	0-0-2	2	1	SDC
8.	RA23S08	Basic of Process Instrumentation	L	0-0-2	2	1	SDC
9.	RA23S09	Basic Mechatronics	L	0-0-2	2	1	SDC
10.	RA23S10	Turning -Numerical control programming	L	0-0-2	2	1	SDC
Level III							
11.	RA23S11	Introduction to PLM	L	0-0-2	2	1	SDC
12.	RA23S12	Advanced Modelling & Kinematics	L	0-0-2	2	1	SDC
13.	RA23S13	CNC Turning- Operation and Machining	L	0-0-2	2	1	SDC
14.	RA23S14	Advanced Simulation Process	L	0-0-2	2	1	SDC
15.	RA23S15	Basic of Industrial Robotics – KUKA robots	L	0-0-2	2	1	SDC

EN23C01 **FOUNDATION ENGLISH** **L T P C**
2 0 2 3

COURSE OBJECTIVES:

- To develop students' foundational skills in reading, writing, grammar and vocabulary to enable them to understand and produce various forms of communication.
- To enhance students' proficiency in reading comprehension, narrative and comparative writing.
- To comprehend and analyse descriptive texts and visual images
- To articulate similarities and differences in oral and written forms.
- To improve students' proficiency in reading and writing formal letters and emails.

UNIT I BASICS OF COMMUNICATION **6**

Reading - Telephone message, bio-note; Writing – Personal profile; Grammar – Simple present tense, Present continuous tense, wh-questions, indirect questions; Vocabulary – Word formation (Prefix and Suffix).

LAB ACTIVITY: **6**

Listening – Telephone conversation; Speaking Self-introduction; Telephone conversation – Video conferencing etiquette

UNIT II NARRATION **6**

Reading – Comprehension strategies - Newspaper Report, An excerpt from an autobiography; Writing – Narrative Paragraph writing (Event, personal experience etc.); Grammar – Subject-verb agreement, Simple past, Past continuous Tenses; Vocabulary – One-word substitution

LAB ACTIVITY: **6**

Listening – Travel podcast; Speaking – Narrating and sharing personal experiences through a podcast

UNIT III DESCRIPTION **6**

Reading – A tourist brochure, Travel blogs, descriptive article/excerpt from literature, visual images; Writing –Descriptive Paragraph writing, Grammar – Future tense, Perfect tenses, Preposition; Vocabulary – Descriptive vocabulary

LAB ACTIVITY: **6**

Listening – Railway / Airport Announcements, Travel Vlogs; Speaking – Describing a place or picture description

UNIT IV COMPARE AND CONTRAST **6**

Reading – Reading and comparing different product specifications - Writing – Compare and Contrast Essay, Coherence and cohesion; Grammar – Degrees of Comparison; Vocabulary – Transition words (relevant to compare and contrast)

LAB ACTIVITY: **6**

Listening – Product reviews, Speaking – Product comparison based on product reviews - similarities and differences

UNIT V EXPRESSION OF VIEWS 6

Reading – Formal letters, Letters to Editor ; Writing – Letter writing/ Email writing (Enquiry / Permission, Letter to Editor); Grammar – Compound nouns, Vocabulary – Synonyms, Antonyms

LAB ACTIVITY: 6

Listening – Short speeches; Speaking – Making short presentations (JAM)

TOTAL: 60 PERIODS

TEACHING METHODOLOGY

Interactive lectures, role plays, group discussions, listening and speaking labs, technology enabled language teaching, flipped classroom.

EVALUATION PATTERN

Internal Assessment

Written assessments

Assignment

Lab assessment

Listening

Speaking

External Assessment

End Semester Examination

LEARNING OUTCOMES

By the end of the courses, students will be able to

- Use appropriate grammar and vocabulary to read different types of text and converse appropriately.
- Write coherent and engaging descriptive and comparative essay writing.
- Comprehend and interpret different kinds of texts and audio visual materials
- Critically evaluate reviews and articulate similarities and differences
- Write formal letters and emails using appropriate language structure and format

TEXT BOOKS:

1. “English for Engineers and Technologists” Volume I by Orient Blackswan, 2022
2. “English for Science & Technology - I” by Cambridge University Press, 2023

REFERENCES

1. “Interchange” by Jack C.Richards, Fifth Edition, Cambridge University Press, 2017.
2. “English for Academic Correspondence and Socializing” by Adrian Wallwork, Springer, 2011.
3. “The Study Skills Handbook” by Stella Cortrell, Red Globe Press, 2019
4. www.uefap.com

Mapping of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										√		√
CO2										√		
CO3										√		√
CO4										√		
CO5										√		√

MA23C01	MATRICES AND CALCULUS	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To develop the use of matrix algebra techniques in solving practical problems.
- To familiarize the student with functions of several variables.
- To solve integrals by using Beta and Gamma functions.
- To acquaint the student with mathematical tools needed in evaluating multiple integrals.
- To acquaint the students with the concepts of vector calculus which naturally arise in many engineering problems.

UNIT I MATRICES 9+3

Eigenvalues and Eigenvectors of a real matrix – Properties of Eigenvalues and Eigenvectors- Cayley-Hamilton theorem (excluding proof) – Diagonalization of matrices - Reduction of Quadratic form to canonical form by using orthogonal transformation - Nature of a Quadratic form.

UNIT II FUNCTIONS OF SEVERAL VARIABLES 9+3

Limit, continuity, partial derivatives – Homogeneous functions and Euler's theorem - Total derivative – Differentiation of implicit functions – Jacobians -Taylor's formula for two variables - Errors and approximations – Maxima and Minima of functions of two variables – Lagrange's method of undermined multipliers.

UNIT III INTEGRAL CALCULUS 9+3

Improper integrals of the first and second kind and their convergence – Differentiation under integrals - Evaluation of integrals involving a parameter by Leibnitz rule – Beta and Gamma functions-Properties – Evaluation of single integrals by using Beta and Gamma functions..

UNIT IV MULTIPLE INTEGRALS 9+3

Double integrals – Change of order of integration – Double integrals in polar coordinates – Area enclosed by plane curves – Triple integrals – Volume of Solids – Change of variables in double and triple integrals-

Evaluation of double and triple integrals by using Beta and Gamma functions.

UNIT V VECTOR CALCULUS 9+3

Gradient of a scalar field, directional derivative – Divergence and Curl – Solenoidal and Irrotational vector fields - Line integrals over a plane curve - Surface integrals – Area of a curved surface – Volume Integral - Green's theorem, Stoke's and Gauss divergence theorems (without proofs)– Verification and applications in evaluating line, surface and volume integrals.

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students wherever applicable from the content of the course.

General engineering applications / branch specific applications from the content of each units wherever possible will be introduced to students.

Suggested Laboratory based exercises / assignments / assessments :

Matrices

1. Finding eigenvalues and eigenvectors
2. Verification of Cayley-Hamilton theorem
3. Eigenvalues and Eigenvectors of similar matrices
4. Eigenvalues and Eigenvectors of a symmetric matrix
5. Finding the powers of a matrix
6. Quadratic forms

Functions of Several Variables

1. Plotting of curves and surfaces
2. Symbolic computation of partial and total derivatives of functions

Integral Calculus

1. Evaluation of beta and gamma functions
2. Computation of error function and its complement

Multiple Integrals

1. Plotting of 3D surfaces in Cartesian and Polar forms

Vector Calculus

1. Computation of Directional derivatives
2. Computation of normal and tangent to the given surface

OUTCOMES:

CO 1 :Use the matrix algebra methods for solving practical problems.

CO 2 :Use differential calculus ideas on several variable functions.

CO 3 :Apply different methods of integration in solving practical problems by using Beta and Gamma functions.

CO 4 :Apply multiple integral ideas in solving areas and volumes problems.

CO 5 :Apply the concept of vectors in solving practical problems.

TEXT BOOKS:

1. Joel Hass, Christopher Heil, Maurice D.Weir "'Thomas' Calculus", Pearson Education., New Delhi, 2018.
2. Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, 45th Edition, New Delhi, 2020.
3. James Stewart, Daniel K Clegg & Saleem Watson "Calculus with Early Transcendental Functions", Cengage Learning, 6th Edition, New Delhi,2023.

REFERENCES:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India Pvt Ltd., New Delhi, 2018.
2. Greenberg M.D., “Advanced Engineering Mathematics”, Pearson Education2nd Edition, 5th Reprint, Delhi, 2009.
3. Jain R.K. and Iyengar S.R.K., “Advanced Engineering Mathematics”,Narosa Publications, 5th Edition, New Delhi, 2017.
4. Narayanan S. and Manicavachagom Pillai T. K., “Calculus" Volume I and II, S. Viswanathan Publishers Pvt. Ltd., Chennai, 2009.
5. Peter V.O’Neil, “Advanced Engineering Mathematics”, Cengage Learning India Pvt., Ltd, 7 th Edition, New Delhi , 2012.
6. Ramana B.V., “Higher Engineering Mathematics”, Tata McGraw Hill Co. Ltd., 11th Reprint, New Delhi, 2010.

CO – PO Mapping:

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**P11**	**P12**
CO1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO5 :	3	3	2	3	1	2	1	1	1	1	1	3

PH23C01	ENGINEERING PHYSICS	L	T	P	C
	(Common to all branches of B.E/B.Tech Programmes)	3	0	2	4

COURSE OBJECTIVES

- To familiarize with crystal structure, bonding and crystal growth.
- To impart knowledge on Mechanics of Materials.
- To impart knowledge of oscillations, sound and Thermal Physics
- To facilitate understanding of optics and its applications, different types of Lasers and fiber optics.
- To introduce the basics of Quantum Mechanics and its importance.

UNIT I CRYSTAL PHYSICS 9+6

Crystal Bonding – Ionic – covalent – metallic and van der Walls's/ molecular bonding. Crystal systems - unit cell, Bravais lattices, Miller indices - Crystal structures - atomic packing density of BCC, FCC and HCP structures. NaCl, Diamond, Graphite, Graphene, Zincblende and Wurtzite structures - crystal imperfections- point defects - edge and screw dislocations – grain boundaries. Crystal Growth – Czocharalski method – vapor phase epitaxy – Molecular beam epitaxy- Introduction to X-Ray Diffractometer.

1. Determination of Lattice parameters for crystal systems.
2. Crystal Growth – Slow Evaporation method
3. Crystal Growth Sol – Gel Method

UNIT II MECHANICS OF MATERIALS 9+6

Rigid Body – Centre of mass – Rotational Energy - Moment of inertia (M.I)- Moment of Inertia for uniform objects with various geometrical shapes. Elasticity –Hooke's law - Poisson's ratio - stress-strain diagram for ductile and brittle materials – uses- Bending of beams – Cantilever - Simply supported beams - uniform and non-uniform bending - Young's modulus determination - I shaped girders –Twisting couple – Shafts. Viscosity – Viscous drag – Surface Tension.

1. Non-uniform bending -Determination of Young's modulus of the material of the beam.
2. Uniform bending -Determination of Young's modulus of the material of the beam
3. Viscosity – Determination of Viscosity of liquids.

UNIT III OSCILLATIONS, SOUND AND THERMAL PHYSICS 9+6

Simple harmonic motion - Torsional pendulum –- Damped oscillations –Shock Absorber - Forced oscillations and Resonance –Applications of resonance.- Waves and Energy Transport –Sound waves – Intensity level – Standing Waves - Doppler effect and its applications - Speed of blood flow. Ultrasound – applications - Echolocation and Medical Imaging. Thermal Expansion – Expansion joints – Bimetallic strip – Seebeck effect – thermocouple -Heat Transfer Rate – Conduction – Convection and Radiation.

1. Torsional pendulum-Determination of rigidity modulus of wire and moment of inertia of the disc
2. Melde's string experiment - Standing waves.
3. Ultrasonic interferometer – determination of sound velocity and liquids compressibility

UNIT IV OPTICS AND LASERS 9+6

Interference - Thin film interference - Air wedge- Applications -Interferometers–Michelson

Interferometer -– Diffraction - CD as diffraction grating – Diffraction by crystals -Polarization - polarizers -– Laser – characteristics – Spontaneous and Stimulated emission- population – inversion - Metastable states - optical feedback - Nd-YAG laser, CO_2 laser, Semiconductor laser - Industrial and medical applications - Optical Fibers – Total internal reflection – Numerical aperture and acceptance angle – Fiber optic communication – Fiber sensors – Fiber lasers.

1. Laser - Determination of the width of the groove of the compact disc using laser.
   Laser Parameters
   -Determination of the wavelength of the laser using grating
2. Air wedge -Determination of the thickness of a thin sheet/wire
3. Optical fibre -Determination of Numerical Aperture and acceptance angle
   -Determination of bending loss of fibre.
4. Michelson Interferometer (Demonstration)

UNIT V QUANTUM MECHANICS 9+6

Black body radiation (Qualitative) – Planck's hypothesis – Einstein's theory of Radiation - Matter waves–de Broglie hypothesis - Electron microscope – Uncertainty Principle – The Schrodinger Wave equation (time-independent and time-dependent) – Meaning and Physical significance of wave function - Normalization - Particle in an infinite potential well-particle in a three-dimensional box - Degenerate energy states - Barrier penetration and quantum tunneling - Tunneling microscope.

1. Photoelectric effect – Determination of Planck's constant.
2. Black Body Radiation (Demonstration)
3. Electron Microscope (Demonstration)

TOTAL: 75 PERIODS

COURSE OUTCOMES:

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

CO1: Understand the significance of crystal structure and bonding. Learn to grow crystals.

CO2: Obtain knowledge on important mechanical and thermal properties of materials and determine them through experiments.

CO3: Conceptualize and visualize the oscillations and sound.

CO4: Grasp optical phenomenon and their applications in real life.

CO5: Appreciate and evaluate the quantum phenomenon.

CO6 Develop skill set to solve engineering problems and design experiments.

TEXT BOOKS:

1. Raymond A. Serway, John W. Jewett, Physics for Scientists and Engineers, Thomson Brooks/Cole, 2013.
2. D. Halliday, R. Resnick and J. Walker, Principles of Physics. John Wiley & Sons, 10th Edition, 2015.
3. N. Garcia, A. Damask and S. Schwarz, Physics for Computer Science Students, Springer-Verlag, 2012.
4. Alan Giambattista, Betty McCarthy Richardson and Robert C. Richardson, College Physics, McGraw-Hill Higher Education, 2012.

REFERENCES:

1. R. Wolfson, Essential University Physics. Volume 1 & 2. Pearson, 2016.
2. D. Kleppner and R. Kolenkow. An Introduction to Mechanics, McGraw Hill Education, 2017.
3. K. Thyagarajan and A. Ghatak. Lasers: Fundamentals and Applications. Springer, 2012

CO – PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1		1							
CO2	3	2	1	1								
CO3	3	2	1	1								
CO4	3	2	1	1	1							
CO5	3	2	1	1	1							
CO6	3	2	1	2								

ME23C01	ENGINEERING DRAWING AND 3D MODELLING	L	T	P	C
		2	0	4	4

COURSE OBJECTIVES

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

1. Understand and use the engineering curves in engineering applications and projection techniques to construct conic curves, points and lines.
2. Develop skills in projecting surfaces and solids and create 2D models using CAD software.
3. Develop skills in 3D projection and 3D modeling of simple parts manually as well as using CAD software.
4. Understand and apply sectioning techniques to solids and assemble components.
5. Develop skills in lateral surface development and sheet metal design.

INTRODUCTION

Manual drawing tools (Mini Drafter, Set Squares, Protractor, Compass, and different grades of pencil). **'**BIS' specifications and rules of Engineering Drawing – Arrows (2H thin line body, HB Filled head and L:W = 3:1 ratio), lettering (Digital fonts, font sizes pertaining to usage and representation), types of line and their syntax (Drawing based – Continuous thin & thick, dashed, dashed dotted and Application based – extension, dimensioning, construction, projection, reference, axis, section, hatching, and break lines), scaling (up, down and equal), and dimensioning. Placing and positioning the 'A3' size drawing sheet over the drawing table. Principal planes and projection, Division of line and circle in to equal parts, and construction of polygons

UNIT i: ENGINEERING CURVES, PROJECTION OF POINTS AND LINES 6+12

Construction of conic curves with their tangent and normal – ellipse, parabola, and hyperbola by eccentricity method

Construction of special curves with their tangent and normal – cycloid, epicycloid, and involute

Projection of points and I angle projection of lines inclined to both principal planes by rotating line method and trapezoidal rule – marking their traces.

Lab exercises: Study exercise – Introduction to Sketching (or) Drawing, and modification tools in CAD software (AutoCAD, CREO, CATIA, Solid Works, Inventor, Fusion 360)

Activities based learning: Identification of the curves used in the application given in the flash card, demonstration of the instantaneous centre of rotation of governors with respect to angle of inclination of the arms of the governors

UNIT II PROJECTION OF SURFACES & SOLIDS, AND 2D MODELING 6+12

Projection of surfaces inclined to both the principal planes – polygonal, trapezoidal, rhomboidal and circular

Projection of solids – prisms, pyramids, and axisymmetric solids when the axis inclined to both the principal planes – freely hanging – contour resting condition on either of the planes by rotating object method

Lab exercises: Construction of basic sketches – lines, circle, polygon, spline curves, coils, along with dimensioning. Familiarizing with geometric constraints and their types

Activities based learning: Making the solids using cardboards, shadow mapping and contour drawing at different orientation of the solids using torches,

UNIT III 3D PROJECTION OF SOLIDS AND 3D MODELING OF SIMPLE PARTS 6+12

Free hand sketching – I & III angle projections of engineering parts and components

Isometric projection of combination of solids – prisms, pyramids, axisymmetric solids, frustum

Perspective projection of prisms, pyramids and axisymmetric solids by visual ray method

Lab exercises: 3D Modeling and 2D drafting of machine parts

Activities based learning: Flipped classroom for Free hand sketching, Jig saw activity for Isometric projection, arts and crafts for perspective view

UNIT IV SECTION OF SOLIDS AND SECTIONED DRAFTING OF ASSEMBLED COMPONENTS 6+12

Section of simple and hollow solids – prisms, pyramids and axisymmetric solids, solids with holes/ slots when the section plane perpendicular to one principal plane and inclined to other principal plane ('On the axis' and 'from the axis' conditions)

Application based – section of beams (I, T, L, and C), section of pipe bracket, wood joints, composite walls, shells, flange of a coupling and other similar applications

Lab exercises: Assembly of parts with respect to engineering constraints, and sectioned drafting of assembled components

Activities based learning: Making of mitered joint in wood, sectioning the beams in different angles of orientation and identifying the true shape

UNIT V LATERAL SURFACE DEVELOPMENT AND SHEET METAL DESIGN 6+12

Lateral surface development of sectioned solids when the section plane perpendicular to VP and inclined to HP.

Application based – construction of funnel, chimney, dish antenna, door latch, trays, AC vents, lamp shade, commercial packaging boxes with respect to sectioning conditions and other similar applications

Lab exercises: Sheet metal design and drafting, drafting of coils, springs and screw threads

Activities based learning: Fabrication of funnels, chimney, lamp shade, boxes using card boards, ply woods, acrylics

Total: 90 Hours

Note: Activities based learning should not be covered in the regular class hours. It should be given as assignments to the group of maximum 3 members

Question pattern suggestion: Part – A (Either or type) (5 × 16 = 80) & Part – B (Compulsory) (1 × 20 = 20)

COURSE OUTCOME:-

After successful completion of the course, the students will be able to:

CO1: Construct and identify different types of conic curves and special curves, and project the points and lines pertaining to engineering applications

CO2: Project and visualize surfaces and solids in different orientations and utilize the CAD tools for designing.

CO3: Create and draft accurate 3D models and 2D drawings of machine parts manually as well as using CAD softwares

CO4: Determine the true shape of a sectioned solid and draft the assemble parts accordingly

CO5: Develop lateral surfaces of sectioned solids and design sheet metal components

TEXT BOOKS:

1. Engineering Drawing" by N S Parthasarathy and Vela Murali
2. Engineering Drawing and Graphics with Auto CAD" by Venugopal K

REFERENCE BOOKS:

1. "Basic Engineering Drawing: Mechanical Semester Pattern" by Mehta and Gupta
2. "Engineering Drawing" by Basant Agrawal and C M Agrawal
3. "Engineering Drawing With Auto CAD" by B V R Gupta
4. "Engineering Drawing" by P S Gill
5. "Engineering Drawing with an Introduction to AutoCAD" by Dhananjay Jolhe
6. "Engineering Drawing" by M B Shah
7. "Fundamentals of Engineering Drawing" by Imtiaz Hashmi
8. "Computer Aided Engineering Drawing" by S Trymbaka Murthy
9. "CAED : Computer Aided Engineering Drawing for I/II Semester BE/Btech Courses" by Reddy K B
10. "Computer-Aided Engineering Drawing" by Subrata Pal

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2		1				3	1		3	3	3	2
2	3	3	2		2				3	2		3	3	3	2
3	3	3	3	1	2				3	3		3	3	3	2
4	3	3	3	1	3				3	3		3	3	3	2
5	3	3	3	1	3				3	3		3	3	3	2

ME23C03	ENGINEERING MECHANICS	L T P C 3 1 0 4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for:

- Determining the resultant forces acting on a particle in 2D and 3D and for applying methods of equilibrium on a particle in 2D and 3D.
- Evaluating the reaction forces for bodies under equilibrium, for determining the moment of a force, moment of a couple, for resolving force into a force-couple system and for analyzing trusses
- Assessing the centroids of 2D sections / center of gravity of volumes and for calculating area moments of inertia for the sections and mass moment of inertia of solids.
- Evaluating the frictional forces acting at the contact surfaces of various engineering systems and for applying the work-energy principles on a particle.
- Determining kinetic and kinematic parameters of the rigid bodies subjected to concurrent coplanar forces.

UNIT I STATICS OF PARTICLES 9+3

Fundamental Concepts and Principles, Systems of Units, Method of Problem Solutions, Statics of Particles -Forces in a Plane, Resultant of Forces, Resolution of a Force into Components, Rectangular Components of a Force, Unit Vectors. Equilibrium of a Particle- Newton's First Law of Motion, Space and Free-Body Diagrams, Forces in Space, Equilibrium of a Particle in Space.

UNIT II EQUILIBRIUM OF RIGID BODIES AND TRUSSES 9+3

Principle of Transmissibility, Equivalent Forces, Vector Product of Two Vectors, Moment of a Force about a Point, Varignon's Theorem, Rectangular Components of the Moment of a Force, Scalar Product of Two Vectors, Mixed Triple Product of Three Vectors, Moment of a Force about an Axis, Couple - Moment of a Couple, Equivalent Couples, Addition of Couples, Resolution of a Given Force into a Force -Couple system, Further Reduction of a System of Forces, Equilibrium in Two and Three Dimensions - Reactions at Supports and Connections – Analysis of Trusses – Method of Joints and Method of Sections.

UNIT III DISTRIBUTED FORCES 9+3

Centroids of lines and areas – symmetrical and unsymmetrical shapes, Determination of Centroids by Integration, Theorems of Pappus-Guldinus, Distributed Loads on Beams, Centre of Gravity of a Three-Dimensional Body, Centroid of a Volume, Composite Bodies, Determination of Centroids of Volumes by Integration.

Moments of Inertia of Areas and Mass - Determination of the Moment of Inertia of an Area by Integration , Polar Moment of Inertia , Radius of Gyration of an Area , Parallel-Axis Theorem , Moments of Inertia of Composite Areas, Moments of Inertia of a Mass - Moments of Inertia of Thin Plates , Determination of the Moment of Inertia of a Three-Dimensional Body by Integration.

UNIT IV FRICTION AND WORK PRINCIPLES 9+3

The Laws of Dry Friction. Coefficients of Friction, Angles of Friction, Wedges, Wheel Friction. Rolling Resistance, Ladder friction. Work of a Force, Kinetic Energy of a Particle, Principle of Work and Energy, Principle of Impulse and Momentum, Impact, Method of Virtual Work - Work of a Force, Potential Energy, Potential Energy and Equilibrium.

UNIT V DYNAMICS OF PARTICLES AND RIGID BODIES 9+3

Kinematics - Rectilinear Motion and Curvilinear Motion of Particles. Kinetics- Newton's Second Law of Motion -Equations of Motions, Dynamic Equilibrium, Energy and Momentum Methods – Kinematics of Rigid Bodies and Plane Kinetics.

TOTAL : 60 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

1. To determine the resultant forces acting on a particle in 2D and 3D and to apply methods of equilibrium on a particle in 2D and 3D.
2. Evaluate the reaction forces for bodies under equilibrium, to determine moment of a force, moment of a couple, to resolve force into a force-couple system and to analyze trusses
3. Assess the centroids of 2D sections / center of gravity of volumes and to calculate area moments of inertia for the sections and mass moment of inertia of solids.
4. Evaluate the frictional forces acting at the contact surfaces of various engineering systems and apply the work-energy principles on a particle. evaluate the kinetic and kinematic parameters of a particle.
5. Determine kinetic and kinematic parameters of the rigid bodies subjected to concurrent coplanar forces.

TEXT BOOKS:

1. Beer Ferdinand P, Russel Johnston Jr., David F Mazurek, Philip J Cornwell, Sanjeev Sanghi, Vector Mechanics for Engineers: Statics and Dynamics, McGraw Higher Education., 12th Edition, 2019.

2. Vela Murali, "Engineering Mechanics-Statics and Dynamics", Oxford University Press, 2018.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2	3									3		
2	3	3	2	3									3		
3	3	3	2	3									3		
4	3	3	2	3									3		
5	3	3	2	3									3		
Avg	3	3	2	3									3		

ME23C04	MAKERSPACE	L	T	P	C
		1	0	4	3

COURSE OBJECTIVES:

1. To practice the usage of various tools towards assembly and dis-assembly of different items / equipment.
2. To make simple part / component using welding processes.
3. To train on the basic wiring practices of boards, machines, etc.
4. To provide a hands-on experience on the use of electronic components, equipment, sensors and actuators.
5. To expose to modern computer tools and advanced manufacturing / fabrication processes.

LIST OF ACTIVITIES **1L,4P**

(A). Dis-assembly & Assembly Practices

i. Tools and its handling techniques.
ii. Dis-assembly and assembly of home appliances – Grinder Mixer Grinder, Ceiling Fan, Table Fan & Washing Machine.
iii. Dis-assembly and assembly of Air-Conditioners & Refrigerators.
iv. Dis-assembly and assembly of a Bicycle.

(B). Welding Practices

i. Welding Procedure, Selection & Safety Measures.
ii. Power source of Arc Welding – Gas Metal Arc Welding & Gas Tungsten Arc Welding processes.
iii. Hands-on session of preparing base material & Joint groove for welding.
iv. Hands-on session of MAW, GMAW, GTAW, on Carbon Steel & Stainless Stell plates / pipes, for fabrication of a simple part.

(C). Electrical Wiring Practices

i. Electrical Installation tools, equipment & safety measures.
ii. Hands-on session of basic electrical connections for Fuses, Miniature Circuit Breakers and Distribution Box,
iii. Hands-on session of electrical connections for Lightings, Fans, Calling Bells.
iv. Hands-on session of electrical connections for Motors & Uninterruptible Power Supply.

(D). Electronics Components / Equipment Practices

i. Electronic components, equipment & safety measures.
ii. Dis-assembly and assembly of Computers.
iii. Hands-on session of Soldering Practices in a Printed Circuit Breaker.
iv. Hands-on session of Bridge Rectifier, Op-Amp and Transimpedance amplifier.
v. Hands-on session of integration of sensors and actuators with a Microcontroller.
vi. Demonstration of Programmable Logic Control Circuit.

(E).Contemporary Systems

i. Demonstration of Solid Modelling of components.
ii. Demonstration of Assembly Modelling of components.
iii. Fabrication of simple components / parts using 3D Printers.
iv. Demonstration of cutting of wood / metal in different complex shapes using Laser Cutting Machine.

TOTAL: 75 Periods (15 Lecture + 60 Practical)

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:

CO1: Assemble and dis-assemble various items / equipment.
CO2: Make simple parts using suitable welding processes.
CO3: Setup wiring of distribution boards, machines, etc.
CO4: Utilise the electronic components to fabricate a simple equipment, aided with sensors and actuators.
CO5: Take advantage of modern manufacturing practices.

REFERENCES:

1. Stephen Christena, Learn to Weld: Beginning MIG Welding and Metal Fabrication Basics, Crestline Books, 2014.
2. H. Lipson, Fabricated - The New World of 3D Printing, Wiley, 1st edition, 2013.
3. Code of Practice for Electrical Wiring Installations (IS 732:2019)
4. A.S. Sedra and K.C. Smith, Microelectronic Circuits, Oxford University Press, 7th ed. (Indian edition), 2017.
5. Mazidi, Naimi, Naimi, AVR Microcontroller and Embedded Systems: Using Assembly and C, Pearson India, 1st edition 2013.
6. Visualization, Modeling, and Graphics for Engineering Design, D.K. Lieu, S.A. Sorby, Cengage Learning; 2nd edition.

UC23H01 **தமிழர் மரபு** **L T P C**
1 0 0 1

அலகு I **மொழி மற்றும் இலக்கியம்**: **3**
இந்திய மொழிக் குடும்பங்கள் – திராவிட மொழிகள் – தமிழ் ஒரு செம்மொழி – தமிழ் செவ்விலக்கியங்கள் - சங்க இலக்கியத்தின் சமயச் சார்பற்ற தன்மை – சங்க இலக்கியத்தில் பகிர்தல் அறம் – திருக்குறளில் மேலாண்மைக் கருத்துக்கள் – தமிழ்க் காப்பியங்கள், தமிழகத்தில் சமண பௌத்த சமயங்களின் தாக்கம் - பக்தி இலக்கியம், ஆழ்வார்கள் மற்றும் நாயன்மார்கள் – சிற்றிலக்கியங்கள் – தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி – தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்பு.

அலகு II **மரபு – பாறை ஓவியங்கள் முதல் நவீன ஓவியங்கள் வரை – சிற்பக் கலை**: **3**
நடுகல் முதல் நவீன சிற்பங்கள் வரை – ஐம்பொன் சிலைகள்– பழங்குடியினர் மற்றும் அவர்கள் தயாரிக்கும் கைவினைப் பொருட்கள், பொம்மைகள் – தேர் செய்யும் கலை – சுடுமண் சிற்பங்கள் – நாட்டுப்புறத் தெய்வங்கள் – குமரிமுனையில் திருவள்ளுவர் சிலை – இசைக் கருவிகள் – மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் – தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு.

அலகு III **நாட்டுப்புறக் கலைகள் மற்றும் வீர விளையாட்டுகள்**: **3**
தெருக்கூத்து, கரகாட்டம், வில்லுப்பாட்டு, கணியான் கூத்து, ஒயிலாட்டம், தோல்பாவைக் கூத்து, சிலம்பாட்டம், வளரி, புலியாட்டம், தமிழர்களின் விளையாட்டுகள்.

அலகு IV **தமிழர்களின் திணைக் கோட்பாடுகள்**: **3**
தமிழகத்தின் தாவரங்களும், விலங்குகளும் – தொல்காப்பியம் மற்றும் சங்க இலக்கியத்தில் அகம் மற்றும் புறக் கோட்பாடுகள் – தமிழர்கள் போற்றிய அறக்கோட்பாடு – சங்ககாலத்தில் தமிழகத்தில் எழுத்தறிவும், கல்வியும் – சங்ககால நகரங்களும் துறை முகங்களும் – சங்ககாலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி – கடல்கடந்த நாடுகளில் சோழர்களின் வெற்றி.

அலகு V **இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்குத் தமிழர்களின் பங்களிப்பு**: **3**
இந்திய விடுதலைப்போரில் தமிழர்களின் பங்கு – இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப் பண்பாட்டின் தாக்கம் – சுயமரியாதை இயக்கம் – இந்திய மருத்துவத்தில், சித்த மருத்துவத்தின் பங்கு – கல்வெட்டுகள், கையெழுத்துப்படிகள் - தமிழ்ப் புத்தகங்களின் அச்சு வரலாறு.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)

5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

UC23H01 HERITAGE OF TAMILS L T P C
1 0 0 1

UNIT I LANGUAGE AND LITERATURE 3

Language Families in India - Dravidian Languages – Tamil as aClassical Language - Classical Literature in Tamil – Secular Nature of Sangam Literature – Distributive Justice in Sangam Literature - Management Principles in Thirukural - Tamil Epics and Impact of Buddhism & Jainism in Tamil Land - Bakthi Literature Azhwars and Nayanmars - Forms of minor Poetry - Development of Modern literature in Tamil - Contribution of Bharathiyar and Bharathidhasan.

UNIT II HERITAGE - ROCK ART PAINTINGS TO MODERN ART – SCULPTURE 3

Hero stone to modern sculpture - Bronze icons - Tribes and their handicrafts - Art of temple car making - - Massive Terracotta sculptures, Village deities, Thiruvalluvar Statue at Kanyakumari, Making of musical instruments - Mridhangam, Parai, Veenai, Yazh and Nadhaswaram - Role of Temples in Social and Economic Life of Tamils.

UNIT III FOLK AND MARTIAL ARTS 3

Therukoothu, Karagattam, Villu Pattu, Kaniyan Koothu, Oyillattam, Leather puppetry, Silambattam, Valari, Tiger dance - Sports and Games of Tamils.

UNIT IV THINAI CONCEPT OF TAMILS 3

Flora and Fauna of Tamils & Aham and Puram Concept from Tholkappiyam and Sangam Literature - Aram Concept of Tamils - Education and Literacy during Sangam Age - Ancient Cities and Ports of Sangam Age - Export and Import during Sangam Age - Overseas Conquest of Cholas.

UNIT V CONTRIBUTION OF TAMILS TO INDIAN NATIONAL MOVEMENT AND INDIAN CULTURE 3

Contribution of Tamils to Indian Freedom Struggle - The Cultural Influence of Tamils over the other parts of India – Self-Respect Movement - Role of Siddha Medicine in Indigenous Systems of Medicine – Inscriptions & Manuscripts – Print History of Tamil Books.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

NCC Credit Course Level 1*

UC23P01	(ARMY WING) NCC Credit Course Level - I	L	T	P	C
		2	0	0	2

NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour 'Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

UC23P02 **NCC Credit Course Level 1***

(NAVAL WING) NCC Credit Course Level – I **L T P C**

2 0 0 2

NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

NCC Credit Course Level 1*

UC23P03	**(AIR FORCE WING) NCC Credit Course Level – I**	**L T P C** **2 0 0 2**

NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

EN23C02 PROFESSIONAL COMMUNICATION L T P C
2 0 2 3

COURSE OBJECTIVES

- To read and comprehend different forms of official texts.
- To develop students' writing skills in professional context.
- To actively listen, read and understand written and oral communication in a professional context.
- To comprehend and analyse the visual content in authentic context.
- To write professional documents with clarity and precision

UNIT I CAUSE AND EFFECT 6

Reading – Newspaper articles on Social and Environmental issues; Writing – Instructions, Cause and effect essay; Grammar - Modal verbs; Vocabulary – Cause and effect, Idioms

LAB ACTIVITY: 6

Listening and Speaking – Listen to news reports and summarise in oral form.

UNIT II CLASSIFICATION 6

Reading – An article, social media posts and classifying based on the content; Writing – Definition, Note making, Note taking (Cornell notes etc.) and Summarising; Grammar – Connectives; Vocabulary – Phrasal verbs

LAB ACTIVITY: 6

Listening and speaking: Social interaction (Conversation including small talk)

UNIT III PROBLEM AND SOLUTION 6

Reading – Visual content (Tables/charts/graphs) for comprehension; Writing - Problem and Solution Essay; Grammar – If conditionals; Vocabulary – Sequential words.

LAB ACTIVITY: 6

Listening – Group discussion; Speaking – Participating in a group discussion

UNIT IV REPORT 6

Reading – Formal report on accidents (industrial/engineering); Writing – Industrial Accident report; Grammar – Active and passive voice, Direct and Indirect speech; Vocabulary – Numerical adjectives.

LAB ACTIVITY: 6

Listening / watching – Television documentary and discussing its content, purpose etc.

UNIT V JOB APPLICATION AND INTERVIEW 6

Reading - Job advertisement and company profile; Writing – Job application (cover letter and CV) Grammar – Mixed Tenses; Vocabulary – Collocations related to work environment

LAB ACTIVITY: 6

Listening – Job interview; Speaking – Mock interviews

TOTAL: 60 PERIODS

TEACHING METHODOLOGY

Interactive lectures, role plays, group discussions, listening and speaking labs, technology enabled language teaching, flipped classroom.

EVALUATION PATTERN

Internal Assessment
Written assessments
Assignment
Lab Assessment
Group discussion (Peer assessment)
Listening

External Assessment
End Semester Examination

LEARNING OUTCOMES

By the end of the courses, students will be able to

- To apply appropriate language structure and vocabulary to enhance both spoken and written communication in formal contexts.
- Comprehend different forms of official documents
- Write professional documents coherently and cohesively.
- Interpret verbal and graphic content in authentic context
- Analyse and evaluate verbal and audio visual materials.

TEXT BOOKS

1. “English for Engineers and Technologists” Volume 2 by Orient Blackswan, 2022
2. “English for Science & Technology - II” by Cambridge University Press, 2023.

REFERENCES

1. “Communicative English for Engineers and Professionals” by Bhatnagar Nitin, Pearson India, 2010.
2. ”Take Off – Technical English for Engineering” by David Morgan, Garnet Education, 2008.
3. “Advanced Communication Skills” by Mathew Richardson, Charlie Creative Lab, 2020.
4. www.uefap.com

CO – PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										√		√
CO2										√		√
CO3										√		√
CO4										√		√
CO5										√		√

MA23C02	ORDINARY DIFFERENTIAL EQUATIONS AND TRANSFORM TECHNIQUES	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To acquaint the students with Differential Equations which are significantly used in engineering problems.
- To make the students to understand the Laplace transforms techniques.
- To develop the analytic solutions for partial differential equations used in engineering by Fourier series.
- To acquaint the student with Fourier transform techniques used in wide variety of situations in which the functions used are not periodic.
- To develop Z- transform techniques in solving difference equations.

UNIT I ORDINARY DIFFERENTIAL EQUATIONS 9+3

Homogeneous linear ordinary differential equations of second order -superposition principle - general solution- Particular integral - Operator method - Solution by variation of parameters - Method of undetermined coefficients - Homogeneous equations of Euler–Cauchy and Legendre's type – System of simultaneous linear differential equations with constant coefficients.

UNIT II LAPLACE TRANSFORMS 9+3

Existence theorem - Transform of standard functions – Transform of Unit step function and Dirac delta function – Basic properties - Shifting theorems - Transforms of derivatives and integrals – Transform of periodic functions - Initial and Final value theorem - Inverse Laplace transforms- Convolution theorem (without proof) – Solving Initial value problems by using Laplace Transform techniques.

UNIT III FOURIER SERIES 9+3

Dirichlet's conditions – General Fourier series – Odd and even functions – Half-range Sine and Cosine series – Complex form of Fourier series – Parseval's identity – Computation of harmonics.

UNIT IV FOURIER TRANSFORMS 9+3

Fourier integral theorem – Fourier transform pair - Fourier sine and cosine transforms – Properties – Transform of elementary functions – Inverse Fourier Transforms - Convolution theorem (without proof) – Parsevals's identity.

UNIT V Z – TRANSFORM AND DIFFERENCE EQUATIONS 9+3

Z-transform – Properties of Z-transform – Inverse Z-transform – Convolution theorem – Evaluation of Inverse Z transform using partial fraction method and convolution theorem - Initial and final value theorems – Formation of difference equations – Solution of difference equations using Z - transform.

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students from the content of the course wherever applicable.

Branch specific / General Engineering applications based on the content of each units will be introduced to students wherever possible.

Suggested Laboratory based exercises / assignments / assessments :

Ordinary differential equations

1. Symbolic computation of linear ordinary differential equations
2. Solving System of simultaneous linear differential equations using ODE SOLVER

Laplace transforms

1. Symbolic computation of Laplace transform and Inverse Laplace transform
2. Plotting Laplace transforms

Fourier Series

1. Symbolic computation of Fourier Coefficients
2. Computation of harmonics
3. Plotting truncated Fourier Series

Fourier Transform

1. Symbolic computation of Fourier Transforms
2. Plotting truncated Fourier Transforms

Z – transform

1. Symbolic computation of Z-Transforms

OUTCOMES:

CO1 :Solve higher order ordinary differential equations which arise in engineering applications.

CO2 :Apply Laplace transform techniques in solving linear differential equations.

CO3 :Apply Fourier series techniques in engineering applications.

CO4 :Understand the Fourier transforms techniques in solving engineering problems.

CO5 :Understand the Z-transforms techniques in solving difference equations.

TEXT BOOKS:

1. Grewal B.S., “Higher Engineering Mathematics”, Khanna Publishers, 45th Edition, New Delhi, 2020.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India Pvt Ltd., New Delhi, 2018.

REFERENCES:

1. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008
2. Greenberg M.D., “Advanced Engineering Mathematics”, Pearson Education2nd Edition, 5th Reprint, Delhi, 2009.
3. Jain R.K. and Iyengar S.R.K., “Advanced Engineering Mathematics”,Narosa Publications, 5 th Edition, New Delhi, 2017.
4. Peter V.O’Neil, “Advanced Engineering Mathematics”, Cengage Learning India Pvt., Ltd, 7 th Edition, New Delhi , 2012.
5. Ramana B.V., “Higher Engineering Mathematics”, Tata McGraw Hill Co. Ltd., 11th Reprint, New Delhi, 2010.

CO – PO Mapping:

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**P11**	**P12**
CO 1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 5 :	3	3	2	3	1	2	1	1	1	1	1	3

PH23201	APPLIED MATERIAL SCIENCE	L	T	P	C
		3	0	0	3

COURSEOBJECTIVES:

1. To make the students to understand the basics of crystallography and its importance in studying materials properties.
2. To inculcate the knowledge of phase relationships for the understanding of material properties.
3. To understand the electrical properties of materials including free electron theory, applications of quantum mechanics and magnetic materials.
4. To instil knowledge on physics of semiconductors, determination of charge carriers and device applications.
5. To establish a sound grasp of knowledge on different optical properties of materials, optical displays and applications.

UNIT – I CONSTITUTION OF ALLOYS 9

Polymorphism – Phase Changes – Solid Solution (Interstitial and Substitution) – Gibbs Phase Rule - Phase Equilibrium – Solubility Limit – Nucleation and Growth- Unary Phase Diagram (Iron) – Binary Phase Diagrams: Isomorphous Systems (Cu-Ni) – Fe-Fec Diagram – Invariants Reactions – Microstructural Development– Homogeneous And Heterogeneous Nucleation- Heat Treatable Alloy- Wrought Alloy- Cast Alloys- Introduction to Heat Treatment for Steel and Aluminium Alloys –List Typical Alloys of Steel, Aluminium, Titanium, Copper and Magnesium and their Properties.

UNIT – II NON METALLIC MATERIALS AND COMPOSITES 9

Types And Properties of Commodity Polymers and Engineering Polymers - Natural and Synthetic Rubbers – Crystal Structure of Ceramics- Types and Properties of Structural (Al_2O_3, ZrO_2, Si_3N_4, WC, BC, hBN) and Functional Ceramics (SiC, PZT, $BaTiO_3$, AlN) - Composites and Their Classification and Applications- Carbon-Carbon Composites- Nanomaterials – Quantum Confinement- Typical Property Enhancement- Nanocomposite.

UNIT – III MECHANICAL PROPERTIES OF MATERIALS 9

Elastic, Anelastic and Viscoelastic Behavior of Materials– Stress Field - Interaction Between Dislocations -Strengthening Mechanism- Effect Of Temperature-Thermal Expansion, Conductivity and Stresses- Burgers Vector and Elastic Strain Energy- Slip Systems, Plastic Deformation of Materials- Deformation Mechanism Maps - Cyclic Loading - Types of Fracture – Fracture Mechanics - Fracture Toughness Ductile-Brittle Transition - Types of Wear - Corrosion – Creep- Mechanisms of Creep-Creep Resistance Materials. Fatigue Failure-The S-N Curves-Factors Tthat Affect Fatigue Life.

UNIT – IV ELECTRICAL AND ELECTRONIC PROPERTIES OF MATERIALS 9

Classical Free Electron Theory - Expression for Electrical Conductivity – Energy Band Structures in Solids- Density of Energy States – Electron in Periodic Potential –Electron Mobility and Resistivity of Metals-Intrinsic and Extrinsic Semi Conduction of Materials- Factors Influence Carrier Mobility- The Hall Effect- Semiconductor Devices- Electrical Conduction in Ceramics and Polymers- Dielectric Behavior- Ferroelectricity –Piezoelecticity- Example of Material and Application.

UNIT – V MAGNETIC AND OPTICAL PROPERTIES OF MATERIALS 9

Magnetic Materials: Dia, Para and Ferromagnetic Effects – Paramagnetism in the Conduction Electrons in Metals – Exchange Interaction and Ferromagnetism – Quantum Interference Devices – GMR Devices. The Influence of Temperature on Magnetic Behavior- Domains and Hysteresis- Soft and Hard Magnetic Materials – Magnetic Storage. Example of Material and Application Classification of Optical Materials – Optical – Refraction, Reflection, Absorption, Transmission and Color. Optoelectronic Devices: Light Detectors and Solar Cells – Light Emitting

Diode – Laser Diode - Optical Processes in Organic Semiconductor Devices –Excitonic State – Luminescence – Photoconductivity-Laser- Optical Fibers in Communications.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, the students should be able to

CO1: Distinguish basics of crystallography and its importance for varied materials properties.
CO2: Know the properties of materials through the study of phase relationships.
CO3: Describe on the electrical and magnetic properties of materials and their applications
CO4: Recognise clearly of semiconductor physics and functioning of semiconductor devices
CO5: Comprehend the optical properties of materials and working principles of various optical devices.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	2	1	2	1	1	-	-	-	-	-	-	2	2	-
CO2	2	2	2	1	-	-	-	-	-	-	-	1	2	2	1
CO3	2	2	1	1	2	1	-	-	-	-	-	-	1	2	2
CO4	2	2	2	2	2	1	1	-	-	-	-	-	2	2	1
CO5	1	1	1	1	2	1	2	-	-	-	-	2	1	1	2
CO/PO & PSO Average	**1.8**	**1.8**	**1.4**	**1.4**	**1.7**	**1**	**1.5**	**-**	**-**	**-**	**-**	**1.5**	**1.6**	**1.8**	**1.5**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS:

1. V.Raghavan. Materials Science and Engineering: A First Course, Prentice Hall India Learning Private Limited, 2015.
2. SafaKasap, Principles of Electronic Materials and Devices, Mc-Graw Hill, fourth edition, 2020.
3. Jasprit Singh, Semiconductor Devices: Basic Principles, ChaukhambaAuriyantaliya, 2019.
4. Jasprit Singh, Semiconductor Optoelectronics: Physics and Technology, Mc-Graw Hill India (2019)
5. Safa kasap, Optoelectronics & Photonics: Principles and Practices, 2nd edition Pearson, 2013.

REFERENCES:

1. R.Balasubramaniam, Callister's Materials Science and Engineering. Wiley (Indian Edition), 2014.
2. Wendelin Wright and Donald Askeland, Essentials of Materials Science and Engineering,CL Engineering, 2013.
3. Robert F.Pierret, Semiconductor Device Fundamentals, Pearson, 2006.
4. Simon Sze and Ming-kwei Lee, Semiconductor Devices: Physics and Technology, Wiley, 2015.
5. Pallab Bhattacharya, Semiconductor Optoelectronic Devices, Pearson, 2017.

CY23C01 ENGINEERING CHEMISTRY L T P C

3 0 2 4

UNIT I WATER TECHNOLOGY

Water – sources and impurities – water quality parameters: colour, odour, pH, hardness, alkalinity, TDS, COD, BOD, and heavy metals. Boiler feed water – requirement – troubles (scale & sludge, caustic embrittlement, boiler corrosion and priming & foaming. Internal conditioning – phosphate, Calgon, and carbonate treatment. External conditioning – demineralization. Municipal water treatment (screening, sedimentation, coagulation, filtration, disinfection-ozonolysis, UV treatment, chlorination), Reverse Osmosis – desalination.

PRACTICAL:

- Estimation of HCl using Na_2CO_3 as the primary standard
- Determination of alkalinity in the water sample.
- Determination of hardness of water by EDTA method.
- Determination of DO content of water sample by Winkler's method.

UNIT II NANOCHEMISTRY

Basics-distinction between molecules, nanomaterials and bulk materials; size-dependent properties (optical, electrical, mechanical, magnetic and catalytic). Types –nanoparticle, nanocluster, nanorod, nanowire and nanotube. Preparation of nanomaterials: sol-gel, solvothermal, laser ablation, chemical vapour deposition, electrochemical deposition and electro-spinning. Characterization - Scanning Electron Microscope and Transmission Electron Microscope - Principle and instrumentation (block diagram). Applications of nanomaterials – medicine including AYUSH, automobiles, electronics, and cosmetics.

PRACTICAL:

- Preparation of nanoparticles by Sol-Gel method/sonication method.
- Preparation of nanowire by Electrospinning.
- Study of morphology of nanomaterials by scanning electron microscopy

UNIT III CORROSION SCIENCE

Introduction to corrosion – chemical and electrochemical corrosions – mechanism of electrochemical and galvanic corrosions – concentration cell corrosion-soil, pitting, inter-granular, water line, stress and microbiological corrosions-galvanic series-factors influencing corrosion- measurement of corrosion rate. Electrochemical protection – sacrificial anodic protection and impressed current cathodic protection. Protective coatings-metallic coatings (galvanizing, tinning), organic coatings (paints). Paints: Constituents and functions.

PRACTICAL:

- Corrosion experiment-weight loss method.
- Salt spray test for corrosion study.
- Corrosion prevention by electroplating.
- Estimation of corroded Iron by Potentiometry/UV-visible spectrophotometer

UNIT IV ENERGY SOURCES

Electrochemical cell, redox reaction, electrode potential – oxidation and reduction potential. Batteries – Characteristics; types of batteries; primary battery (dry cell), secondary battery (lead acid, lithium-ion battery) and their applications. Emerging energy sources – metal hydride battery, hydrogen energy, Fuel cells – H_2-O_2 fuel cell. Supercapacitors –Types and Applications, Renewable Energy: solar heating and solar cells. Recycling and disposal of batteries.

PRACTICAL:

- Study of components of Lead acid battery.
- Measurement of voltage in a photovoltaic cell.
- Working of $H_2 – O_2$ fuel cell

UNIT V POLYMER CHEMISTRY

Introduction: Functionality-degree of polymerization. Classification of polymers (Source, Structure, Synthesis and Intermolecular forces). Mechanism of free radical addition polymerization. Properties of polymers: Tg, tacticity, molecular weight-number average, weight average, viscosity average and polydispersity index (Problems). Techniques of polymerization: Bulk, emulsion, solution and suspension. Compounding and Fabrication Techniques: Injection, Extrusion, Blow and Calendaring. Polyamides, Polycarbonates and Polyurethanes – structure and applications. Recycling of polymers.

PRACTICAL:

- Determination of molecular weight of a polymer using Ostwald viscometer.
- Preparation of a polymer.
- Determination of molecular weight by Gel Permeation Chromatography.

TOTAL: 75 PERIODS

COURSE OUTCOMES:

CO1: To demonstrate knowledge of water quality in various industries and develop skills in analyzing water quality parameters for both domestic and industrial purposes.

CO2: To identify and apply fundamental concepts of nanoscience and nanotechnology for engineering and technology applications, and to develop skills in synthesizing nanomaterials and studying their morphology.

CO3: To apply fundamental knowledge of corrosion protection techniques and develop skills to conduct experiments for measuring and preventing corrosion.

CO4: To study the fundamentals of energy storage devices and develop skills in constructing and experimenting with batteries.

CO5: To recognize and apply basic knowledge of different types of polymeric materials and develop skills in preparing and determining their applications for futuristic material fabrication needs.

TEXT BOOKS:

1. Jain P. C. & Monica Jain., “Engineering Chemistry”, 17th Edition, Dhanpat Rai Publishing Company (P) Ltd, New Delhi, 2015.
2. Sivasankar B., “Engineering Chemistry”, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 2012.
3. Dara S.S., “A Textbook of Engineering Chemistry”, Chand Publications, 2004.
4. Laboratory Manual - Department of Chemistry, CEGC, Anna University (2023).

REFERENCES:

1. Schdeva M.V., “Basics of Nano Chemistry”, Anmol Publications Pvt Ltd, 2011.
2. Friedrich Emich, “Engineering Chemistry”, Medtech, 2014.
3. Gowariker V.R., Viswanathan N.V. and Jayadev Sreedhar, “Polymer Science” New AGE International Publishers, 2009.
4. Vogel’s Textbook of Quantitative Chemical Analysis (8th edition, 2014).

CO - PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	-	-	-	3	-	-	-	-	-
CO2	3	-	2	-	2	-	3	-	-	-	-	-
CO3	3	3	2	-	2	-	3	-	-	-	-	-
CO4	3	3	-	-	-	-	3	-	-	-	-	-
CO5	3	-	-	-	-	-	3	-	-	-	-	-
Avg	3	3	-	-	-	-	3	-	-	-	-	-

1’ = Low; ‘2’ = Medium; ‘3’ = High

CS23C04	PROGRAMMING IN C	L	T	P	C
		2	0	4	4

UNIT I BASICS OF C PROGRAMMING 6+12

Introduction to programming paradigms –- Structure of C program - C programming: Data Types - Constants - Keywords - Operators: Precedence and Associativity - Expressions - Input/Output statements, Assignment statements - Decision making statements - Switch statement.

PRACTICALS

1. Designing programs with algorithms/flowchart
2. Programs for i/o operations with different data types

UNIT II LOOP CONTROL STATEMENTS AND ARRAYS 6+12

Iteration statements: For, while, Do-while statements, nested loops, break & continue statements - Introduction to Arrays: Declaration, Initialization - One dimensional array -Two dimensional arrays – Searching and sorting in Arrays – Strings – string handling functions - array of strings

PRACTICALS

1. Programs using various operators
2. Programs using decision making and branching statements
3. Programs using for, while, do-while loops and nested loops.
4. Programs using arrays and operations on arrays.
5. Programs implementing searching and sorting using arrays
6. Programs implementing string operations on arrays

UNIT IIl FUNCTIONS AND POINTERS 6+12

Modular programming - Function prototype, function definition, function call, Built-in functions – Recursion – Recursive functions - Pointers - Pointer increment, Pointer arithmetic - Parameter passing: Pass by value, Pass by reference, pointer and arrays, dynamic memory allocation

PRACTICALS

1. Programs using functions
2. Programs using recursion
3. Programs using pointers & strings with pointers
4. Programs using Dynamic Memory Allocation

UNIT IV STRUCTURES AND UNION 6+12

Storage classes, Structure and union, Features of structures, Declaration and initialization of structures, array of structures, Pointer to structure, structure and functions, typedef , bit fields , enumerated data types, Union.

PRACTICALS

1. Programs using Structures
2. Programs using Unions
3. Programs using pointers to structures and self-referential structures.

UNIT V MACROS AND FILE PROCESSING 6+12

Preprocessor directives – Simple and Conditional macros with and without parameters - Files - Types of file processing: Sequential and Random access – File operations – read, write & seek.

PRACTICALS

1. Programs using pre-processor directives & macros
2. Programs to handle file operations
3. Programs to handle file with structure

TOTAL: 90 (30+60) PERIODS

TEXT BOOKS:

1. Kernighan, B.W and Ritchie,D.M, "The C Programming language", Second Edition, Pearson Education, 2015.
2. Yashwant Kanetkar, Let us C, 17th Edition, BPB Publications, 2020.

REFERENCE BOOKS:

1. Pradip Dey, Manas Ghosh, "Computer Fundamentals and Programming in C", Second Edition, Oxford University Press, 2013.
2. Ashok N Kamthane, Programming in C, Pearson, Third Edition, 2020
3. Reema Thareja, "Programming in C", Oxford University Press, Second Edition, 2016.
4. Paul Deitel and Harvey Deitel, "C How to Program with an Introduction to C++", Eighth edition, Pearson Education, 2018.
5. Byron S. Gottfried, "Schaum's Outline of Theory and Problems of Programming with C'" McGraw-Hill Education, 1996.
6. Anita Goel and Ajay Mittal, "Computer Fundamentals and Programming in C", 1st Edition, Pearson Education, 2013.

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

CO1: Write simple C programs using basic constructs.

CO2: Design searching and sorting algorithms using arrays and strings.

CO3: Implement modular applications using Functions and pointers.

CO4: Develop and execute applications using structures and Unions.

CO5: Illustrate algorithmic solutions in C programming language using files.

Total Hours: 90 (30+60)

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2	3	1	3	2	1	-	-	-	2	-	3	1	2	2
2	2	1	1	3	2	1	-	-	-	-	-	3	1	2	2
3	2	2	1	3	2	1	-	-	3	-	3	3	1	2	2
4	2	1	1	3	2	1	-	-	3	-	3	3	1	2	2
5	2	3	1	3	2	1	-	-	-	2	3	3	1	2	2

1 - low, 2 - medium, 3 – high

EE23C04 ELECTRICAL, ELECTRONICS AND MEASUREMENTS ENGINEERING

L	T	P	C
3	0	2	4

UNIT – I ELECTRICAL CIRCUITS 9

DC Circuits: Circuit Components: Resistor, Inductor, Capacitor – Ohm's Law -Kirchhoff's Laws – Independent and Dependent Sources – Simple problems- Nodal Analysis, Mesh analysis with Independent sources only (Steady state) – Introduction to AC Circuits and Parameters: Waveforms, Average value, RMS Value, Instantaneous Power, Real Power, Reactive Power and Apparent Power, Power Factor – Steady State Analysis of RLC Circuits-Introduction to Balanced 3-Phase Circuits.

UNIT – II ELECTRICAL MACHINES 9

Construction and Working Principle – DC Separately and Self excited Generators, EMF Equation, Types and Applications. Working Principle of DC motors, Torque Equation, Types and Applications. Construction, Working Principle and Applications of Transformer - Three phase Alternator, Synchronous motor and Single and Three Phase Induction Motor.

UNIT – III ANALOG ELECTRONICS 9

Semiconductor Materials: Silicon & Germanium – PN Junction Diodes, Zener Diode – Characteristics Applications – Bipolar Junction Transistor-Biasing, JFET, SCR, MOSFET, IGBT – Types, I-V Characteristics and Applications, Rectifier and Voltage regulators.

UNIT – IV LINEAR INTEGRATED CIRCUITS 9

Ideal OP – Amp Characteristics, Basic Applications of Op-Amp – Inverting and Non- inverting Amplifiers, Summer, Differentiator and Integrator - S/H Circuit, D/A Converter (R-2R ladder), A/D Converters-Flash type ADC using OP-AMPS. Functional Block, Characteristics of 555 Timer – Astable Multi-Vibrator Mode.

UNIT – V MEASUREMENTS AND INSTRUMENTATION 9

Functional Elements of an Instrument, Standards and Calibration, Operating Principle, Types - Moving Coil and Moving Iron Instruments, Measurement of Three Phase Power, Energy Meter, Instrument Transformers -CT and PT, Multimeter- DSO- Block Diagram.

TOTAL: 45 PERIODS

Laboratory Experiments:

LIST OF EXPERIMENTS:

ELECTRICAL

1. Verification of ohms and Kirchhoff's Laws.
2. Load test on DC Shunt Motor.
3. Load test on Single Phase Transformer.
4. Load test on 3 Phase Induction Motor.

ELECTRONICS

1. Half wave and full wave Rectifiers.
2. Application of Zener diode as shunt regulator.
3. Inverting and non-inverting amplifier using operational amplifier.
4. Astable multivibrator using IC 555.

TOTAL: 30 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO 1: Explain the working principle and applications of electrical machines, electronic elements and measurement instruments. (L2)

CO 2: Demonstrate the basic concepts of electrical, electronic circuits and measurement devices. (L1)
CO 3: Analyze the electrical and electronic circuits. (L4)
CO 4: Select the electric, electronic circuit, electrical machines and instruments for the applications. (L3)
CO 5: Interpret the characteristics of electrical machines and instruments. (L5)

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	2	2	-	-	-	-	-	-	-	1	-	3	1
CO2	2	3	2	3	-	-	-	-	-	-	-	1	-	2	1
CO3	3	2	1	1	-	-	-	-	-	-	-	1	-	2	1
CO4	1	2	2	2	-	-	-	-	-	-	-	1	-	3	2
CO5	1	1	2	2	-	-	-	-	-	-	-	2	-	2	3
CO/PO & PSO Average	**2**	**2.2**	**1.8**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1.2**	**-**	**2.4**	**1.6**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS:

1. Del Toro 'Electrical Engineering Fundamentals' Pearson Education, New Delhi, 2022.
2. Alan S. Moris, Principles of Measurements and Instruments, Prentice-Hall of India Pvt. Ltd., New Delhi, 1988.
3. SmarjitGhosh 'Fundamentals of Electrical and Electronics Engineering, 2nd Edition 2010.

REFERENCES:

1. Rajendra Prasad 'Fundamentals of Electrical engineering', ThirdEdition, Prentice Hall of India, 2014.
2. Sanjeev Sharma 'Basics of Electrical Engineering' Wiley, 2019.
3. John Bird, Electrical Circuits theory and Technology, Taylor & Francis Ltd, Seventh Edition, 2022.
4. Doebelin, E.O., Measurements Systems – Application and Design', McGrawHill Publishing Co, 2019.
5. D.Roy Choudhury, Shail B. Jain, Linear Integrated Circuits, New age international Publishers, 2018.

UC23H02 தமிழரும் தொழில்நுட்பமும்/Tamils and Technology L T P C
1 0 0 1

அலகு I <u>நெசவு மற்றும் பானைத் தொழில்நுட்பம்</u>: 3

சங்க காலத்தில் நெசவுத் தொழில் – பானைத் தொழில்நுட்பம் – கருப்பு சிவப்பு பாண்டங்கள் – பாண்டங்களில் கீறல் குறியீடுகள்.

அலகு II <u>வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்</u>: 3

சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்க காலத்தில் வீட்டுப் பொருட்களில் வடிவமைப்பு- சங்க காலத்தில் கட்டுமான பொருட்களும் நடுகல்லும் – சிலப்பதிகாரத்தில் மேடை அமைப்பு பற்றிய விவரங்கள் – மாமல்லபுரச் சிற்பங்களும், கோவில்களும் – சோழர் காலத்துப் பெருங்கோயில்கள் மற்றும் பிற வழிபாட்டுத் தலங்கள் – நாயக்கர் காலக் கோயில்கள் - மாதிரி கட்டமைப்புகள் பற்றி அறிதல், மதுரை மீனாட்சி அம்மன் ஆலயம் மற்றும் திருமலை நாயக்கர் மஹால் – செட்டிநாட்டு வீடுகள் – பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோ-சாரோசெனிக் கட்டிடக் கலை.

அலகு III <u>உற்பத்தித் தொழில் நுட்பம்</u>: 3

கப்பல் கட்டும் கலை – உலோகவியல் – இரும்புத் தொழிற்சாலை – இரும்பை உருக்குதல், எஃகு – வரலாற்றுச் சான்றுகளாக செம்பு மற்றும் தங்க நாணயங்கள் – நாணயங்கள் அச்சடித்தல் – மணி உருவாக்கும் தொழிற்சாலைகள் – கல்மணிகள், கண்ணாடி மணிகள் – சுடுமண் மணிகள் – சங்கு மணிகள் – எலும்புத்துண்டுகள் – தொல்லியல் சான்றுகள் – சிலப்பதிகாரத்தில் மணிகளின் வகைகள்.

அலகு IV <u>வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில் நுட்பம்</u>: 3

அணை, ஏரி, குளங்கள், மதகு – சோழர்காலக் குமுழித் தூம்பின் முக்கியத்துவம் – கால்நடை பராமரிப்பு – கால்நடைகளுக்காக வடிவமைக்கப்பட்ட கிணறுகள் – வேளாண்மை மற்றும் வேளாண்மைச் சார்ந்த செயல்பாடுகள் – கடல்சார் அறிவு – மீன்வளம் – முத்து மற்றும் முத்துக்குளித்தல் – பெருங்கடல் குறித்த பண்டைய அறிவு – அறிவுசார் சமூகம்.

அலகு V <u>அறிவியல் தமிழ் மற்றும் கணித்தமிழ்</u>: 3

அறிவியல் தமிழின் வளர்ச்சி –கணித்தமிழ் வளர்ச்சி – தமிழ் நூல்களை மின்பதிப்பு செய்தல் – தமிழ் மென்பொருட்கள் உருவாக்கம் – தமிழ் இணையக் கல்விக்கழகம் – தமிழ் மின் நூலகம் – இணையத்தில் தமிழ் அகராதிகள் – சொற்குவைத் திட்டம்.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு:

தமிழ்நாடு பாடநூல் மற்றும்
கல்வியியல் பணிகள் கழகம்).

2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils – The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi – 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

TAMILS AND TECHNOLOGY

L	T	P	C
1	0	0	1

UNIT I WEAVING AND CERAMIC TECHNOLOGY 3

Weaving Industry during Sangam Age – Ceramic technology – Black and Red Ware Potteries (BRW) – Graffiti on Potteries.

UNIT II DESIGN AND CONSTRUCTION TECHNOLOGY 3

Designing and Structural construction House & Designs in household materials during Sangam Age -Building materials and Hero stones of Sangam age – Details of Stage Constructions in Silappathikaram - Sculptures and Temples of Mamallapuram - Great Temples of Cholas and other worship places - Temples of Nayaka Period -Type study (Madurai Meenakshi Temple)- Thirumalai NayakarMahal -ChettiNadu Houses, Indo-Saracenic architecture at Madras during British Period.

UNIT III MANUFACTURING TECHNOLOGY 3

Art of Ship Building - Metallurgical studies -Iron industry - Iron smelting, steel -Copper and gold- Coins as source of history - Minting of Coins – Beads making-industries Stonebeads - Glass beads - Terracotta beads -Shell beads/ bone beats - Archeological evidences - Gem stone types described in Silappathikaram.

UNIT IV AGRICULTURE ANDIRRIGATION TECHNOLOGY 3

Dam, Tank, ponds, Sluice, Significance of KumizhiThoompuof Chola Period,Animal Husbandry - Wells designed for cattle use - Agriculture and Agro Processing -

KnowledgeofSea -Fisheries – Pearl - Conche diving - Ancient Knowledge ofOcean - KnowledgeSpecificSociety.

UNIT V SCIENTIFIC TAMIL & TAMIL COMPUTING 3

Development of Scientific Tamil - Tamil computing – Digitalization of Tamil Books – Development of Tamil Software – Tamil Virtual Academy – Tamil Digital Library – Online Tamil Dictionaries – Sorkuvai Project.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCEBOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும்
   கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils – The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi – 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

MA23C03	LINEAR ALGEBRA AND NUMERICAL METHODS	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To understand Vector spaces and its basis and dimension.
- To understand the linear maps between vector spaces and their matrix representations.
- To understand the diagonalizatition of a real symmetric matrix.
- To understand Inner product spaces and its projections.
- To understand numerical techniques for solving linear systems, eigenvalue problems and generalized inverses.

UNIT I VECTORSPACES 9+3

Vector Spaces – Subspaces – Linear Combinations - Linear Span – Linear Dependence - Linear Independence – Bases and Dimensions.

UNIT II LINEAR TRANSFORMATIONS 9+3

Linear Transformation – Null Space, Range Space - Dimension Theorem - Matrix representation of Linear Transformation – Eigenvalues and Eigenvectors of Linear Transformation – Diagonalization of Linear Transformation – Application of Diagonalization in Linear System of Differential Equations.

UNIT III INNER PRODUCT SPACES 9+3

Inner Products and Norms - Inner Product Spaces - Orthogonal Vectors – Gram Schmidt Orthogonalization Process – Orthogonal Complement – Least Square Approximations.

UNIT IV NUMERICAL SOLUTION OF LINEAR SYSTEM OF EQUATIONS 9+3

Solution of Linear System of Equations – Direct Methods: Gauss Elimination Method – Pivoting, Gauss Jordan Method, LU Decomposition Method and Cholesky Decomposition Method - Iterative Methods: Gauss-Jacobi Method, Gauss-Seidel Method and SOR Method.

UNIT V NUMERICAL SOLUTION OF EIGENVALUE PROBLEMS AND GENERALISED INVERSES 9+3

Eigen Value Problems: Power Method – Inverse Power Method – Jacobi’s Rotation Method - QR Decomposition - Singular Value Decomposition Method.

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students from the content of the course wherever applicable.

Branch specific / General Engineering applications based on the content of each units will be introduced to students wherever possible.

Suggested Laboratory based exercises / assignments / assessments :

1. Linear independence/dependence of vectors
2. Computation of eigenvalues and eigenvectors
3. Diagonalization of Linear Transformation
4. Gram Schmidt Orthogonalization Process
5. Solution of algebraic and transcendental equations
6. Matrix Decomposition methods (LU / Cholesky Decomposition)
7. Iterative methods of Gauss-Jacobi and Gauss-Seidel
8. Matrix Inversion by Gauss-Jordan method
9. Eigen values of a matrix by Power method and by Jacobi's method
10. QR decomposition method
11. Singular Value Decomposition Method

OUTCOMES:

CO1: Solve system of linear equations using matrix operations and vector spaces using Algebraic methods.

CO2: Understand the linear maps between vector spaces and its utilities.

CO3: Apply the concept of inner product of spaces in solving problems.

CO4: Understand the common numerical methods and how they are used to obtain approximate solutions

CO5: Analyse and evaluate the accuracy of common numerical methods.

TEXT BOOKS:

1. Faires, J.D. and Burden, R., "Numerical Methods", Brooks/Cole (Thomson Publications), Fourth Edition, New Delhi, 2012.
2. Friedberg, S.H., Insel, A.J. and Spence, E., "Linear Algebra", Pearson Education, Fifth Edition, New Delhi, 2018.
3. Williams, G, "Linear Algebra with Applications", Jones & Bartlett Learning, First Indian Edition, New Delhi, 2019.

REFERENCES:

1. Bernard Kolman, David R. Hill, "Introductory Linear Algebra", Pearson Education, First Reprint, New Delhi, 2010.
2. Gerald, C.F, and Wheatley, P.O., "Applied Numerical Analysis", Pearson Education, Seventh Edition, New Delhi, 2004.
3. Kumaresan, S., "Linear Algebra – A geometric approach", Prentice – Hall of India, Reprint, New Delhi, 2010.
4. Richard Branson, "Matrix Operations", Schaum's outline series, Mc Graw Hill, New York, 1989.
5. Strang, G., "Linear Algebra and its applications", Cengage Learning, New Delhi, 2005.

CO – PO Mapping:

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**P11**	**P12**
CO 1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 5 :	3	3	2	3	1	2	1	1	1	1	1	3

AU23C02	MECHANICS OF SOLIDS	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

- To know about how a solid (materials, structures) behaves when it is exposed to forces and deformations.
- To apply the fundamental concepts of principle of superposition, equilibrium, compatibility, force deformation, and stress-strain relationships to the solid and structural mechanics problems.
- To analyze determinate and indeterminate bars, beams, to determine axial forces, torques, shear forces, and bending moments
- To have physical insight into distribution of stresses and strains in structural members
- To identify the biaxial stresses in acting in a body or an element.

UNIT – I STRESS, STRAIN AND AXIAL LOADING **9**

Stress and strain, elastic limit, Hooke's law, factor of safety, shear stress, shear strain, relationship between elastic constants. Stresses in stepped bars, uniformly varying sections, composite bars due to axial force. Lateral strain, Poisson's ratio, volumetric strain, changes in dimensions and volume. Thermal stresses and impact loading. Design of truss.

UNIT – II STRESSES IN BEAMS **9**

Beam – Definition, types of end supports, types of beam, types of loading. Shear force diagram and bending moment diagram for cantilever, simply supported and overhanging beams under point load, UDL, UVL and moments. Euler beam theory - Bending equation, section modulus, Bending stress in beams – Shear stress in beams. Unsymmetric bending

UNIT – III DEFLECTION OF BEAMS AND COLUMNS **9**

Governing differential equation - Problems on Double integration method - Macaulay's Method – Moment area method. Concepts of Conjugate Beam method and Method of superposition. Castiglianos 1st and 2nd theorems. Columns – different end conditions – buckling load – Euler's theory – Rankine's formula.

UNIT – IV TORSION AND SPRINGS **9**

Theory of torsion and assumptions - torsion equation, polar modulus, stresses in solid and hollow circular shafts, power transmitted by a shaft, shafts in series and parallel, deflection in shafts fixed at the both ends. Springs – types, Deflection expression for closed coiled helical spring – Stress in springs - design of springs.

UNIT – V BIAXIAL STRESS **9**

Principal stresses, normal and tangential stresses, maximum shear stress - analytical and graphical method. Stresses in combined loading. Thin walled cylinder under internal pressure – changes in dimensions – volume. spherical shells subjected to internal pressure – deformation in spherical shells – Lame's theory. Strain energy. Theories of failures.

TOTAL: 45 PERIODS

LIST OF EXPERIMENTS

Ex. No	Name of the Experiments	Unit
1	Tension Test.	1
2	Torsion Test.	4
3	Testing of Springs	4
4	Impact test i) Izod ii) Charpy	1
5	Hardness Test i) Vickers ii) Brinell iii) Rockwell iv) Shore	1
6	Deflection of Beams	3

TOTAL = 30 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Know about how a solid (materials, structures) behaves when it is exposed to forces and deformations.

CO2: Apply the fundamental concepts of principle of superposition, equilibrium, compatibility, force-deformation, and stress-strain relationships to the solid and structural mechanics problems

CO3: Analyze determinate and indeterminate bars, beams, to determine axial forces, torques, shear forces, and bending moments.

CO4: Have physical insight into distribution of stresses and strains in structural members.

CO5: Identify the biaxial stresses in acting in a body or an element.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	3	3	3	1	1	-	2	2	-	3	3	3	3
CO2	3	3	3	3	3	1	1	-	2	2	-	3	3	3	3
CO3	3	3	3	3	3	1	1	-	2	2	-	3	3	3	3
CO4	3	3	3	3	3	1	1	-	2	2	-	3	3	3	3
CO5	3	3	3	3	3	1	1	-	2	2	-	3	3	3	3
CO/PO & PSO Average	**3**	**3**	**3**	**3**	**3**	**1**	**1**	**-**	**2**	**2**	**-**	**3**	**3**	**3**	**3**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. James M Gere, Barry J Goodno, "Mechanics of Materials, SI Edition", 9th Edition, Cengage Learning India Pvt. Ltd., 2022
2. Russell C. Hibbeler, "Mechanics of Materials", 10th Edition, Pearson education, 2022
3. Stephen Timoshenko, ‘Strength of Materials’, Vol I & II, CBS Publishers and Distributors, 3rd Edition, 2021.

REFERENCES

1. Eric M. Taleff, Roy R. Craig, "Mechanics of Materials", 4rd Edition, John Wiley & Sons, 2020
2. R.K.Rajput, 'Strength of Materials', S Chand; 6th Edition, 2015.
3. Timothy A. Philpot, "Mechanics of Materials: An Integrated Learning System," 4th Edition, Wiley, 2017.
4. William A. Nash, Merle C. Potter, "Schaum's Outline of Strength of Materials", 7th Edition, McGraw Hill Education, 2019
5. Ramamrutham S, "Strength Of Materials", Dhanpat Rai Publishing Company, 16th Edition, 2012
6. Clive L. Dym, Irving H. Shames, "Solid Mechanics: A Variational Approach, Augmented Edition", Springer publishers, 2013
7. Saad, M. H., "Elasticity: Theory, Applications and Numerics", Academic Press; 3rd Edition, 2014
8. Timoshenko, S. P., J. N. Goodier, "Theory of Elasticity", McGraw Hill Education; 3rd Edition, 2017
9. Srinath, L. S, "Advanced Mechanics of Solids", McGraw Hill Education, 3rd Edition, 2017
10. Crandal, S, Lardner, T, Dahl, N and Sivakumar, M. S., An Introduction to Mechanics of Solids", McGraw-Hill Education; 3rd Edition, 2012.

PR23C01	THEORY OF MACHINES	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To impart knowledge on various types of mechanisms and synthesis.
2. To understand the effects of friction in motion in transmission and machine components.
3. To familiarize higher pairs like cams and gears transmission.
4. To impart knowledge of mechanical vibrations
5. To study the undesirable effects of unbalances resulting from prescribed motions in mechanisms.

UNIT – I MECHANISMS 9

Definition – Machine and Structure – Kinematic link, pair and chain – classification of Kinematic pairs– Single and Multi DoF– Inversion of mechanisms along with their practical applications. Introduction to Kinematic analysis and synthesis of simple mechanisms – Determination of velocity and acceleration of mechanism by polygon method, instantaneous centre method and vector approaches.

UNIT – II FRICTION 9

Types of friction – friction in screw and nut – screw jack - bearings – clutch - brakes –belt (Flat and V).

UNIT – III GEARS AND CAMS 9

Gear – basic terminology of gears–laws of gearing – interference– geometric and kinematic considerations for various tooth profiles, the cycloidal and involute profiles, standards in tooth forms, spur gears and other types of gears. Gear trains, Simple, compound and epicyclic gear trains and their applications-Cam-terminology-different types of cams and followers – Cam design for different follower motion curves, graphical construction of cam profiles for different types of followers.

UNIT – IV VIBRATIONS 9

Basic terminology related to vibrations, free and forced vibrations without and with damping – critical speed of shafts - Torsional vibrations in shafts.

UNIT – V BALANCING, GOVERNORS, AND GYROSCOPES 9

Static and dynamic balancing – balancing of rotating and reciprocating masses - principles of balancing machine. Governors - Analysis of different types of governors - Gyroscopic - applications of gyroscope - Gyroscopic effects.

TOTAL: 45 PERIODS

LIST OF EXPERIMENTS:

1. Analysis of kinematic chains. (Unit –I)
2. Determination of Mass moment of inertia of Fly wheel and Axle system by a) compound pendulum, b) turn table apparatus and c) bifilar suspension. (Unit –V)
3. Motorized gyroscope – Study of gyroscopic effect and couple. (Unit –V)

4. Governor - Determination of range sensitivity, effort etc., for Watt, Porter, Proell and Hartnell Governors. (Unit –V)
5. Cams – Cam profile drawing, Motion curves and study of jump phenomenon. (Unit –III)
6. Single and Multi-degrees of freedom -Spring Mass System. (Unit –IV)
7. Determination of torsional natural frequency of single and Double Rotor systems. (Unit –IV)
8. Whirling of shafts – Determination of critical speeds of shafts with concentrated loads. (Unit –IV)
9. Balancing of rotating masses. (Unit –V)
10. Vibration analysis – Shaker Table. (Unit –IV)

TOTAL = 30 PERIODS

Any 7 Experiments

TOTAL: 75 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

1. Apply the kinematics mechanism to industrial needs.
2. Discuss the frictional effects in machine elements.
3. Estimate gear, gear trains and cam and their parameters for transmission systems.
4. Examine the outcomes of free, forced and damped vibrations.
5. Analyse the undesirable effect of unbalancing.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	1	1	-	-	1	1	1	1	-	2	1	-	1
CO2	3	2	1	1	-	-	1	1	1	1	-	2	1	-	1
CO3	3	2	1	1	-	-	1	1	1	1	-	2	1	-	1
CO4	3	2	1	1	-	-	1	1	1	1	-	2	1	-	1
CO5	3	2	1	1	-	-	1	1	1	1	-	2	1	-	1
CO/PO & PSO Average	**3.0**	**2.0**	**1.0**	**1.0**	**-**	**-**	**1.0**	**1.0**	**1.0**	**1.0**	**-**	**2.0**	**1.0**	**-**	**1.0**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS:

1.Sadhu Singh, "Theory of Machines", Pearson Education, 2013.
2. Rattan S.S., “Theory of machines”, Tata McGraw Hill publishing Co., 4th edition 2014.

REFERENCES:

1. Gosh A and Mallick A.K., “Theory of Machines and Mechanisms”, Affiliated East West press, 2009.
2. Malhotra D.R. and Gupta H.C, “The Theory of machines”, Satya Prakasam, Publications, 2008.
3. Rao J.S. and Dukkipati R.V., “Mechanism and Machine Theory”, Second Edition, Wiley
4. Eastern Limited, 2006.
5. Shigley J.E. and Uicker J.J., “Theory of Machines and Mechanisms”, McGraw Hill, 2006.
6. Ambekar A.G., “Mechanism and Machine Theory”, PHI India Pvt Ltd, 2015

RA23301	DIGITAL ELECTRONICS AND MICROPROCESSOR	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To present the Digital fundamentals, Boolean algebra and its applications in digital systems
2. To familiarize with the design of various combinational digital circuits using logic gates
3. To introduce the analysis and design procedures for synchronous and asynchronous sequential circuits
4. To explain the various semiconductor memories and related technology
5. To introduce the electronic circuits involved in the making of logic gate

UNIT – I DIGITAL FUNDAMENTALS 9

Number Systems – Decimal, Binary, Octal, Hexadecimal, 1‘s and 2‘s Complement, Codes – Binary, BCD, Excess 3, Gray, Alphanumeric Codes, Boolean Theorems, Logic Gates, Universal gates, Sum of Products and Product of Sums, Karnaugh Map Minimization.

UNIT – II COMBINATIONAL LOGIC CIRCUITS 9

Design of Half and Full Adders, Half and Full Subtractors, Binary Parallel Adder, Multiplexer, Demultiplexer, Encoder, Decoder, Priority Encoder.

UNIT – III SEQUENTIAL LOGIC CIRCUITS AND MEMORY DEVICES 9

Flip Flops – SR, JK, T, D; Design of clocked Sequential Circuits - Design of Counters, Shift registers, Stable and Unstable States, Design of Asynchronous circuits, Basic memory structure – ROM - PROM – EPROM – EEPROM, RAM – Static and dynamic RAM – Overview of Field Programmable Gate Arrays (FPGA).

UNIT – IV 8085 PROCESSOR 9

Introduction to 8085- Comparison of 8085 vs 8086 - Pin Diagram-Architecture – Memory Organization – I/O Ports and Data Transfer Concepts – Timing Diagram – Interrupts-Addressing Modes, Instruction set.

UNIT – V 8085 PROGRAMMING 9

Assembly language Programming: 8255 Architecture, Operating Modes and applications – Stepper Motor, Traffic Light Control- 7 segment display, keyboard interfacing

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: State the fundamental operating concepts in digital logic circuits and microprocessors.
CO2: Recognize the use of various digital logic circuits and sub units in microprocessors.
CO3: Construe the information flow in digital logic circuits and the architectures of microprocessors.
CO4: Design the digital logic circuits and microprocessor for given applications.
CO5: Evaluate the design of DLC and Microprocessor interfacing.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	1	-	-	-	-	-	1	-	1	1	1	1
CO2	2	1	-	1	-	-	-	-	-	1	-	1	1	1	1
CO3	2	-	-	-	-	-	-	-	-	1	-	1	1	1	1
CO4	2	1	-	1	-	-	-	-	-	1	-	1	1	1	1
CO5	2	1	1	1	-	-	-	-	-	1	-	1	1	1	1
CO/PO & PSO Average	**2**	**1**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**1**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS:

1. M. Morris Mano and Michael D. Ciletti, “Digital Design”, 6th Edition, Pearson, 2018.
2. R.S. Gaonkar, ‘Microprocessor Architecture Programming and Application with 8085’, 6th Edition Wiley Eastern Ltd., New Delhi, 2013.

REFERENCES:

1. Charles H.Roth. “Fundamentals of Logic Design”, 6th Edition, Thomson Learning, 2013.
2. Thomas L. Floyd, “Digital Fundamentals”, 11th Edition, Pearson Education Inc, 2017
3. Krishna Kant, “Microprocessor and Microcontrollers”, 2nd Edition, Eastern Company Edition, Prentice Hall of India, New Delhi, 2014.

RA23302	ELECTRICAL DRIVES AND ACTUATORS	L	T	P	TCP
		3	0	4	5

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

- To familiarize a relay and power semiconductor devices
- To get a knowledge on drive characteristics
- To obtain the knowledge on DC motors and drives.
- To obtain the knowledge on AC motors and drives.
- To obtain the knowledge on Stepper and Servo motor.

UNIT – I RELAY AND POWER ELECTRONIC DEVICES 9

Study of Switching Devices – Relay and Types, Switching characteristics -BJT, SCR, TRIAC, GTO, MOSFET, IGBT and IGCT-SCR, MOSFET and IGBT - Triggering and Commutation Circuit - Introduction to Driver and Snubber Circuits.

UNIT – II DRIVE CHARACTERISTICS 9

Electric Drive – Equations Governing Motor Load Dynamics – Steady State Stability – Multi Quadrant Dynamics: Acceleration, Deceleration, Torque, and Direction.Starting & Stopping – Selection of Motor, Selection of Panel – Selection of Cables.

UNIT – III DC MOTORS AND DRIVES 9

Types of PMDC & BLDC Motors - Principle of Operation- EMF and Torque Equations - Characteristics and Control – Drives - H Bridge - BLDC Motors - Single and Three Phases – 4 Quadrant Operation - Hub Motors- Linear Motors– Applications.

UNIT – IV AC MOTORS AND DRIVES 9

Introduction – Induction Motor Drives – Speed Control of 3-Phase Induction Motor – Stator Voltage Control – Stator Frequency Control – Stator Voltage and Frequency Control - Servo Mechanism –- AC Servo Motor and Drive– Applications.

UNIT – V DC SERVO AND STEPPER MOTOR 9

DC Servo Motor- Applications- Stepper Motor: Classifications- Construction and Principle of Operation – Modes of Excitation-Drive System-Logic Sequencer – Applications- Frameless Motors, Direct Drive and Piezomotor

TOTAL: 45 PERIODS

LIST OF EXPERIMENTS:

Ex. No	Name of the Experiments	Unit
1	Switching circuits of MOSFET, and IGBT	**1**
2	Switching circuits of SCR and TRAIC.	**1**
3	Gate pulsation generation using PWM signals.	**1**
4	Speed control of DC motor using Power Electronic Drive.	**2**
5	Position and direction control DC servomotor using Power Electronic Drive.	**2**
6	Direction and speed control of BLDC using Power Electronic Drive.	**3**
7	Position, Direction and speed control of PMDC motors using Power Electronic Drive.	**3**
9	Four quadrant operation of three-phase Induction Motor using Power Electronic Drive.	**4**
8	Position, Direction and speed control of stepper Motor.	**5**
10	AC synchronous servomotor position, direction and speed control using Power Electronic Drive	**5**

TOTAL: 60 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO 1: Recognize the principles and working of relays, power electronic drives and motors.
CO 2: Explain the working characteristics of various drives and motors.
CO 3: Apply the solid-state switching circuits to operate various types of Motors.
CO 4: Interpret the working of Motors and Driver circuits.
CO 5: Suggest the Motors and Drivers for given applications.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	1	-	-	-	-	-	1	-	1	2	1	1
CO2	2	1	-	1	-	-	-	-	-	1	-	1	2	1	1
CO3	2	1	-	1	-	-	-	-	-	1	-	1	2	1	1
CO4	2	1	-	1	-	-	-	-	-	1	-	1	2	1	1
CO5	2	1	-	1	-	-	-	-	-	1	-	1	2	1	1
CO/PO & PSO Average	**2**	**1**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS:

1. Bimbhra P.S., "Power Electronics", 5th Edition, Kanna Publishers, New Delhi, 2018.
2. Mehta V.K. & Rohit Mehta, "Principles of Electrical Machines", 2nd Edition, S.Chand& Co. Ltd., New Delhi, 2016.

REFERENCES:

1. Gobal K. Dubey, "Fundamentals of Electrical Drives", 2nd Edition, Narosa Publishing House, New Delhi, 2001.
2. Theraja B.L. &Theraja A.K., "A Text Book of Electrical Technology", 2nd Edition, S.Chand& Co. Ltd., New Delhi, 2012.
3. Singh M.D. &Kanchandhani K.B., "Power Electronics", 2nd edition McGraw Hill, New Delhi, 2017.

RA23303	KINEMATICS OF ROBOTICS	L	T	P	TCP
		3	0	2	4

COURSE OBJECTIVES

- To introduce Robots history, terminologies, classification and configurations.
- To get knowledge about basic Geometrical and Algebraic approach to solve forward kinematics of serial manipulator.
- To get knowledge about advanced forward kinematics of serial manipulator.
- To get knowledge about inverse kinematics of various serial manipulator.
- To get knowledge about Jacobian aspects and infinitesimal motion of robot mechanisms.

UNIT – I OVERVIEW OF ROBOTICS 9

Introduction to Robotics - History - Definitions - Law of Robotics – Types of Robots– Terminologies – Classifications Overview – Links & Joints - Degrees of Freedoms - Coordinate Systems - Work Volume - Precision, Repeatability & Accuracy - Position and Orientation of Objects - Roll, Pitch and Yaw Angles - Joint Configuration of Five Types of Serial Manipulators - Wrist Configuration - End Effector - Manipulability of Manipulators -Selection and Application of Serial Manipulators and end effector

UNIT – II FORWARD KINEMATICS - GEOMETRICAL AND ALGEBRAIC APPROACH 9

Need for Forward and Inverse Kinematics Equation – Parameters in Design and Control – Methods of Forward and Inverse Kinematics- Geometrical and Algebraic Approach in Forward Kinematics Solution, 1 DOF - 2 DOF Planar Robot (2P and 2R); 3DOF 2RP Spatial Robot.

UNIT – III FORWARD KINEMATIC MODELING – DENAVIT-HARTEBERG (DH) APPROACH 9

Unit Circle Trigonometry - Translation Matrix - Rotation Matrix, Euler Angles - Quaternion Fundamental –Dot and Cross Products - Frames and Joint Coordinates - Homogeneous Transformation - D-H Convention and Procedures and Solutions: 3 DOF Wrist, RR Planar, 3 DOF RRP, Cartesian, Cylindrical, Spherical, SCARA and Articulated 3 DOF Robots - 3 DOF Robot with Wrist – 6 DOF robots

UNIT – IV INVERSE KINEMATICS 9

Introduction to Inverse Kinematics -Issues in Inverse kinematics - Inverse kinematics of 2 DOF Planar robot - 2 and 3 DOF planar and Spatial robot - Tool Configuration - Inverse Kinematics of 3 Axis Robot and 6 Axis Robot - Inverse kinematics Computation- Closed Loop Solution

UNIT – V JACOBIAN AND DIFFERENTIAL MOTION 9

Forward and Inverse Jacobian- Introduction - Singularity - Linear and Angular Velocity of End Effector using Jacobian - Differential Operator - Finding New Location of End Effector Based on Differential Motion.

TOTAL: 45 PERIODS

LIST OF EXPERIMETS

Ex. No	Name of the Experiments	Unit
1.	Verification of Forward Kinematics for 1 and 2 DOF Robot in geometrical approach	2
2.	Verification of translational and rotational motion using HTM Module.	3
3.	Verification of Forward Kinematics for 2DOF Robot by using D-H transformation	2
4.	Verification of Forward Kinematics for 3DOF Robot.	3
5.	Verification of Forward Kinematics for 6 DOF Robot by using D-H transformation	3
6.	Verification of Inverse Kinematics for 1 and 2 DOF Robot	4
7.	Verification of Inverse Kinematics for 3DOF Robot.	4
8.	Verification of Forward Jacobian and Singularity test	5
9.	Verification of Inverse Jacobian	5
10.	Verification of Singularity of the robot configuration	5

(Minimum 7 experiments at least 1 in each concepts)

Software tool required: Roboanalyzer/ Matlab/ python

COURSE OUTCOMES

At the end of the course students able to

CO1: Describe the history, classifications, terminologies and its configuration of robots.
CO2: Generalize the foundational concepts of robot and its kinematics.
CO3: Apply the algebraic, geometric and D-H foundations and other concepts for kinematics solution development.
CO4: Evaluate configuration, forward and inverse kinematic model for planar and spatial multi-DOF manipulators.
CO5: Choose the appropriate robot configurations, assess kinematic solutions, and analyze differential motion of robots, considering factors such as velocity, acceleration, and singularity avoidance.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	-	-	1	-	-	-	-	-	1	-	1	2	2	1
CO2	2	1	1	1	-	-	-	-	-	1	-	1	2	2	1
CO3	2	2	2	1	-	-	-	-	-	1	-	1	2	2	1
CO4	2	2	2	1	-	-	-	-	-	1	-	1	2	2	1
CO5	2	2	1	1	-	-	-	-	-	1	-	1	2	2	1

CO/PO & PSO Average	**2**	**1.7**	**1.5**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS:

1. John J. Craig, “Introduction to Robotics”, 3rdEdition, Addison Wesley, ISE 2020.
2. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2ndedition, 2017.

REFERENCES:

1. S K Saha, Introduction to Robotics, Tata McGraw-Hill, 2nd edition, 2019.
2. Arthor Critchlow, “Introduction to Robotics”, 1stedition, Macmillan, 2009.
3. Mohsen Shahinpoor, “A Robot Engineering Text Book”, 1stedition, Harper and Row, 2004.
4. Deb S.R., “Robotics Technology and Flexible Automation”, 2ndedition, Tata McGraw - Hill Publisher, 2017.
5. J. Srinivas, R. V. Dukkipati, K., “Robotics: Control and Programming”, Narosa Publishing House, 2009.
6. Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd., 2016.
7. King-Sun Fu, C.S.George Lee, Ralph Gonzalez, "Robotics: Control, Sensing, Vision and Intelligence", Tata McGraw Hill, 1986
8. Peter Corke, "Robotics, Vision and Control: Fundamental Algorithms in MATLAB", Springer, 2011

RA23401	SENSORS AND SIGNAL CONDITIONING	L	T	P	TCP
		3	0	2	4

COURSE OBJECTIVES

- To comprehend the concepts of sensors and measurement technology.
- To learn the various motion, proximity and ranging sensors
- To learn the various Force, Magnetic and Heading Sensors
- To learn the various Optical, Pressure and Temperature Sensors.
- To learn the fundamentals of signal conditioning, data acquisition and communication systems used in mechatronics system development**.**

UNIT – I INTRODUCTION 9

Basics of Measurement – Classification of Errors – Error Analysis – Static and Dynamic Characteristics of Transducers – Classification of Sensors – Sensor Calibration Techniques – Sensor Output Signal Types.

UNIT – II MOTION, PROXIMITY AND RANGING SENSORS 9

Proximity Sensors- Types, Motion Sensors – Potentiometers, Resolver, Encoders – Optical, Magnetic and Inductive, LVDT – RVDT – Synchro – Microsyn, Accelerometer,GPS, Range Sensors – Ultrasonic Ranging, IR Sensor, LIDAR.

UNIT – III FORCE, MAGNETIC AND HEADING SENSORS 9

Strain Gauge, Load Cell, Magnetic Sensors –Types, Principle, Requirement and Advantages: Magneto Resistive – Hall Effect – Current Sensor - Heading Sensors –Compass, Gyroscope and IMU, Inclinometers.

UNIT – IV OPTICAL, PRESSURE AND TEMPERATURE SENSORS 9

Photo Conductive Cell, Photo Voltaic cell, LDR – Fiber Optic Sensors – Pressure Diaphragm, Bellows, Piezoelectric – Tactile Sensors, Temperature – IC sensor, Thermistor, RTD, Thermocouple and IR Temperature sensor and camera. Acoustic Sensors, Flow and Level Measurement, Smart Sensors - Film Sensor, MEMS & Nano Sensors.

UNIT – V SIGNAL CONDITIONING AND DATA ACQUISITION 9

Bridge Circuits - Amplification – Analog Filters – Sample and Hold Circuits – A/D Conversation - Data Acquisition: Single Channel and Multi-Channel Data Acquisition – Signal Characteristics – Data Logging – Signal Processing Technique overview –Case Studies in Sensors and Transducers in Robotics, Manufacturing, Automobile, Aerospace, Home Automation, and Environmental Monitoring.

TOTAL: 45 PERIODS

LIST OF EXPERIMENTS

Ex. No	Name of the Experiments	Unit
1	Speed, Position and Direction Measurement Using Encoders.	
2	Determination of Load, Torque and Force using Strain Gauge.	3
3	Determination of the characteristics of Pressure Sensor and Piezoelectric Force Sensor.	4
4	Determination of Displacement using LVDT.	2
5	Determine the Characteristics of Various Temperature Sensors.	4
6	Determine the Characteristics of Various Light Detectors (OpticalSensors).	4
7	Distance Measurement using Ultrasonic and Laser Sensor	2
8	Determine angular velocity of gyroscope	3
9	Vibration measurement using Accelerometer.	2
10	Direction measurement using Magnetometer.	3
11	Force measurement using 3 axis force sensor.	3
12	Force Measurement using tactile sensors.	3
13	Data acquisition, visualization and analysis of signals.	5

(Any 8 experiments)

TOTAL = 30 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Identify the terminologies of sensors, transducers and elements of DAQ.
CO2: Describe specification and working of sensors, transducers and DAQ.
CO3: Acquire the signals using sensors and transducersfor the given applications.
CO4: Suggest the appropriate sensors and data acquisition systems for different applications.
CO5: Synthesize the different sensors using Data acquisition systems for signal processing and decision making.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	1	-	-	-	-	-	1	-	1	2	2	2
CO2	2	1	-	1	-	-	-	-	-	1	-	1	2	2	2
CO3	2	1	-	1	-	-	-	-	-	1	-	1	2	2	2
CO4	2	1	-	1	-	-	-	-	-	1	-	1	2	2	2
CO5	2	1	-	1	-	-	-	-	-	1	-	1	2	2	2
CO/PO & PSO Average	**2**	**1**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**2**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS:

1. Ernest O Doebelin, “Measurement Systems – Applications and Design”, Tata McGraw- Hill, 2019
2. Sawney A K and PuneetSawney, “A Course in Mechanical Measurements and Instrumentation and Control”, 12th edition, DhanpatRai& Co, New Delhi, 2013.

REFERENCES:

1. C. Sujatha, Dyer, S.A., Survey of Instrumentation and Measurement, John Wiley & Sons, Canada, 2004.
2. Hans Kurt Tönshoff (Editor), Ichiro, “Sensors in Manufacturing” Volume 1, Wiley-VCH, 2010.
3. John Turner and Martyn Hill, “Instrumentation for Engineers and Scientists”, Oxford Science Publications, 2009.
4. Patranabis D, “Sensors and Transducers”, 2nd Edition, PHI, New Delhi, 2013.
5. Richard Zurawski, “Industrial Communication Technology Handbook” 2nd edition, CRC Press, 2015.

RA23402	EMBEDDED SYSTEMS AND PROGRAMMING	L	T	P	TCP
		3	0	4	5

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

- To familiarize the architecture and fundamental units of microcontroller.
- To know the microcontroller programming methodology and to acquire the interfacing skills and data exchange methods using various communication protocols.
- To design the interface circuit and programming of I/O devices, sensors and actuators.
- To acquaint the knowledge of real time embedded operating system for advanced system developments.
- To familiar RTOS based I/O interfacing

UNIT I MICROCONTROLLER 9

Overview of Microprocessor and Microcontroller- Functions of ALU – CISC and RISC –8051 Microcontroller– Architecture, Peripheral Features and Specifications - Memory Organization - Timing Diagram- Instruction Sets – Addressing Modes- Timer and Counter - Interrupts

UNIT II PROGRAMMING AND COMMUNICATION 9

Compiler and IDE - C Programming for 8051 Microcontroller – Basic Arithmetic and Logical Programming Interfacing and Programming of Serial Communication, I^2C, SPI and CAN of 8051 Microcontroller – Bluetooth and WI-FI interfacing of 8051 Microcontroller.

UNIT III PERIPHERAL INTERFACING 9

I/O Programming – Interfacing of Memory, Key Board, Displays – Alphanumeric and Graphic, RTC, Interfacing of ADC and DAC, Sensors, Relay, Solenoid, Heater, - PWM Programming – Stepper Motors, DC Motor - Closed Loop Control Programming of Servomotor – Overview of Advanced Microcontrollers.

UNIT IV SINGLE BOARD COMPUTERSAND OPERATING SYSTEMS 9

Single Board Computer - Architecture Overview, Hardware Considerations: GPIO, Logic States, CPU, Internal and External Memory, Network and Peripheral Features – Camera, Ethernet, WIFI - Real Time Embedded Operating Systems - RTOS Concepts and Definitions, Real-Time Design Issues, RTOS Building Blocks, Real-Time Kernel– Supported OS and Libraries Overview.

UNIT V SBC INTERFACING 9

Real Time Programming Languages – Comparison of C and Python syntax for Embedded Systems-Interfacing I/O with Single Board Computers - GPIO Programming– Realization of IOT in SBC-Case Studies – Home Automation

TOTAL: 45 PERIODS

LIST OF EXPERIMENTS

Ex. No	Name of the Experiments	Unit
1	Assembly Language Programming and Simulation of 8051. a) Data Transfer b) Arithmetic Instructions c) Counters d) Boolean and logical Instructions e) Code Conversion	2

2	LED interfacing using 8051 Microcontroller.	3
3	Alphanumeric and Graphic LCD Interfacing using 8051 Microcontroller.	3
4	Input switches and keyboard interfacing of 8051Microcontroller.	3
5	Sensor Interfacing with ADC to 8051 and DAC & RTC Interfacing with 8051Microcontroller.	3
6	Timer, Counter and Interrupt Program Application for 8051.	3
7	Stepper Motor (Unipolar & Bipolar Motor) Control to Interfacing with 8051Microcontroller.	3
8	PWM Servo Motor Control to Interfacing with 8051Microcontroller.	3
9	I^2C Programming of 8051 Microcontroller.	3
10	Interfacing and Programming of Bluetooth and Wi-Fi with 8051Microcontroller.	3
11	GPIO Programming of Real Time Embedded Operating Systems.	4,5
12	Interfacing and Programming of Sensor with Real Time Embedded Operating Systems.	4,5
13	Interfacing and Programming of Camera with Real Time Embedded Operating Systems.	4,5
14	Interfacing and Programming of Actuator with Real Time Embedded Operating Systems.	4,5

TOTAL = 60 PERIODS

COURSE OUTCOMES

successful completion of the course, students should be able to:

CO 1: State the basic terminologies of microcontroller and SBC.

CO 2: Express the architecture, functions and features of microcontroller and SBC.

CO 3: Design the microcontroller/SBCfor interfacing the sensors, actuators and other I/O's for automation.

CO 4: Programming the microcontroller and SBC.

CO 5: Evaluate the design, interfacing and programming of microcontroller and SBC for the given application.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	1	-	-	-	-	-	1	-	1	2	2	2
CO2	2	-	-	1	-	-	-	-	-	1	-	1	2	2	2
CO3	2	-	3	1	-	-	-	-	-	1	-	1	2	2	2
CO4	2	2	-	1	-	-	-	-	-	1	-	1	2	2	2
CO5	2	-	3	1	-	-	-	-	-	1	-	1	2	2	2
CO/PO & PSO Average	**2**	**2**	**3**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**2**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Frank Vahid and Tony Givagis, “Embedded System Design”, 2011, Wiley.
2. James W. Stewart, “The 8051 Microcontroller Hardware, Software and Interfacing”, Regents Prentice Hall, 2003.
3. John B. Peatman, “Design with Microcontrollers”, McGraw Hill International, USA, 2005.
4. Kenneth J. Aylala, “The 8051 Microcontroller, the Architecture and Programming Applications”, 2005.

REFERENCES:

1. Muhammad Ali Mazidi and Janice GillispicMazidi, “The 8051 Microcontroller and Embedded Systems”, Pearson Education, 2014.
2. Simon Monk, Programming the Raspberry Pi, Second Edition: Getting Started with Python McGraw Hill TAB; 2nd edition,2015

RA23403	MOTION CONTROL SYSTEMS	L	T	P	TCP
		3	0	2	4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

- To introduce the components and their representation of control systems
- To learn various methods for analysing the time response, frequency response and stability of the systems.
- To learn the various approach for the system frequency analysis
- To understand the concept of stability analysis
- To know about the state variable methods of control system analysis

UNIT – I SYSTEMS COMPONENTS AND REPRESENTATION 9

Control System: Terminology and Basic Structure-Feed Forward and Feedback Control Theory-Mechanical, Electrical, Thermal and Fluid System Transfer Function Models-Block Diagram Models-Signal Flow Graphs

UNIT – II TIME RESPONSE ANALYSIS 9

Transient Response- Steady State Response -Measures of Performance of the standard First Order and Second Order System - Effect on an Additional Zero and Pole- Steady Error Constant and System-Type Number- Concept of Stability - Routh Stability Criterion - Relative Stability - Root Locus Concept - Sketching and Analysis Root Locus - Nyquist Stability Criterion overview.

UNIT – III FREQUENCY RESPONSE AND SYSTEM ANALYSIS 9

Closed Loop Frequency Response - Performance Specification in Frequency Domain-Frequency Response of Standard Second Order System - Bode Plot - Sketching and Analysis, Polar Plot - Sketching and Analysis, Design of Compensators using Bode Plots and Root Locus- Analysis

UNIT – IV CONTROLLER DESIGN AND STATE SPACE MODELLING 9

Analog PID Controller Combination - Analytical Design for PD, PI, and PID Control Systems – Tuning - Modelling and Control Servomotors - State Space Modelling - Concepts of Controllability and Observability- Open Modelling

UNIT – V PLC AND MOTION CONTROLLERS 9

Overview of PID Architectures in PLC – Need for Motion Controllers- Architecture and Peripheral Feature of Motion Controllers, Communication Protocols – Overview of Codesys Platform - Software Environment and Standard Programming – Single and Multi Axis Motion Control for Robots and CNC Machines.

TOTAL: 45 PERIODS

LIST OF EXPERIMENTS

Ex. No	Name of the Experiments	Unit
1	Mathematical Modelling and Simulation of a Physical Systems andSimulation and Reduction of Cascade and Parallel, and Closed	1

	Loop Sub-System.	
2	Simulation and Analysis of First and Second Order System Equations in Time and Frequency Domain.	2
3	Simulation and Analysis of System using Root-Locus and Bode Plot.	2,3
4	Simulation and Implementation of PID Combination for First Order Systems.	4
5	Simulation and Implementation of PID Combination Second Order Systems.	4
6	Auto tuning of PID parameters and analysis of PID Control.	4
7	State Space Modelling	
8	Programming and control single and multi-axis motion control of servomotor.	5
9	Programming and control single and multi-axis motion control of using stepper motors.	5
10	Programming and control single and multi-axis motion control of DC servo with linear drives.	5

(Minimum 8 experiments)

TOTAL = 30 PERIODS

COURSE OUTCOMES

After completion the above subject, students will be able to

CO1: Describe the terminologies, definitions, and performance measures of the control system.

CO2: Identify the parameters of mathematical modelling of systems/ time and frequency domain methods for analysis.

CO3: Design control system representations, such as signal flow graphs, block diagrams, transfer functions, state space models, as well as apply stability analysis methods, compensators, and control methods.

CO4: Evaluate system modelling and stability, considering the accuracy and reliability of the models and analysing the stability characteristics of the control system.

CO5: Suggest the modelling and analytical methods, control technique and controller for the given applications.

Mapping of COs with POs and PSOs

COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	1	-	-	-	-	-	1	-	1	2	2	1
CO2	2	1	-	1	-	-	-	-	-	1	-	1	2	2	1
CO3	2	1	2	1	-	-	-	-	-	1	-	1	2	2	1
CO4	2	1	2	1	-	-	-	-	-	1	-	1	2	2	1
CO5	2	1	1	1	-	-	-	-	-	1	-	1	2	2	1
CO/PO & PSO Average	**2**	**1**	**1.6**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**2**	**1**

1 – Slight, 2 – Moderate, 3 – Substantial

TEXT BOOKS

1. Ogata, "Modern Control Engineering", Pearson Education India, 5th edition, 2015.
2. Norman. S. Nise, “Control Systems Engineering”, Wiley India edition, 2018.

REFERENCES:

1. Benjamin.C.Kuo, “Automatic Control Systems”, Prentice Hall of India, 9th Edition, 2014.
2. J.Nagrath and M.Gopal, “Control System Engineering”, New Age International Publishers, 5th Edition, 2021.
3. S.K.Bhattacharya, “Control System Engineering”, Pearson, 3rd Edition, 2013.
4. Nagoor Kani, “Control Systems”, RBA Publications, 2017.
5. Gary L. Pratt PE, “The Book of CODESYS: The ultimate guide to PLC and Industrial Controls programming with the CODESYS IDE and IEC 61131-3”,Control Sphere LLC; First Edition, 2021
6. https://www.codesys.com/

RA23404	DESIGN OF ROBOT ELEMENTS	L	T	P	TCP
		3	0	2	4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

- To introduce the students to the fundamentals of machine design, material selection and to solve the basic design problems.
- To learn to derive various parameters for modelling links and joints in a robot.
- To learn about Fundamentals of Computer Graphics
- To learn and understand curves and surfaces in robot modelling.
- To learn to derive various parameters for modelling end-effectors of a robot.

(Use of P S G Design Data Book permitted)

UNIT – I FUNDAMENTALS OF MECHANICAL DESIGN 9

Fundamentals of Machine Design-Engineering Design, Phases of Design, Design Consideration - Standards and Codes -Selection of Materials - Design against Static and Dynamic Load –Modes of Failure, Factor of Safety, Principal Stresses, Theories of Failure-Stress Concentration, Stress Concentration Factors, Variable Stress, Fatigue Failure, Endurance Limit, Design for Finite and Infinite Life, Soderberg and Goodman Criteria– Fundamentals of Safety- Mass and Centre of Gravity

UNIT – II DESIGN OF LINKS, JOINTS, BEARINGS AND GEARS 9

Loads and Forces on Links and Joints - Design of Solid and Hollow Shafts - Rigid and Flexible Couplings -Threaded Fasteners, Bearings– Terminologies, Standards and Types – Link Design: Path and Motion Synthesis – Cognate Linkages – Design of Spherical Joints, Gears - Terminologies, Standards, Types and Selection of Gears.

UNIT – III DESIGN OF GRIPPERS 9

Grippers – Types of Grippers Mechanisms – Gripping Methods – Gripping Force Analysis – Gripper Design – Two Finger Gripper – Three Finger Gripper – Magnetic Gripper Design – Vacuum Gripper Design – Hooks – Scoops – Spools – Miscellaneous Grippers.

UNIT – IV FUNDAMENTALS OF COMPUTER DESIGN 9

Introduction to CAD -Product Cycle- Design Process - Computer Aided Design – Computer Graphics– Co-ordinate Systems- 2D and 3D Transformations- Homogeneous Coordinates - Graphic Primitives (Point, Line, Circle Drawing Algorithms) – Clipping- Viewing Transformation.

UNIT – V CURVES AND MODELLING 9

Representation of Curves - Hermite Cubic Spline Curve, Bezier Curve, B-Spline Curves, Fundamentals of Solid Modelling, Different Solid Representation Schemes, Half - Spaces, Boundary Representation (B-rep), Constructive Solid Geometry (CSG), Sweep Representation, Analytic Solid Modeling, Perspective, Parallel Projection, Hidden Line Removal Algorithms - Assembly Modelling- CAD Approach for Link, Joint, Gear and Bearing, Gripper –– Motion Simulation

TOTAL: 45 PERIODS

LIST OF EXPERIMETS

Ex. No	Name of the Experiments	Unit
1	2D Sketch of a Gear.	2
2	2D Sketch and 3D modelling of Sheet Metal Components.	4,5
3	3D Modelling Mounting clamp for motor.	2
4	3D Modelling of GT2 pulley and belt drive system.	2
5	3D Modelling Ball Screw and Nut assembly.	2
6	3D Modelling and motion simulation of Rotational Joint assembly.	2
7	3D Modelling and motion simulation of Prismatic Joint assembly.	2
8	3D modelling and motion simulation of Cartesian Robot.	2
9	3D modelling and motion simulation of Articulated, Spherical, Cylindrical, SCARA Robot.	2
10	3D modelling and motion simulation of fingered gripper assembly.	3
11	Study on Design of Harmonic Gear drive for robot.	2

TOTAL = 30 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Visualize the concepts, constraints and terminologies behind the design and elements of robot.
CO2: Generalize the requirement for design of robot elements andstate parameters involved.
CO3: Design robot elements theoretically and using software tools, applying engineering principles and considering factors like structural integrity, motion capabilities, and interaction with the environment.
CO4: Model, assemble, and simulate the robot elements using software tools, evaluating their performance and behaviour under different conditions.
CO5: Develop and implement the designed robot and its models, showcasing the ability to translate theoretical designs into functional robotic systems.

Mapping of COs with POs and PSOs

COs/ Pos &PSOs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	1	1	-	-	-	-	-	1	-	1	2	2	1
CO2	2	1	2	1	-	-	-	-	-	1	-	1	2	2	1
CO3	2	1	2	1	-	-	-	-	-	1	-	1	2	2	1
CO4	1	1	2	1	2	-	-	-	-	1	-	1	2	2	1
CO5	1	1	2	2	2	-	-	-	-	1	-	1	2	2	1
CO/PO & PSO Average	**1.6**	**1**	**1.8**	**1.2**	**2**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Joseph Edward Shigley, Charles R. Mischke “Mechanical Engineering Design”, McGraw Hill, International Edition, 2008.
2. Sharma. C.S. and Kamlesh Purohit, “Design of Machine Elements”, Prentice Hall of India Private Limited, 2003
3. Ibrahim Zeid, “CAD/CAM theory and Practice”, Tata McGraw Hill, 2nd edition, 2009
4. Ashby. M.F., “Materials Selection in Mechanical Design”, Third edition, Butterworth- Heineman, New York, 16th edition, 2012

REFERENCES:

1. Bhandari. V.B., “Design of Machine Elements”, Tata McGraw-Hill Publishing Company Limited, fifth edition, 2020.
2. Robert L. Norton, “Machine Design – An Integrated Approach”, Pearson Pvt Ltd,Sixth Edition 2019.
3. Charles. J. A. and Crane. F. A. A, “Selection and Use of Engineering Materials”, second edition, Butterworth-Heinemann Ltd., 2rd edition 2013.
4. Kevin Otto, Kristin Wood, “Product Design”, Pearson Education, 2nd edition, 2013.
5. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2012.
6. Dragomir N. Nenchev, Atsushi Konno, TeppeiTsujita, “Humanoid Robots: Modelling and Control”, Butterworth-Heinemann, 2018
7. Zeid, I., CAD/CAM, McGraw Hill, 2008.
8. David Rogers, J. Alan Adams, "Mathematical Elements for Computer Graphics", McGraw Hill, 2nd edition, 1989

RA23405	THERMAL AND FLUID SYSTEMS	L	T	P	TCP
		2	0	2	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

- To impart knowledge of basic principles of thermodynamics via real world engineering examples
- To introduce various types of compressors and modes of heat transfer, related to real time scenarios of thermodynamics applied in engineering practice
- To learn about the types and basic properties of fluids.
- To impart basic knowledge of the dynamics of fluids and boundary layer concept.
- To study the working principles and calculate various parameters to evaluate the performance of a hydraulic pump system.

UNIT – I BASIC THERMODYNAMICS 6

Systems, Closed, Open and Isolated. Property, State, Path and Process, Quasi-Static Process, Zeroth Low, First Law. Steady Flow Energy Equation. Engineering Applications of Steady Flow Energy Equation. Second Law, Kelvin-Planck Statement – Clausius Statement – Concept of Entropy

UNIT – II COMPRESSORS 6

Classifications of Compressors, Single Stage and Multi Stage, Effect of Intercooler in Multi Stage Compressor, Perfect and Imperfect Intercooler, Work Done by the Compressor, Reciprocating, Rotary, Axial, Vane Compressors. Study of IC Engines, Heat Transfer, Modes of Heat Transfer.

UNIT – III BASIC EQUATIONS 6

Properties of Fluids – Fluid Statics - Pressure Measurements - Buoyancy and Floatation - Flow Characteristics- Concept of Control Volume and System - Reynold's Transportation Theorem - Continuity Equation, Energy Equation and Momentum Equation - Applications.

UNIT – IV FLOW THROUGH PIPES AND BOUNDARY LAYER 6

Flow Measurement, Orifice meter, Venturimeter and Pitot Tube-Reynold's Experiment - Laminar Flow Through Circular Conduits - Darcy Weisbach Equation - Friction Factor - Moody Diagram - Major and Minor Losses - Hydraulic and Energy Gradient Lines - Pipes in Series and Parallel - Boundary Layer Concepts - Types of Boundary Layer Thickness.

UNIT – V PUMPS 6

Classification of pumps - Centrifugal pumps - Working principle - Heads and Efficiencies– Velocity triangles - Work Done by The Impeller - Performance Curves - Reciprocating Pump Working Principle - Indicator Diagram and it's Variations - Work Saved by Fitting Air Vessels - Rotary Pumps.

TOTAL: 30 PERIODS

LIST OF EXPERIMENTS

Ex. No	Name of the Experiments	Unit
1	Draw the Valve timing diagram and Port timing diagram.	2
2	Determination of flash point, fire point and viscosity of lubricating oil.	2
3	Performance test on multi stage reciprocating air compressor.	2
4	Determination of Conduction, Convection and Radiation constants.	2
5	Performance test on vapour compression system.	2
6	Determine the coefficient of discharge using Flow through Venturimeter.	3
7	Determination of Flow through pipe losses (Major and Minor Losses).	4
8	Conduct the performance test for Centrifugal pump.	5
9	Conduct the performance test for Reciprocating pump.	5
10	Conduct the performance characteristics of Francis turbine.	5

Any 7 experiments

TOTAL: 30 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Describe the concepts in thermodynamics.
CO2: Interpret the working of thermal systems.
CO3: Exhibit the basic understanding on fluid properties and fluid statics.
CO4: Analyze laminar and turbulent flow problems.
CO5: Acquire knowledge on the various types of fluid machines.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	2	1	1	-	-	-	-	-	1	-	1	1	1	1
CO2	2	2	1	1	-	-	-	-	-	1	-	1	1	1	1
CO3	2	2	1	1	-	-	-	-	-	1	-	1	2	1	1
CO4	2	2	1	1	-	-	-	-	-	1	-	1	1	1	1
CO5	2	2	1	1	-	-	-	-	-	1	-	1	1	1	1
CO/PO & PSO Average	2	2	1	1	**-**	-	-	**-**	**-**	**1**	**-**	1	1.2	1	1
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Nag. P.K., “Engineering Thermodynamics”, Tata McGraw-Hill, New Delhi, 2017.
2. Modi P.N. and Seth, S.M. Hydraulics and Fluid Mechanics, Standard Book House, New Delhi, 22nd edition, 2019.

REFERENCES

1. Arora C.P, “Thermodynamics”, Tata McGraw-Hill, New Delhi, 2017.
2. Ramalingam K.K. “Thermodynamics”, Sci-Tech Publications, 2009.
3. Pani B S, Fluid Mechanics: A Concise Introduction, Prentice Hall of India Private Ltd, 2016.
4. Ramamurtham. S, Hydraulics, Fluid Mechanics and Fluid Machines, Dhanpat Rai Publishing Co Pvt.,9th edition, 2014.

UC23U01 **UNIVERSAL HUMAN VALUES** **L T P C**
1 0 2 2

COURSE OBJECTIVE:

The objective of the course is four-fold:

1. Development of a holistic perspective based on self-exploration about themselves (human being), family, society and nature/existence.
2. Understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence
3. Strengthening of self-reflection.
4. Development of commitment and courage to act.

MODULE I: INTRODUCTION **(3L,6P)**

Purpose and motivation for the course, recapitulation from Universal Human Values-I, Self-Exploration– Its content and process; 'Natural acceptance' and Experiential Validation- as the process for self-exploration Continuous Happiness and Prosperity- A look at basic Human Aspirations Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario, Method to fulfil the above human aspirations: understanding and living in harmony at various levels.

Practical Session: *Include sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking*

MODULE II: HARMONY IN THE HUMAN BEING **(3L,6P)**

Understanding human being as a co-existence of the sentient 'I' and the material 'Body', Understanding the needs of Self ('I') and 'Body' - happiness and physical facility, Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer), Understanding the characteristics and activities of 'I' and harmony in 'I', Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail, Programs to ensure Sanyam and Health.

Practical Session: *Include sessions to discuss the role others have played in making material goods available to me. Identifying from one's own life. Differentiate between prosperity and accumulation. Discuss program for ensuring health vs dealing with disease.*

MODULE III: HARMONY IN THE FAMILY AND SOCIETY **(3L,6P)**

Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship, Understanding the meaning of Trust; Difference between intention and competence, Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship, Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals, Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.

***Practical Session**: Include sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives*

MODULE IV: HARMONY IN THE NATURE AND EXISTENCE (3L,6P)

Understanding the harmony in the Nature, Interconnectedness and mutual fulfilment among the four orders of nature- recyclability and self regulation in nature, Understanding Existence as Co-existence of mutually interacting units in all- pervasive space, Holistic perception of harmony at all levels of existence.

***Practical Session:** Include sessions to discuss human being as cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.*

MODULE V: IMPLICATIONS OF HARMONY ON PROFESSIONAL ETHICS (3L,6P)

Natural acceptance of human values, Definitiveness of Ethical Human Conduct, Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order, Competence in professional ethics: a. Ability to utilize the professional competence for augmenting universal human order b. Ability to identify the scope and characteristics of people friendly and eco-friendly production systems, c. Ability to identify and develop appropriate technologies and management patterns for above production systems. Case studies of typical holistic technologies, management models and production systems, Strategy for transition from the present state to Universal Human Order: a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers b. At the level of society: as mutually enriching institutions and organizations, Sum up.

***Practical Session:** Include Exercises and Case Studies will be taken up in Sessions E.g. To discuss the conduct as an engineer or scientist etc.*

TOTAL: 45 (15 Lectures + 30 Practicals) PERIODS

COURSE OUTCOME:

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

1. Become more aware of themselves, and their surroundings (family, society, nature);
2. Have more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind.
3. Have better critical ability.
4. Become sensitive to their commitment towards what they have understood (human values, human relationship and human society).
5. Apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.

REFERENCES:

1. Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 3rd revised edition, 2023.
2. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
3. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.

4. The Story of Stuff (Book).
5. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
6. Small is Beautiful - E. F Schumacher.
7. Slow is Beautiful - Cecile Andrews.
8. Economy of Permanence - J C Kumarappa
9. Bharat Mein Angreji Raj - PanditSunderlal
10. Rediscovering India - by Dharampal
11. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
12. India Wins Freedom - Maulana Abdul Kalam Azad
13. Vivekananda - Romain Rolland (English)
14. Gandhi - Romain Rolland (English)

Web URLs:

1. Class preparations: https://fdp-si.aicte-india.org/UHV-II%20Class%20Note.php
2. Lecture presentations: https://fdp-si.aicte-india.org/UHV-II_Lectures_PPTs.php
3. Practice and Tutorial Sessions: https://fdp-si.aicte-india.org/UHV-II%20Practice%20Sessions.php

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						1	1	1	3			3
CO2						1	1	1	3			3
CO3						3	3	2	3		1	3
CO4						3	3	2	3		1	3
CO5						3	3	3	3		2	3

RA23501	MANUFACTURING SYSTEMS AND PROCESS	L	T	P	TCP
		2	0	2	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

- To learn about casting process and its classifications
- To learn about welding process.
- To learn about various Machining process
- To learn about forming and shaping of plastics.
- To learn about metal forming and powder metallurgy

UNIT – I CASTING **6**

Casting Types, Procedure to Make Sand Mould, Types of Core Making, Moulding Tools, Machine Moulding, Special Moulding Processes - Investment Mounding, Pressure Die Casting, Casting Defects.

UNIT – II WELDING **6**

Classification of Welding Processes. Principles of Gas Welding, Arc Welding and its types, Resistance Welding, Defects in Welding.

UNIT – III MACHINING **6**

General Principles (With Schematic Diagrams Only) of Working and Commonly Performed Operations in the Following Machines: Lathe, Milling, Drilling, Grinding. Basics of CNC Machines and CNC Programming.

UNIT – IV MOULDING OF PLASTICS **6**

Characteristics of The Forming and Shaping Processes for Plastics – Moulding of Thermoplastics – Working Principles and Typical Applications of - Injection Moulding– Blow Moulding – Rotational Moulding – Film Blowing – Extrusion - Typical Industrial Applications – Processing of Thermosets– Bonding of Thermoplastics.

UNIT – V METAL FORMING AND POWDER METALLURGY **6**

Principles and Applications of the Following Processes: Forging, Rolling, Extrusion, Wire Drawing and Spinning- Introduction to Additive Manufacturing

TOTAL: 30 PERIODS

LIST OF EXPERIMETS

Ex. No	Name of the Experiments	Unit
1	Fabricating simple structural shapes using Gas Metal Arc Welding machine.	2
2	Preparing green sand moulds with cast patterns.	1
3	Casting aluminium parts using stir casting machine.	1
4	Reducing the thickness of the plates using rolling machine.	5
5	Reducing the diameter of on circular parts using wire drawing process machine.	5
6	Taper Turning and Eccentric Turning on circular parts using lathe machine.	3

7	Shaping – Square and Hexagonal Heads on circular parts using shaper machine.	4
8	Milling contours on plates using vertical milling machine.	4
9	Generating gears using gear hobbing machine.	4
10	Grinding components using cylindrical, surface and centreless grinding machine.	4

(Any 7 experiments)

TOTAL = 30 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Identifythe concepts casting, welding, machining, forming and powder metallurgy process
CO2: Describe the working of various manufacturing process.
CO3: Illustrate the construction and working mechanisms of manufacturing equipment used in different processes, highlighting their key components and functionalities.
CO4: Evaluate the performance of each manufacturing process.
CO5: Analyze and recommend the suitable manufacturing process for a given component, taking into account the component's specifications, material properties, production requirements, and other relevant factors.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	1	-	1	-	-	-	-	-	1	-	1	2	1	1
CO2	3	2	1	1	-	-	-	-	-	1	-	1	2	1	1
CO3	3	2	1	1	-	-	-	-	-	1	-	1	2	1	1
CO4	3	2	-	1	-	-	-	-	-	1	-	1	2	1	1
CO5	3	2	1	1	-	-	-	-	-	1	-	1	2	1	1
CO/PO & PSO Average	**3**	**1.8**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Hajra Choudhury, “Elements of Workshop Technology”, Vol. I and II, Media Promoters and Publishers Pvt., Ltd., Mumbai, 2010.
2. Nagendra Parashar B.S. and Mittal R.K., “Elements of Manufacturing Processes”, Prentice-Hall of India Private Limited, 2012.

REFERENCES:

1. Adithan. M and Gupta. A.B., “Manufacturing Technology”, New Age, 2007.
2. “H.M.T. Production Technology – Handbook”, Tata McGraw-Hill, 2017.
3. Jain. R.K. and S.C. Gupta, “Production Technology”, Khanna Publishers. 16th Edition, 2012.
4. Roy. A. Linberg, “Process and Materials of Manufacture”, PHI, 2015.
5. Serope Kalpajian, Steven R.Schmid, “Manufacturing Processes for Engineering Materials”, Fourth Edition, Pearson Education, Inc. 2018.

RA23C02	INDUSTRIAL AUTOMATION	L	T	P	TCP
		3	0	2	4

COURSE OBJECTIVES:

- To Understand the need of automation in industry
- To Identify suitable industrial automation hardware for given application
- To Apply the program logic controller for automation
- To Understand the operation structure and material handling in total Integrated automation system
- To Design, model and analyse the plant model suitable for digital manufacturing

UNIT I AUTOMATION OVERVIEW AND PLC **9**

Automation Overview, Types of Industrial Automation, Requirement of Automation Systems, Architecture of Industrial Automation System, PLC Architecture, Memory, PLC Programming languages, Input and Output Modules, Timer and Counter, IEC Standards, Ladder programming

UNIT II INPUT DEVICES **9**

Input Types and Standards - Analog and Digital Signals - Voltage and Control Inputs - Sensors used for Industrial Automation –Interfacing of Pressure Sensor, Temperature Sensor, Flow Sensor, Level Sensor, Force, Speed and Displacement Sensor –Proximity Sensor- Man-Machine Interfaces.

UNIT III OUTPUT DEVICES AND DATA COMMUNICATION **9**

Relays and Transistors – Heaters, Valves - Hydraulic and Pneumatics, Electric Motors - Industrial Data Communications - Fiber Optics – Modbus: RS232, RS485, RS422 – HART – Device Net – Profibus – Fieldbus – Ethernet, Profinet - Ethernet IP/TCP - EtherCAT-CAN- wireless protocols - WiFi

UNIT IV SUPERVISORY CONTROL **9**

Introduction to Supervisory Control Systems – SCADA - Distributed Control System (DCS) – Safety Systems – DCS - Network Management - Process Control Systems – Case Studies and Programming,

UNIT V PLANT DESIGN AND SIMULATION **9**

Plant Layout - Plant Design - Plant Simulation - Basics and Modelling - Attributes for Plant Control and Statistics - Industry Versions 3.0, 4.0 and 5.0 - Smart Factories - Digital Twin - Programming Case Studies of PLC.

TOTAL :45 PERIODS

LIST OF EXPERIMENTS

Ex. No	Name of the Experiments	Unit
1	Design a Ladder Logic Program for various Logic Gates AND, OR, NOT, NOR, NAND, EX-OR and EX-NOR.	1
2	Develop Ladder Diagram Programming to set Timer and Counter in PLC.	1
3	Develop PLC Program to Control Traffic Light.	2,3,4,5
4	Develop PLC Program to Maintain the Pressure and Level in a Bottle Filling System.	2,3,4,5
5	Develop Ladder Diagram Program in PLC For Material Filling, Object Shorting, Orientation Check and Material Property Check.	2,3,4,5

6	Develop the Ladder Diagram Program in PLC for Material Handling, Delaying Conveyor, Feeding, Pick and Place Operation.	2,3,4,5
7	Sensor and Actuator Interfacing in PLC and PLC to PLC Communication.	2,3,4,5
8	HMI GUI design and linking tags	4

TOTAL = 30 PERIODS

COURSE OUTCOMES:

Upon successful completion of the course, students should be able to:

CO1: State the fundamentals of automation includingPLC, I/Os, communication protocols and simulation.
CO2: Describe the architecture, input/outputs, communication systems and programming languages.
CO3: Interface the input and output devices to PLC.
CO4: Program a PLC for various applications, utilizing appropriate programming languages and techniques.
CO5: Simulate and analyze PLC programming and models for plant design, evaluating their performance and functionality.

Mapping of COs with POs and PSOs

COs/POs & PSOs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	1	1	-	-	-	-	-	1	-	1	2	1	1
CO2	2	1	1	1	-	-	-	-	-	1	-	1	2	2	1
CO3	1	1	1	1	-	-	-	-	-	1	-	1	2	1	1
CO4	1	2	1	2	-	-	-	-	-	1	-	1	2	2	1
CO5	1	2	1	2	-	-	-	-	-	1	-	1	2	1	2
CO/PO & PSO Average	**1.4**	**1.4**	**1**	**1.4**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**1.4**	**1.2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS:

1. Richard L.Shell, Ernest L.Hall., “Handbook of Industrial Automation”, Marcel Dekker Inc, 2000.
2. Frank D, Petruzella, “Programmable Logic Controller” McGraw – Hill Publications, 2016.

REFERENCES:

1. Tan Kok Kiong, Andi Sudjana Putra., “Drives and Control for Industrial Automation”, Advances in Industrial Control, Springer, 2011.
2. Mackay S., Wrijut E., Reynders D. and Park J., “Practical Industrial Data Networks Design,Installation and Troubleshooting”, Newnes Publication - Elsevier, 2004.
3. Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, APress, 2016.
4. Rajput R.K. Robotics and Industrial Automation, S Chand Publishing, revised edition, 2008.

RA23502	AUTONOMOUS MOBILE ROBOTS	L	T	P	TCP
		2	0	2	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

- To introduce mobile robotic technology and its types in detail.
- To learn the kinematics of wheeled and legged robot.
- To familiarize the intelligence into the mobile robots using various sensors.
- To acquaint the localization strategies and mapping technique for mobile robot.
- To aware the collaborative mobile robotics in task planning, navigation and intelligence.

UNIT – I INTRODUCTION TO MOBILE ROBOTICS 6

Introduction – Locomotion of the Robots – Key Issues on Locomotion – Legged Mobile Roots – Configurations and Stability – Wheeled Mobile Robots – Design Space and Mobility Issues – Unmanned Aerial and Underwater Vehicles – Teleportation and Control – Autonomous Mobile Robot-UAV.

UNIT – II KINEMATICS 6

Kinematic Models – Representation of Robot – Forward Kinematics – Wheel and Robot Constraints – Degree of Mobility and Steerability – Manoeuvrability – Workspace – Degrees of Freedom – Path and Trajectory Considerations – Motion Controls – Holonomic -Non Holonomic Robots – Open Loop and Feedback Motion Control – Humanoid Robot - Kinematics Overview.

UNIT – III PERCEPTION 6

Sensor for Mobile Robots – Classification and Performance Characterization – Wheel/Motor Sensors – Heading Sensors – Ground-Based Beacons - Active Ranging - Motion/Speed Sensors – Vision Based Sensors – Uncertainty - Statistical Representation - Error Propagation - Feature Extraction Based on Range Data (Laser, Ultrasonic, Vision-Based Ranging) - Visual Appearance based Feature Extraction.

UNIT – IV LOCALIZATION 6

The Challenge of Localization - Sensor Noise and Aliasing - Effector Noise – Localization Based Navigation Versus Programmed Solutions - Belief Representation – Single - Hypothesis Belief And Multiple-Hypothesis Belief - Map Representation - Continuous Representations - Decomposition Strategies - Current Challenges In Map Representation - Probabilistic Map- Based Localization - Markov Localization - Kalman Filter Localization - Landmark-Based Navigation- Indoor Navigation and Control - Globally Unique Localization - Positioning Beacon Systems - Route-Based Localization - Autonomous Map Building - Stochastic Map Technique - Simultaneous Localization and Mapping (SLAM)- Other Mapping Techniques.

UNIT – V NATURALLY INSPIRED ROBOTICS 6

Introduction - Competences for Navigation: Planning and Reacting - Path Planning - Obstacle Avoidance - Navigation Architectures - Modularity for Code Reuse and Sharing - Control Localization - Techniques for Decomposition - Case Studies – Collaborative Robots – Swarm Robots.

TOTAL: 30 PERIODS

LIST OF MINI PROJECTS

Ex. No	List of Projects
1	Modelling, simulation and control of wheeled robot real time and in ROS/ any other platform.
2	Modelling and simulation of SWARM robotsin ROS/ any other platform
3	Design and simulation of Industry standard automated guided vehicle.
4	Design and simulation of Industry standard autonomous mobile robot.
6	Design, development, and realization of line following robot.
7	Design and development of obstacle avoidance robot using sensors.
8	Design and development of vision based autonomous robot navigation.
9	Design and development of LIDAR based autonomous robot navigation.
10	Design and development of legged robots.

Students with 3 member team has to undergo any of the projects and problem statement must be accepted by course instructor. The evaluation through internal mode with periodic review of presentation and report.

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Reproduce the foundations of concepts of mobile robotics construction, localization and navigation

CO2: Express the hardware and software relevant features ofrobotics.

CO3: Deploy the perception, localization and navigation techniques inthe context of mobile robots.

CO4: Demonstrate the architecture, control and algorithms for mobile robotics.

CO5: Evaluate the hardware components, planning and navigation algorithms, and the use of bio-inspired techniques in mobile robotics.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	1	1	1	-	-	-	-	1	-	1	2	1	1
CO2	2	2	1	1	2	-	-	-	-	1	-	1	2	2	1
CO3	2	1	1	1	1	-	-	-	-	1	-	1	2	1	1
CO4	2	1	1	1	1	-	-	-	-	1	-	1	2	1	1
CO5	2	2	1	1	1	-	-	-	-	1	-	1	2	1	1
CO/PO & PSO Average	**2**	**1.4**	**1**	**1**	**1.2**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**1.2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Roland Siegwart and IllahR.Nourbakish, “Introduction to Autonomous Mobile Robots” MIT Press, Cambridge, 2011.
2. Dragomir N. Nenchev, Atsushi Konno, TeppeiTsujita, “Humanoid Robots: Modelling and Control”, Butterworth-Heinemann, 2018

REFERENCES:

1. Mohanta Jagadish Chandra, “Introduction to Mobile Robots Navigation”, LAP Lambert Academic Publishing, 2015.
2. Peter Corke, “Robotics, Vision and Control”, Springer, 2017.
3. Ulrich Nehmzow, “Mobile Robotics: A Practical Introduction”, Springer, 2012.
4. Xiao Qi Chen, Y.Q. Chen and J.G. Chase, “Mobile Robots - State of the Art in Land, Sea, Air, and Collaborative Missions”, Intec Press, 2009.
5. Alonzo Kelly, Mobile Robotics: Mathematics, Models, and Methods, Cambridge University Press, 2013, ISBN: 978-1107031159.

RA23503	ROBOT DYNAMICS AND CONTROL	L	T	P	TCP
		3	0	2	4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

- To learn and understand generalized co-ordinates, Jacobian matrix Mass Distribution and other fundamental equations.
- To understand Lagrangean and Hamiltonian mechanics
- To understand nonlinearities in control system
- To Understand various force control strategies
- To understand various concepts in linearizing a no linear signal

UNIT – I ROBOT STATICS 9

Generalized Co-ordinates - Generalized Forces - Equation of Motions – Static Forces in Manipulators - Jacobian Matrix - Jacobians in the Force Domain - Cartesian Transformation of Velocities and Static Forces - Acceleration of a Rigid Body - Mass Distribution –Non-Rigid Body Effects - Newton's Equation - Euler's Equation – Langrage Equation.

UNIT – II ROBOT DYNAMICS 9

General Expressions for Kinetic and Potential Energy - Kinetic Energy for an N-Link Robot - Potential Energy for an N-Link Robot - Equations of Motion - Lagrangean Multiplier - Langrage's Equation - Hamilton Equation - Hamilton Vector Field- Euler - Lagrange Equation – State Vector and Equation Formulation.

UNIT – III ROBOT CONTROL SYSTEM 9

The Manipulator Control Problem, Linear Second-Order Model of Manipulator. Functions of Controller and Power Amplifier. Joint Actuators- Stepper Motor, Servo Motor. Control Schemes: PID Control Scheme – Position and Force Control Schemes. Robotic Sensors and its Classification, Internal Sensors – Position, Velocity, Acceleration and Force Information, External Sensors – Contact Sensors-Limit Switches, Piezoelectric, Pressure Pads, Non-Contact Sensors – Range Sensors, Vision Sensor-Robotic Vision System, Description of Components of Vision System.

UNIT – IV CONTROL OF MANIPULATORS 9

Linear Time Varying and Linearization – Input and Output Stability - Background: The Frobenius Theorem –Single-Input Systems. Introduction to Nonlinear System – Time Varying Systems - Multi-Input, Multi-Output Control Systems - The Control Problem for Manipulators - Practical Considerations - Current Industrial-Robot Control Systems - Lyapunov Stability Analysis – Cartesian - Based Control Systems - Adaptive Control - Limit Cycle - Describing Function.

UNIT – V FORCE CONTROL 9

Constrained Dynamics - Static Force/Torque Relationships - Constraint Surfaces - Natural and Artificial Constraints - Network Models and Impedance - Impedance Operators - Classification of Impedance Operators - Force Control Strategies - Impedance Control - Hybrid Impedance Control – PID controllers

TOTAL: 45 PERIODS

LIST OF EXPERIMETS

Ex. No	Name of the Experiments	Unit
1	Forward Dynamics of 2R planar robot	1,2
2	Inverse Dynamics of 2R planar robot	1,2
3	forward Dynamic Analysis of 3/6 DOF robot	1,2
4	Inverse Dynamic Analysis of 3/6 DOF robot	1,2
5	Simulation of PID/ other controller realization for 1 DOF robot stabilization	3,4,5
6	Simulation of PID/ other controller realization for 2 DOF robot stabilization	3,4,5
7	Simulation of PID/ other controller realization for 3 DOF robot stabilization	3,4,5
8	Simulation of PID/ other controller realization for with disturbance rejection.	3,4,5

TOTAL = 30 PERIODS

COURSE OUTCOMES

Upon the completion of this course, the students will be able to;

CO1: State the generalized concepts, methods in dynamics and control of robot.
CO2: Describe the methods in dynamics and control of robot.
CO3: Develop the dynamic and control model of the manipulator.
CO4: Analyse the parameters and linear and nonlinearities in the dynamics of the manipulator.
CO5: Evaluate dynamics and control methods and responses of the manipulator.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	1	1	-	-	-	-	-	-	-	1	2	1	1
CO2	2	1	1	1	-	-	-	-	-	-	-	1	2	1	1
CO3	2	1	1	1	-	-	-	-	-	-	-	1	2	1	1
CO4	2	3	1	1	-	-	-	-	-	-	-	1	2	1	1
CO5	2	3	2	1	-	-	-	-	-	-	-	1	2	1	1
CO/PO & PSO Average	**2**	**1.8**	**1.2**	**1**	-	-	-	-	-	-	-	**1**	**2**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Mark W. Spong, Seth Hutchinson, M. Vidyasagar.," Robot modeling and control" 2nd Edition, 2020
2. John J. Craig, "Introduction to Robotics – Mechanics and control", 3rd Edition, Prentice hall, 2022.
3. Groover. M.P., Weis. M., Nagel. R.N. and Odrey.N.G. "Industrial Robotics Technology, Programming and Applications", 2nd edition McGraw-Hill, Int., 2017.

REFERENCES:

1. K.S.Fu, Gonzalez, R.C. and Lee, C.S.G. “Robotics Control, Sensing, Vision and Intelligence”, McGraw Hill, 1987.
2. Saeed B. Niku, “Introduction to Robotics: Analysis, Control, Applications”, 2nd edition, John Wiley & sons, Inc., 2020
3. Klafter. R.D., Chmielewski, T.A. and Negin. M. “Robotics Engineering – An Integrated Approach”, Prentice-Hall of India Pvt. Ltd., 2006.

RA23504	FLUID POWER AUTOMATION	L	T	P	TCP
		3	0	2	4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

- To understand the basic principles of fluid power.
- To Know the different properties of hydraulic fluids and their effects
- To Explain the working principles of various pumps
- To understand the working principle of hydraulic and pneumatic components and its selection.
- To design hydraulic and pneumatic circuits for different applications.

UNIT – I BASICS OF FLUID POWER TECHNOLOGY 9

Introduction to Fluid Power Controls – Hydraulics and Pneumatics – Selection Criteria, Application of Fluid Power, Application of Pascal's Law, Transmission and Multiplication of Force – Pressure Losses – Fluids, Selection and Properties – Gas Laws- Properties of Air with Pressure and Temperature - ISO Symbols.

UNIT – II FLUID POWER SOURCES 9

Fluid Power Drives – Pumps – Working Principle and Construction Details of Gear, Vane and Piston Pumps, Hydraulic Motors, Hydrostatic Transmission Drives and Characteristics, Hydraulic Supply Components Pneumatic Power Supply – Compressors, Air Distribution, FRL Unit, Air Motors.

UNIT – III FLUID POWER ACTUATORS AND ELEMENTS 9

Control Valves – Pressure, Flow, and Direction - Working Principle and Construction – Special Type - Valves – Cartridge, Modular, Proportional, and Servo Selection and Actuation Methods. Actuators – Selection and Specification, Cylinders, Mounting, Cushioning, Pipe Fittings – Fluid Conditioning Elements – Accumulators- Intensifier.

UNIT – IV HYDRAULIC AND PNEUMATIC CIRCUITS DESIGN 9

Regenerative, Speed Control, Synchronizing Circuits - Design of Hydraulic and Pneumatic Circuits for Automation, Selection and Specification of Circuit Components, Sequencing Circuits, Cascade, And Karnaugh – Veitch Map Method – Circuits for Industrial Application - Case Studies - Grinding, Milling, Shaping, Press and Material Handling

UNIT – V ELECTRO PNEUMATICS AND PLC CIRCUITS 9

Fluidics -Moving Part Logic Circuits - Use of Electrical Timers, Switches, Solenoid, Relays, Proximity Sensors - Electro and Hydro Pneumatics Sequencing Ladder Diagram – PLC – Elements, Functions and Selection – PLC Programming– Ladder and Different Programming Methods - Sequencing Circuits.

TOTAL: 45 PERIODS

LIST OF EXPERIMENTS

Ex. No	Name of the Experiments	Unit
1	Verification of Speed Control Circuits in Pneumatic and Hydraulic circuits.	
2	Verification of Single and Double Acting Cylinder Circuits using Different Directional Control Values.	

3	Experimental Verification of Electro-Pneumatic Circuits.	
4	Experimental Verification of Pneumatic Sequencing Circuits.	
5	Experimental Verification of Logic, Metre-in and Metre-out Pneumatic Circuits.	
6	Experimental Verification of Electro Pneumatic Sequencing Circuits.	
7	Control of PLC Based Electro Pneumatic Sequencing Circuits.	
8	Control of PLC Based Electro Hydraulic Sequencing Circuits.	

(Any 7 Experiments)

TOTAL: 30 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Identify thesymbols, laws and elements of fluid power devices.

CO2: Describe the working of pump, actuators, control elements of fluid power system

CO3: Design the basic and advanced hydraulic and pneumatics circuits.

CO4: Develop the basic, electro pneumatics and hydraulic, PLC integrated circuits for various application including material handling, press, shaping, milling, grinding.

CO5: Appraise the design and working of fluid power circuits.

Mapping of COs with POs and PSOs

COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	1	-	-	-	-	-	1	-	1	2	1	1
CO2	2	-	-	1	-	-	-	-	-	1	-	1	2	1	1
CO3	2	-	2	1	-	-	-	-	-	1	-	1	2	1	1
CO4	2	-	1	1	-	-	-	-	-	1	-	1	2	1	1
CO5	2	-	2	1	-	-	-	-	-	1	-	1	2	1	1
CO/PO & PSO Average	**2**	**-**	**1.6**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Anthony Esposito, “Fluid power with applications”, Pearson education, 7th edition, 2014.
2. Srinivasan R, “Hydraulic and Pneumatic Controls”, Vijay Nicole Imprints, 3rd edition, 2017.

REFERENCES:

1. Andrew Parr, “Hydraulics and Pneumatics”, Jaico Publishing House, 3rd edition, 2013.
2. Jagadeesha T, "Pneumatics:Concepts, Design and Applications", University Press, 2015.
3. Majumdar, “Oil hydraulics: Principles and Maintenance”, Tata McGraw Hill, 13th edition, 2006.
4. Majumdar, “Pneumatic system: Principles and Maintenance”, Tata McGraw Hill, 7th edition 2008.
5. Peter Rohner, “Fluid Power Logic circuit Design”, Macmillan Press Ltd., 2000.
6. Vickers, “Industrial Hydraulics Manual”, Eaton Hydraulics Training, 5th edition, 2006.

RA23D01	CAPSTONE DESIGN PROJECT - I	L	T	P	TCP
		0	0	12	6

COURSE OBJECTIVES

The main learning objective of this course is to prepare the students to

- Develop a basic understanding of engineering design principles of robots and automated systems.
- Apply elementary problem-solving techniques to address fundamental engineering challenges.
- Function effectively in a team setting, fostering collaboration and communication skills.
- Utilize basic research methodologies to generate and evaluate simple design alternatives.
- Understand and consider basic practical constraints, such as cost, time, and materials, in design solutions.

Evaluation

In lower-level Capstone projects, students are expected to build foundational skills in engineering design and teamwork. They conduct basic research and develop a simple project proposal with clear objectives, obtaining faculty approval. Teams are formed based on shared interests, and students work collaboratively, applying basic engineering principles to define problems and generate simple design solutions.

- The projects involve elementary research and design methodologies, formulation of clear problem statements, and development of basic specifications.
- Demonstrate design and simulation models.
- Fabricate and integrate mechanical, electrical, electronics, and control elements for first principle concepts prototypes.
- Students are introduced to practical constraints such as cost, materials, and time, while beginning to consider safety, usability, and feasibility.
- Documentation and presentation skills are emphasized through the preparation of reports and project summaries.

Additionally, students engage in teamwork, understanding the importance of diversity, equity, inclusion, and belonging in collaborative settings. If applicable, they interact with external clients to understand and respond to basic project requirements. These activities provide a strong foundation for more complex projects in higher semesters.

TOTAL = 60 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

1. Demonstrate foundational knowledge of engineering design principles, including problem definition and solution formulation, and apply them to generate simple design alternatives.
2. Conduct basic research and design methodologies to inform project proposals and design solutions, including formulation of problem statements and specifications.
3. Demonstrate the problem statements as prototype projects
4. Function effectively as part of a team, demonstrating collaboration and communication skills, and contribute to team decision-making processes.
5. Understand and incorporate practical constraints such as budget, materials, time, safety, usability, and feasibility into design solutions.
6. Prepare and present a detailed report and project summary, demonstrating documentation and presentation skills.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO/PO & PSO Average															
1 – Slight, 2 – Moderate, 3 – Substantial															

ROXXXX	SENSORS AND SIGNAL CONDITIONING	L	T	P	TCP
		3	0	2	4

COURSE OBJECTIVES

- To comprehend the concepts of sensors and measurement technology.
- To learn the various motion, proximity and ranging sensors
- To learn the various Force, Magnetic and Heading Sensors
- To learn the various Optical, Pressure and Temperature Sensors.
- To learn the fundamentals of signal conditioning, data acquisition and communication systems used in mechatronics system development**.**

UNIT – I INTRODUCTION 9

Basics of Measurement – Classification of Errors – Error Analysis – Static and Dynamic Characteristics of Transducers – Classification of Sensors – Sensor Calibration Techniques – Sensor Output Signal Types.

UNIT – II MOTION, PROXIMITY AND RANGING SENSORS 9

Proximity Sensors- Types, Motion Sensors – Potentiometers, Resolver, Encoders – Optical, Magnetic and Inductive, LVDT – RVDT – Synchro – Microsyn, Accelerometer,GPS, Range Sensors – Ultrasonic Ranging, IR Sensor, LIDAR.

UNIT – III FORCE, MAGNETIC AND HEADING SENSORS 9

Strain Gauge, Load Cell, Magnetic Sensors –Types, Principle, Requirement and Advantages: Magneto Resistive – Hall Effect – Current Sensor - Heading Sensors –Compass, Gyroscope and IMU, Inclinometers.

UNIT – IV OPTICAL, PRESSURE AND TEMPERATURE SENSORS 9

Photo Conductive Cell, Photo Voltaic cell, LDR – Fiber Optic Sensors – Pressure Diaphragm, Bellows, Piezoelectric – Tactile Sensors, Temperature – IC sensor, Thermistor, RTD, Thermocouple and IR Temperature sensor and camera. Acoustic Sensors, Flow and Level Measurement, Smart Sensors - Film Sensor, MEMS & Nano Sensors.

UNIT – V SIGNAL CONDITIONING AND DATA ACQUISITION 9

Bridge Circuits - Amplification – Analog Filters – Sample and Hold Circuits – A/D Conversation - Data Acquisition: Single Channel and Multi-Channel Data Acquisition – Signal Characteristics – Data Logging – Signal Processing Technique overview –Case Studies in Sensors and Transducers in Robotics, Manufacturing, Automobile, Aerospace, Home Automation, and Environmental Monitoring.

TOTAL: 45 PERIODS

LIST OF EXPERIMENTS

Ex. No	Name of the Experiments	Unit
1	Speed, Position and Direction Measurement Using Encoders.	
2	Determination of Load, Torque and Force using Strain Gauge.	3
3	Determination of the characteristics of Pressure Sensor and Piezoelectric Force Sensor.	4
4	Determination of Displacement using LVDT.	2
5	Determine the Characteristics of Various Temperature Sensors.	4
6	Determine the Characteristics of Various Light Detectors (OpticalSensors).	4
7	Distance Measurement using Ultrasonic and Laser Sensor	2
8	Determine angular velocity of gyroscope	3
9	Vibration measurement using Accelerometer.	2
10	Direction measurement using Magnetometer.	3
11	Force measurement using 3 axis force sensor.	3
12	Force Measurement using tactile sensors.	3
13	Data acquisition, visualization and analysis of signals.	5

(Any 8 experiments)

TOTAL = 30 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Identify the terminologies of sensors, transducers and elements of DAQ.
CO2: Describe specification and working of sensors, transducers and DAQ.
CO3: Acquire the signals using sensors and transducersfor the given applications.
CO4: Suggest the appropriate sensors and data acquisition systems for different applications.
CO5: Synthesize the different sensors using Data acquisition systems for signal processing and decision making.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	1	-	-	-	-	-	1	-	1	2	2	2
CO2	2	1	-	1	-	-	-	-	-	1	-	1	2	2	2
CO3	2	1	-	1	-	-	-	-	-	1	-	1	2	2	2
CO4	2	1	-	1	-	-	-	-	-	1	-	1	2	2	2
CO5	2	1	-	1	-	-	-	-	-	1	-	1	2	2	2
CO/PO & PSO Average	**2**	**1**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**2**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS:

3. Ernest O Doebelin, “Measurement Systems – Applications and Design”, Tata McGraw- Hill, 2019
4. Sawney A K and PuneetSawney, “A Course in Mechanical Measurements and Instrumentation and Control”, 12th edition, DhanpatRai& Co, New Delhi, 2013.

REFERENCES:

6. C. Sujatha, Dyer, S.A., Survey of Instrumentation and Measurement, John Wiley & Sons, Canada, 2004.
7. Hans Kurt Tönshoff (Editor), Ichiro, “Sensors in Manufacturing” Volume 1, Wiley-VCH, 2010.
8. John Turner and Martyn Hill, “Instrumentation for Engineers and Scientists”, Oxford Science Publications, 2009.
9. Patranabis D, “Sensors and Transducers”, 2nd Edition, PHI, New Delhi, 2013.
10. Richard Zurawski, “Industrial Communication Technology Handbook” 2nd edition, CRC Press, 2015.

RA23D02	CAPSTONE DESIGN PROJECT – LEVEL II	L	T	P	TCP
		0	0	12	6

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

- Employ advanced problem-solving techniques to develop and evaluate complex design alternatives.
- Collaborate effectively in interdisciplinary design projects that reflect current engineering practices.
- Conduct a comprehensive literature review and utilize advanced research methodologies in design projects.
- Analyze and integrate realistic constraints, including economic factors, sustainability, and global and social impacts, in design solutions.
- Produce detailed system descriptions and comprehensive documentation of the design process and outcomes.

Evaluation

In Capstone project -II, students are expected to deepen their

1. Understanding of engineering design and enhance their problem-solving skills.
2. They conduct comprehensive literature reviews and develop detailed project proposals that include well-defined objectives, scopes, and methodologies, with faculty approval.
3. Teams are self-formed or configured based on interest areas, and students collaborate to tackle more complex, interdisciplinary design projects that reflect current industrial and mechanical engineering practices.
4. Improved the first principle prototype into next level development that might suitable for desired real world functionalities.
5. These projects involve the use of open-ended problems and advanced research and design methodologies, requiring students to formulate detailed problem statements and specifications,
6. Generate and evaluate multiple design alternatives, and consider realistic constraints such as economic factors, sustainability, and global and social impacts. Safety, usability, and feasibility are critical considerations in their designs.
7. Students document their processes and results in detailed reports and deliver comprehensive presentations. Emphasis is also placed on effective teamwork and leadership, with a strong focus on diversity, equity, inclusion, and belonging. In some cases, projects may involve sponsorship from external clients, including early-stage ventures, providing students with practical industry experience and the opportunity to address real-world challenges.

TOTAL: 60 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

1. Demonstrate advanced understanding of engineering design principles, including complex problem definition and solution formulation, and apply these skills to generate and evaluate multiple design alternatives.
2. Conduct thorough literature reviews and advanced research methodologies to inform project proposals and guide the development of design solutions.
3. Collaborate effectively with peers from various disciplines to tackle complex, interdisciplinary design projects that reflect modern engineering practices.
4. Analyse and integrate realistic constraints such as economic factors, sustainability, global, and social impacts into design solutions.

5. Prepare comprehensive documentation and professional-grade presentations that summarize the project process, outcomes, and impact, showcasing advanced communication skills.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO/PO & PSO Average															
1 – Slight, 2 – Moderate, 3 – Substantial															

RA23701	ROBOT TRAJECTORY AND PATH PLANNING	L	T	P	TCP
		3	0	2	4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

- To introduce basic trajectory planning problems.
- To provide a basic review of various path planning theory of manipulator.
- To provide a basic review of various path planning theory of mobile robot.
- To Introduction to the most widely used classical motion planning algorithms.
- To introduce sufficient terminology and concepts in ROS for robot programming.

UNIT – I TRAJECTORY PLANNING APPROACHES 9

Definitions – Task Planning and Trajectory Planning – Representation of End-Effector**:** Cartesian and Joint Space Schemes. Workspace Analysis: Work Envelope of a Multi DOF Manipulator. Applications: Point to Point Motion and Continuous Path Motion - Robot Programming – Case Studies

UNIT – II TRAJECTORY PLANNING OF MANIPULATOR 9

Joint Space Techniques – Motion Profiles – Cubic Polynomial, Linear Segmented Parabolic Blends and Cycloidal Motion - Cartesian Space Technique – Straight Line and Circular Trajectories – Optimization of Joint Angle for the given Pose - Algorithms

UNIT – III PATH PLANNING OF MOBILE ROBOT 9

Introduction - Representation of the Robot's Environment - Review of Configuration Spaces - Visibility Graphs - Voronoi Diagrams - Potential Fields – Attractive and Repulsive – Cell Decomposition - Planning with Moving Obstacles - Probabilistic Roadmaps - Random Trees - Execution of the Quadtree- Based Path Planner Program.

UNIT – IV PATH PLANNING ALGORITHMS 9

Path Planning Algorithms-A* Algorithm, D^* Algorithm and Advanced Algorithms - Path Control. Graph Search and Discrete Planning Algorithms –Sensor-Based Motion Planning Algorithms – The “Bug” Algorithms – The Tangent Bug Algorithm.

UNIT – V PROGRAMMING 9

Robot Language Classification - Programming Methods: Lead Through Method, Teach Pendent Method - Syntax Features and Applications of Various Programming Languages – Examples - Inter Locking Commands - Safety Features – Robot programming in Manufacturing – Mobile Robots in Supply Chain and Warehouse Automation.

Introduction to Robot Operating System (ROS) - ROS Examples - Introduction to Programming using ROS - Industrial ROS - ROS Examples - Programming for Point to Point /Continuous – Operations - Case Study.

TOTAL: 45 PERIODS

LIST OF EXPERIMENTS

Ex. No	Name of the Experiments	Unit
1	Generation of joint and end effector trajectories 1 and 2 DOF robot	1,2

2	Generation of joint and end effector trajectories multi axis robot.	1,2
3	Optimization of joint angle for the given end effector position	3
4	Programming of robot manipulation in simulation platform.	5
5	Programming of serial robot for Pick and place applications	5
6	Programming of serial manipulator for continuous path motions.	5
7	Programming of industrial Robot for welding	5
8	Simulation of path planning algorithms in virtual environment	4
9	Realization of path planning algorithms in mobile robot	4
10	Simulation of mobile robot for SLAM	5

TOTAL = 30 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

1. Evaluate basic trajectory planning problems.
2. Know about the various path planning theory of manipulator.
3. Recognize various path planning theory of mobile robot.
4. Demonstrate the most widely used classical motion planning algorithms.
5. Utilize and apply the necessary terminology, concepts, and tools within the Robot Operating System (ROS) framework for programming and controlling robots, including topics like ROS nodes, topics, messages, and services.

Mapping of COs with POs and PSOs

COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	1	1	-	-	-	-	-	1	-	1	2	1	1
CO2	2	1	1	1	-	-	-	-	-	1	-	1	2	1	1
CO3	2	1	1	1	-	-	-	-	-	1	-	1	2	1	1
CO4	2	1	1	1	-	-	-	-	-	1	-	1	2	1	1
CO5	2	2	1	1	2	-	-	-	-	1	-	1	2	1	1
CO/PO & PSO Average	**2**	**1.2**	**1**	**1**	**2**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Niku S B, "Introduction to Robotics, Analysis, Control, Applications", John-Wiley & Sons Inc, 2020.
2. Howie Choset, Kevin Lynch Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, Sebastian Thrun, "Principles of Robot Motion-Theory, Algorithms, and Implementation", MIT Press, Cambridge, 2016.

REFERENCES:

1. Planning Algorithms by Steve LaValle, Cambridge Univ. Press, New York, 2014.
2. Robot Motion Planning by J.C. Latombe. 2010
3. Patnaik, Srikanta, "Robot Cognition and Navigation an Experiment with Mobile Robots", Springer-Verlag Berlin and Heidelberg, 2011.
4. Reza N Jazar, "Theory of Applied Robotics", Springer, 2022.
5. Morgan Quigley, Brian Gerkey, William D. Smart, Programming Robots with Ros: A Practical

Introduction to the Robot Operating System, First Edition, 2016
6. “Principles of Robot Motion: Theory, Algorithms, and Implementations” by Howie Choset, Kevin Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, 2016

RA23702	ROBOT VISION	L	T	P	TCP
		3	0	2	4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

- To understand the basics concepts of optics and vision systems.
- To learn and understand the fundamentals of image processing
- To impart knowledge on object recognition and feature extraction.
- To understand algorithms in image processing.
- To demonstrate the various applications of machine vision system.

UNIT – I IMAGE ACQUISITION 9

The Nature of Vision- RoboticVision – Need, Applications - Image Acquisition – Physics of Light – Interactions of Light – Refraction at a Spherical Surface – Thin Lens Equation - Illumination Techniques - Linear Scan Sensor, Planar Sensor, Camera Transfer Characteristic, Raster Scan, Image Capture Time, Volume Sensors, Image Representation, Picture Coding Techniques.

UNIT – II IMAGE PROCESSING FUNDAMENTALS 9

Introduction to Digital Image Processing - Image Sampling and Quantization - Image Enhancement: Image Filtering, Radiometric Calibration, Image Smoothing– Geometric Transformation– Image Segmentation – Hough transforms - Edge Linking - Boundary Detection - Region Growing - Region Splitting and Merging-Stereo Vision – Epipolar Geometry

UNIT – III FEATURE EXTRACTION AND OBJECT RECOGNITION 9

Feature Extraction: Region Features, Gray Value Features, Contour Features- Hough Circle Transformation – SIFT and SURF –Freeman Chain Code-Boundary Descriptors-Regional Descriptors – Recognition- Structural Methods- Recognition Procedure, Mahalanobis Procedure

UNIT – IV COLLISION FRONTS ALGORITHM 9

Introduction, Skeleton of Objects. Gradients, Propagation, Definitions, Propagation Algorithm, Thinning Algorithm, Skeleton Lengths of Top Most Objects.

UNIT – V ROBOT VISION APPLICATION 9

Case Study-Automated Navigation Guidance by Vision System – Vision Based Depalletizing- Line Tracking- Automatic Part Recognition. Image Processing Techniques -Implementation through Image Processing Software. (PYTHON, Open CV)

TOTAL: 45 PERIODS

LIST OF EXPERIMENTS

Ex. No	Name of the Experiments	Unit
1	Identification of vision lens, sensors and lighting techniques for robot vision.	1
2	Experimentation on image acquisition towards the computation platform.	1
3	Pre-processing techniques in image processing.	2
4	Edge detection and region of interest extraction.	2

5	Experimentation with image processing algorithm for feature extraction.	3
6	Experimentation with pattern recognition.	3
7	Vision based object detection using Machine Learning Techniques.	3
8	Vision based defect identification.	3,5
9	Vision based image classification using Machine Learning Techniques.	3,5
10	Experimentation for monocular and stereo vision for robot pose estimation.	3,5

(Any 7 experiments)

TOTAL = 30 PERIODS

COURSE OUTCOMES

Upon Completion of the course, the students will be able to

CO 1: Know the various types of sensors, lightings, hardware and concept for robot vision.

CO 2: Acquire the image by the appropriate use of sensors, lightings and hardware.

CO 3: Apply the various techniques of acquisition and image processing in real time applications.

CO 4: Suggest the suitable sensors, lightings, hardware and algorithm.

CO 5: Create, analyse and implement the hardware and image processing methodology for robotic vision.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	1	1	-	-	-	-	1	-	1	2	2	1
CO2	2	1	-	1	1	-	-	-	-	1	-	1	2	2	1
CO3	2	1	-	1	1	-	-	-	-	1	-	1	2	2	1
CO4	2	1	-	1	1	-	-	-	-	1	-	1	2	2	1
CO5	2	2	-	1	1	-	-	-	-	1	-	1	2	2	1
CO/PO & PSO Average	**2**	**1.2**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Rafael C. Gonzales, Richard. E. Woods, “Digital Image Processing Publishers”, Fourth Edition, Pearson, 2018
2. Emanuele Trucco, Alessandro Verri, “Introductory Techniques for 3D Computer Vision”, First Edition, Pearson, 1998.

REFERENCES:

1. Yi Ma, Jana Kosecka, Stefano Soatto, Shankar Sastry, “An Invitation to 3-D Vision From Images to Models”, First Edition, 2004
2. Fu .K.S, Gonzalez .R.S, Lee .C.S.G, “Robotics – Control Sensing, Vision and Intelligence”, Tata McGraw-Hill Education, 2008.
3. RafelC.Gonzalez, Richard E.Woods,Steven L. Eddins, “Digital Image Processing using MATLAB”, 2nd edition, Tata McGraw Hill, 2010.
4. Peter Corke, "Robotics, Vision and Control: Fundamental Algorithms in MATLAB", Springer, 2011

RA23703	MACHINE LEARNING FOR INTELLIGENT SYSTEMS	L	T	P	TCP
		3	0	2	4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

- To introduce basic of machine learning techniques
- To learn about classification methods
- To learn about clustering methods
- To learn about basics of neural networks
- To learn about Deep learning and Reinforcement learning.

UNIT – I INTRODUCTION TO MACHINE LEARNING (ML) 9

Learning – Types of Machine Learning, Supervised and Unsupervised, Classifications vs. Regression,Linear Regression, Evaluation Metrics and Loss Functions in Classification and Regression, Introduction to Fuzzy Logic, Applications of AI in Robotics.

UNIT – II CLASSIFICATION METHODS 9

Linear and NonlinearClassifiers, Support Vector Machine Algorithm, Learning with Trees-Using Decision Trees-Constructing Decision Trees-Classification Example-Decision by Committee: Ensemble Learning – Boosting – Bagging-Random Forests.

UNIT – III UNSUPERVISED LEARNING 9

Introduction to Clustering, Types of Clustering, Agglomerative Clustering, K-Means Clustering, C-means Clustering, PrincipleComponent Analysis (PCA), Application in Feature Selection for Robot Guidance.

UNIT – IV NEURAL NETWORKS (NN) 9

Neural Networks – Perceptron, Multi-Layer Perceptron – Back Propagation of Error-Multi-layer Perceptron in Practice – Deriving Back Propagation – Application of Neural Networks in Robotics.

UNIT – V DEEP LEARNING AND REINFORCEMENT LEARNING 9

Introduction to Deep Learning – CNN – RNN, Reinforcement Learning, Examples for Reinforcement Learning, Markov Decision Process, Major Components of RL, Application of Reinforcement Learning in Robotics.

TOTAL: 45 PERIODS

LIST OF EXPERIMENTS

Ex. No	Name of the Experiments	Unit
1	Basic Programs in Python.	
2	Implementation of Linear regression.	1
3	Implementation of SVM model.	2
4	Implementation of Decision tree model.	2
5	Implementation of K-means clustering algorithm.	3
6	Implementation of MLP model.	4
7	Implementation of CNN model.	5
8	Implementation of reinforced learning	

(Any 7 experiments)

TOTAL = 30 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Know the terms in machine learning and deep learning algorithms.
CO2: Recognize concepts and methods in machine learning and deep learning algorithms.
CO3: Practise the ML and DL Models and theoretical basis.
CO4: Deploy the ML and DL Models for given data/ applications.
CO5: Evaluate and analyse the ML and DL models and results.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	1	1	-	-	-	-	-	1	-	1	2	2	1
CO2	2	1	1	1	-	-	-	-	-	1	-	1	2	2	1
CO3	2	1	1	1	-	-	-	-	-	1	-	1	2	2	1
CO4	2	1	1	1	-	-	-	-	-	1	-	1	2	2	1
CO5	2	1	1	1	-	-	-	-	-	1	-	1	2	2	1
CO/PO & PSO Average	**2**	**1**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Stephen Marsland, “Machine Learning – An Algorithmic Perspective”, Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014.
2. Tom M Mitchell, “Machine Learning”, McGraw Hill Education, 2017.

REFERENCES:

1. Peter Flach, “Machine Learning: The Art and Science of Algorithms that Make Sense of Data”, First Edition, Cambridge University Press, 2012.
2. Jason Bell, “Machine learning – Hands on for Developers and Technical Professionals”, First Edition, Wiley, 2014.
3. EthemAlpaydin, “Introduction to Machine Learning”, Third Edition, Adaptive Computation and Machine Learning Series, MIT Press, 2014.

RA23704	COMPREHENSION	L	T	P	TCP
		0	0	1	1

COURSE OBJECTIVES

The main learning objective of this course is to provide hands on training to the students

1. To comprehend all the foundations learned in Robotics and Automation
2. To verify the learning level in all the courses offered in Robotics and Automation.
3. To apprise the knowledge of the student in technical, non-technical, skill and attitude towards robotics and Automation engineer.

EVALUATION

100% internal evaluation mode.

Out of which 50% weightage for examination-based evaluation properly MCQ.

25% assessed by individual performance in presentation and 25 % for viva voce and interview.

TOTAL = 30 PERIODS

COURSE OUTCOMES

Upon completing this course Students able to

CO1: Demonstrate an understanding of the essential and fundamental concepts of Robotics and Automation, and effectively articulate responses to related concepts and principles.

CO2: Evaluate and propose appropriate technologies for robots and automation in a wide range of applications, considering factors such as task requirements, environmental constraints, and technological advancements.

CO3: Consolidate and apply the acquired knowledge and skills in the field of Robotics and Automation, demonstrating a comprehensive understanding of the subject matter and its practical application.

RA23U02	SUSTAINABILITY FOR AUTOMATION	L	T	P	TCP
		2	0	2	3

MODULE I INTRODUCTION **6**

Principles & Historical perspectives, Importance and need for sustainability in engineering and technology, impact and implications. United Nations Sustainability Development Goals (SDG), UN summit – Rio & outcome, Sustainability and development indicators.

MODULE II ENVIRONMENTAL SUSTAINABILITY **6**

Climate change, Biodiversity loss, Pollution and waste management, Renewable vs. non-renewable resources, Water and energy conservation, Sustainable agriculture and forestry. National and international policies, Environmental regulations and compliance, Ecological Footprint Analysis

MODULE III SOCIAL & ECONOMIC SUSTAINABILITY **9**

Equity and justice, Community development, Smart cities and sustainable infrastructure, Cultural heritage and sustainability, Ethical considerations in sustainable development.Triple bottom line approach, Sustainable economic growth, Corporate social responsibility (CSR), Green marketing and sustainable product design, Circular economy and waste minimization, Green accounting and sustainability reporting.

MODULE IV FOUNDATIONS OF SUSTAINABILITY IN ROBOTICS **9**

Introduction to Sustainability and Robotics -Overview of sustainability concepts; Importance of sustainability in engineering and robotics, Case studies of sustainable robotics applications; recycling robots, agricultural robots, Sustainable Design Principles; Lifecycle assessment in robotics, Analysing the lifecycle of a robotic product, Energy consumption in robotics; Renewable energy sources for robotics.

MODULE V APPLICATIONS AND IMPACTS OF SUSTAINABLE ROBOTICS 30

Environmental monitoring and conservation efforts; underwater robots for marine life monitoring, Social and Economic Impacts of Sustainable Robotics, Ethical considerations in deploying sustainable robotics, Emerging trends and innovations in sustainable robotics.

TOTAL: 60 PERIODS

REFERENCES:

1. Allen, D., & Shonnard, D. R. (2011). Sustainable engineering: Concepts, design and case studies. Prentice Hall.
2. Munier, N. (2005). Introduction to sustainability (pp. 3558-6). Amsterdam, The Netherlands: Springer.
3. Blackburn, W. R. (2012). The sustainability handbook: The complete management guide to achieving social, economic and environmental responsibility. Routledge.
4. Clini, C., Musu, I., & Gullino, M. L. (2008). Sustainable development and environmental management. Published by Springer, PO Box, 17, 3300.
5. Bennett, M., James, P., & Klinkers, L. (Eds.). (2017). Sustainable measures: Evaluation and reporting of environmental and social performance. Routledge.

6. Seliger, G. (2012). Sustainable manufacturing for global value creation (pp. 3-8). Springer Berlin Heidelberg.
7. Stark, R., Seliger, G., & Bonvoisin, J. (2017). Sustainable manufacturing: Challenges, solutions and implementation perspectives. Springer Nature.
8. Davim, J. P. (Ed.). (2013). Sustainable manufacturing. John Wiley & Sons.

RA23U01	STANDARDS FOR ROBOTICS AND AUTOMATION	L	T	P	TCP
		1	0	0	1

MODULE I OVERVIEW OF STANDARDS **6**

Basic concepts of standardization; Purpose of Standardization, marking and certification of articles and processes; Importance of standards to industry, policy makers, trade, sustainability and innovation.Objectives, roles and functions of BIS,Bureau of Indian Standards Act, ISO/IEC Directives; WTO Good Practices for Standardization.Important Indian and International Standards.

MODULE II ROBOTICS AND AUTOMATION STANDARDS **9**

IEC 61131 - sections: is the international standard for programmable controller programming languages.

ISO 10218-1:2011 – PART 1 AND2 - Specifies requirements and guidelines for the inherent safe design, protective measures, and information for use of industrial robots.

IEC 61496-1:2020 specifies general requirements for the design, construction and testing of non-contact electro-sensitive protective equipment (ESPE) designed specifically to detect persons or part of a person as part of a safety-related system.

IEC 61069 Industrial-process measurement, control and automation

ISO 3691-4:2023 – Driverless Trucks “Automated Guided Vehicle”, “Autonomous Mobile Robot”, “Bots”, “Automated Guided Cart”, “Tunnel Tugger”, “Under cart. Standards for Electrical and Mechanical for Manipulators- Explosive Standards -Robots Communication Standards - Safety standards

ISO 13482:2014 Robots and robotic devices.

Standards by ISO/TC 299

TOTAL: 15 PERIODS

RA23D03	CAPSTONE DESIGN PROJECT – LEVEL III	L	T	P	TCP
		0	0	16	8

COURSE OBJECTIVES

The main learning objective of this course is to prepare the students to

- Apply advanced engineering sciences and comprehensive knowledge in designing complex systems or components.
- Generate and rigorously evaluate innovative design alternatives considering a wide range of complex constraints.
- Conduct extensive research, literature reviews, and advanced design methodologies to inform project development.
- Analyse and integrate extensive constraints, including economic, sustainability, global, and social impact, into design solutions.
- Demonstrate exceptional teamwork, leadership, and project management skills, managing complex projects with a commitment to diversity, equity, inclusion, and belonging.

Evaluation

In lower-level Capstone projects, students are expected to build foundational skills in engineering design and teamwork.

They conduct basic research and develop a project proposal with clear objectives, obtaining faculty approval.

Teams are formed based on shared interests, and students work collaboratively, applying basic engineering principles to define problems and generate simple design solutions.

The projects involve elementary research and design methodologies, formulation of clear problem statements, and development of basic specifications.

Students are introduced to practical constraints such as cost, materials, and time, while beginning to consider safety, usability, and feasibility.

Documentation and presentation skills are emphasized through the preparation of reports and project summaries.

Additionally, students engage in teamwork, understanding the importance of diversity, equity, inclusion, and belonging in collaborative settings. If applicable, they interact with external clients to understand and respond to basic project requirements. These activities provide a strong foundation for more complex projects in higher semesters.

TOTAL = 60 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

1. Demonstrate the ability to apply advanced engineering sciences and comprehensive knowledge to design complex systems, components, products, or processes, considering innovative solutions and rigorous evaluation.
2. Conduct comprehensive research and advanced design methodologies to inform project development, including literature reviews, problem statement formulation, and specification creation.
3. Collaborate effectively in interdisciplinary teams, integrating diverse perspectives and expertise to tackle complex, real-world design challenges that reflect cutting-edge industrial and mechanical engineering practices.
4. Analyse and integrate extensive constraints such as economic factors, sustainability, global, and social impacts into design projects, ensuring alignment with ethical and environmental considerations.

- Prepare comprehensive documentation and professional-grade presentations that showcase the advanced project process, detailed system descriptions, outcomes, and impact, demonstrating exceptional communication skills.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO/PO & PSO Average															
1 – Slight, 2 – Moderate, 3 – Substantial															

ROXXXX	PROJECT WORK/ INTERNSHIP CUM PROJECT WORK	L	T	P	TCP
		0	0	16	8

COURSE OBJECTIVES

- Students learn to develop the robot and automation systems, sub-elements and technologies for real word needs.

EVALUATION

(As provided in the regulation)

COURSE OUTCOMES

Upon completing this course Students able to

CO1: Recognize the need for automation and robotics solutions in various contexts and propose suitable solutions to address specific requirements.

CO2: Apply fundamental principles and concepts to develop robots and automation systems, including knowledge of sensors, actuators, control systems, and programming languages.

CO3: Demonstrate proficiency in implementing and utilizing robots, automation, and intelligent techniques, showcasing the ability to design, program, and operate robotic systems with a focus on automation and intelligent decision-making.

Mapping of COs with POs and PSOs															
COs/POs& PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO/PO & PSO Average	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

PROFESSIONAL ELECTIVE COURSES

VERTICAL 1: APPLIED ROBOTICS

RA23001	ROBOTS AND SYSTEMS IN MANUFACTURING	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

- Understand various types of industrial robots and their applications in different industries.
- Gain insights into foundry and welding processes and their robotic applications.
- Study robotic applications in machining, cutting, and adhesion processes.
- Learn principles and techniques for robotic material handling, including machine loading and unloading.
- Explore robotic applications in other applications.

UNIT – I INTRODUCTION 9

Types of industrial robots - Load handling capacity - general considerations in Robotic material handling- material transfer - machine loading and unloading - CNC machine tool loading - Robot-centered cell- Robot-centered manufacturing.

UNIT – II ROBOTS IN FOUNDRY & WELDING 9

Robots in Spot Welding, Arc Welding, Gas Tungsten Arc Welding (GTAW), Gas Metal Arc Welding (GMAW), Laser Beam Welding (LBW), Resistance Spot Welding (RSW), Friction Stir Welding (FSW). Sand casting, Mold Preparation, Die Casting, Investment Casting, Centrifugal Casting – Case Studies.

UNIT – III ROBOTS IN MACHINING & ADHESION 9

Robots in Machine Tool Loading, Robotic Machining, Grinding and Deburring, Polishing and Buffing, Waterjet Cutting, Flame Cutting, Deposition of Material, Gluing and Sealing, Die Bonding – Case Studies.

UNIT – IV ROBOTS IN MATERIAL HANDLING AND IDENTIFICATION 9

Robots in Material Transport Systems - Material Handling, Material Transport Equipment, Analysis of Material Transport Systems. Storage Systems – Introduction, Conventional Storage Methods and Equipment, Automated Storage Systems, Analysis of Storage Systems. Automatic Identification Methods – Case Studies.

UNIT – V ROBOTS IN OTHER APPLICATIONS 9

Robots in Spray Painting, Printed Circuit Board Component Insertion, PCB Handling, Drilling and Testing, Solar Cell Manufacturing, Plastics Material Handling, Shot Peening, Robotic Packaging – Case Studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO 1: Identify and classify different types of industrial robots and their specific uses.
CO 2: Understand and apply various foundry and welding processes using robots.
CO 3: Understand and apply various machining, cutting, and adhesion processes using robots.
CO 4: Evaluate and optimize the load-handling capacity of robots in material handling.
CO 5: Design and implement robotic systems for other specific applications

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	1	1	1	-	-	-	-	-	-	1	-	1	1	1	1
CO2	1	1	1	-	-	-	-	-	-	1	-	1	1	1	1
CO3	1	1	1	-	-	-	-	-	-	1	-	1	1	1	1
CO4	1	1	1	-	-	-	-	-	-	1	-	1	1	1	1
CO5	1	1	1	-	-	-	-	-	-	1	-	1	1	1	1
CO/PO & PSO Average	**1**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**1**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Richard D Klafter, Thomas Achmielewski, MickaelNegin , "Robotic Engineering – An integrated Approach", Prentice Hall India, New Delhi, 2006.
2. Mikell P Groover , "Automation, Production Systems, and Computer-Integrated Manufacturing", Pearson Education, New York, 4th edition 2019.
3. Pires J N, Loureiro A, Bolmsjo G, "Welding Robots: Technology, System Issues and Application", Springer, London, 2010.
4. D.J. Williams, E. Appleton, “Robot Pick place operation: Industrial Robot Applications”· 2012

REFERENCES:

1. Parmar R S, "Welding Processes and Technology", Khanna Publishers, New Delhi, 2nd Edition, 2013.
2. John A. piotrowski, William T. Randolph, "Robotic welding: A Guide to Selection and Application, Welding Division, Robotics International of SME", Publications Development Dept., Marketing Division, 1987.
3. Mikell P Groover, Mitchel Weiss, Roger N Nagel, N.G.Odrey, AshishDutta, "Industrial Robotics (SIE): Technology, Programming and Applications", 2nd Edition, McGraw Hill Education India Pvt Ltd, 2012.
4. YoramKoren, "Robotics for Engineers", McGraw-Hill, 1987.

RA23002	MULTI-AGENT ROBOTICS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

- Know the principles and properties of collaborative robotics in cobotics.
- Explore swarm robotics and its applications in collective decision-making and methodologies.
- Study modular robotics and the design, kinematics, and dynamics of modular robots.
- Examine the concept of naturally inspired collaboration and collective decision-making processes.
- Learn about reconfigurable robots and their formation control and dynamics in swarm systems.

UNIT – I INTRODUCTION TO COBOTICS 9

Collaborative Robotics- Properties - Introduction to Modern Mobile Robots: Swarm Robots, Cooperative and Collaborative Robots, Mobile Robot Manipulators-Current Challenges.

UNIT – II SWARM ROBOTICS 9

Introduction, mapping, kinematics and trajectory error compensation, state transitions, collective decision making and methodologies, swarm robot scenarios-aggregation, clustering dispersion, pattern formation, sorting, flocking and collective motion, shepherding, heterogeneous swarms, Error Detection and Security.

UNIT – III MODULAR ROBOTICS 9

Module Designs - Modular Robot Representation -Modular Serial Robot Kinematics - Kinematic Calibration for Modular Serial Robots- Modular Serial Robot Dynamics - Modular Parallel RobotKinematics.

UNIT – IV NATURALLY INSPIRED COLLABORATION 9

Collective Decision-Making. Group Decision Making in Animals, Collective Motion as Decision Process, Models for Collective Decision-Making Processes, Urn Models, Voter Model ,Majority Rule , Hegselmann and Krause , Kuramoto Model , Axelrod Model, Ising Model, Fiber Bundle Model, Sznajd Model, Bass Diffusion Model, Sociophysics and Contrarians **.**

UNIT – V RECONFIGURABLE ROBOTS 9

V-Shaped Formation Control for Robotic Swarms Constrained by Field of View – formation of reconfigurable virtual linkage - Reconfigurable Formation Control of Multi-Agents - Self-Assembly Modular Robot Platform Based on Sambot - Swarm Dynamics Emerging from Asymmetry.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Demonstrate the collaborative robotics and its properties in cobotics.
CO2: Analyze swarm robotics scenarios and apply collective decision-making methodologies.
CO3: Understand the design, kinematics, and dynamics of modular robots in modular robotics.
CO4: Evaluate and analyze naturally inspired collaboration models and collective decision-making

processes.

CO5: Visualize the concepts of reconfigurable robots and understand their formation control and dynamics in swarm systems.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	1	1	-	-	-	-	-	1	-	1	1	2	2
CO2	2	2	1	1	-	-	-	-	-	1	-	1	1	2	2
CO3	2	1	1	1	-	-	-	-	-	1	-	1	1	2	2
CO4	2	1	1	1	-	-	-	-	-	1	-	1	1	2	2
CO5	2	1	1	1	-	-	-	-	-	1	-	1	1	2	2
CO/PO & PSO Average	**2**	**1.2**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**1**	**2**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Guilin Yang, I-Ming Chen, “Modular Robots: Theory and Practice”, Springer, 2022.
2. GiandomenicoSpezzano, “Swarm Robotics”, Applied Sciences, MDPI, 2019.

REFERENCES:

1. Heiko Hamann, “Collective Decision-Making in Swarm Robotics: A Formal Approach”, Springer, 2019.
2. Jiming Liu , Jianbing Wu, Multiagent Robotic Systems, 2001, CRC press

RA23003	MICRO ROBOTICS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

- Understand the principles and applications of microelectronics system.
- Expose micro scale, technologies for fabricating small devices, bio-inspired design, and applications of the field.
- Recognise various Mathematical formalism for flexures, Electrostatic actuators, Piezo-electric actuators, Magneto-strictive actuator and other sensors.
- Apply micro robotics to various applications.
- Engage implementation of microrobotics.

UNIT – I INTRODUCTION TO MICROROBOTICS 9

Introduction to Micro robotics -MST (Micro System Technology) - Micromachining - Working principles of Microsystems Applications of Microsystems - Micro-fabrication principles-Design selection criteria for micromachining - Packaging and Integration aspects - Micro-assembly platforms and manipulators.

UNIT – II SCALING LAWS AND MATERIALS FOR MEMS 9

Introduction - Scaling laws - Scaling effect on physical properties scaling effects on Electrical properties - scaling effect on physical forces - Physics of Adhesion - Silicon - compatible material system - Shape memory alloys - Material properties - Piezoresistivity, Piezoelectricity and Thermoelectricity.

UNIT – III FLEXURES, ACTUATORS AND SENSORS 9

Elemental flexures - Flexure systems - Mathematical formalism for flexures - Electrostatic actuators - Piezo-electric actuators - Magneto-strictive actuators - Electromagnetic sensors - Optical-based displacement sensors - Motion tracking with microscopes.

UNIT – IV MICROROBOTICS 9

Introduction - Task specific definition of micro-robots - Size and Fabrication Technology based definition of micro- robots - Mobility and Functional-based definition of micro-robots - Applications for MEMS based micro-robots.

UNIT – V IMPLEMENTATION OF MICROROBOTS 9

Arrayed actuator principles for micro-robotic applications - Micro-robotic actuators - Design of locomotive micro-robot devices based on arrayed actuators - Micro-robotics devices - Micro- grippers and other micro-tools - Micro-conveyors - Walking MEMS Micro-robots - Multi-robot system: Micro-robot powering, Micro-robot communication.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Demonstrate knowledge of microsystems and micromachining principles and their applications.
CO2: Analyze the scaling laws and their impact on physical properties and material selection for MEMS.

CO3: Evaluate the functionality and design considerations of flexures, actuators, and sensors used in microsystems.

CO4: Understand the concepts and classifications of micro-robots and their applications in microrobotics.

CO5: Apply the principles and techniques in the implementation and design of micro-robotic devices and systems.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	-	-	-	-	-	-	1	-	1	1	1	1
CO2	2	2	1	1	-	-	-	-	-	1	-	1	1	1	1
CO3	2	2	1	1	-	-	-	-	-	1	-	1	1	1	1
CO4	2	1	1	-	-	-	-	-	-	1	-	1	1	1	1
CO5	2	1	1	-	-	-	-	-	-	1	-	1	1	1	1
CO/PO & PSO Average	**2**	**1.5**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**1**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Mohamed Gad-el-Hak , "The MEMS Handbook", 2nd Edition, CRC Press, New York, 2020.
2. Yves Bellouard,"Microrobotics Methods and Applications",CRC Press, Massachusetts,2019.

REFERENCES:

1. NadimMaluf and KirtWilliams, "An Introduction to Microelectromechanical systems Engineering", 2nd edition, Artech House, 2004.
2. Julian W Gardner, "Microsensors: Principles and Applications", 2nd edition, Wiley, 2007.
3. MetinSitti, "Mobile Microrobotics", MIT Press, 2017.
4. Nicolas Chaillet, Stephane Rangier "Microrobotics for micromanipulation", John Wiley & Sons, 2013.

RA23004	MEDICAL ROBOTICS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

1. Analyze the different types and applications of medical robots in healthcare.
2. Evaluate the technologies and techniques used for localization and tracking in medical robotics.
3. Apply design methodologies and make technological choices for the development of medical robots.
4. Examine the integration of robotics in surgical procedures and the different sub-systems involved.
5. Assess the role of robots in rehabilitation and medical care, including limb rehabilitation and brain-machine interfaces.

UNIT – I INTRODUCTION 9

Types of medical robots - Navigation - Motion Replication - Imaging - Rehabilitation and Prosthetics – State of art of robotics in the field of healthcare-DICOM.

UNIT – II LOCALIZATION AND TRACKING 9

Position sensors requirements - Tracking - Mechanical linkages - Optical – Sound based - Electromagnetic - Impedance-based - In-bore MRI tracking-Video matching - Fiber optic tracking systems - Hybrid systems.

UNIT – III DESIGN OF MEDICAL ROBOTS 9

Characterization of gestures to the design of robots - Design methodologies - Technological choices - Security.

UNIT – IV SURGICAL ROBOTICS 9

Minimally invasive surgery and robotic integration - surgical robotic sub systems - synergistic control - Control Modes - Radiosurgery - Orthopedic Surgery - Urologic Surgery and Robotic Imaging -Cardiac Surgery – Neurosurgery - case studies.

UNIT – V ROBOTS I REHABILITATION AND MEDICAL CARE 9

Rehabilitation for Limbs - Brain-Machine Interfaces - Steerable Needles - Assistive robots - Robots in Physiotherapy - case studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Demonstrate a comprehensive understanding of the types and functionalities of medical robots.
CO2: Apply localization and tracking techniques in the context of medical robotics.
CO3: Design and develop medical robots considering gesture characterization and security aspects.
CO4: Analyze and evaluate the application of surgical robotics in various medical procedures.
CO5: Evaluate the use of robots in rehabilitation and medical care through case studies and examples.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	1	-	1	-	-	-	1	-	1	1	2	2
CO2	2	1	1	1	-	1	-	-	-	1	-	1	1	2	2
CO3	2	1	3	1	-	1	-	1	-	1	-	1	1	2	2
CO4	2	1	1	1	-	1	-	1	-	1	-	1	1	2	2
CO5	2	1	1	1	-	1	-	1	-	1	-	1	1	2	2
CO/PO & PSO Average	**2**	**1**	**1.5**	**1**	**-**	**1**	**-**	**1**	**-**	**1**	**-**	**1**	**1**	**2**	**2**
1 – Slight, 2 – Moderate, 3 – Su0bstantial															

TEXT BOOKS

1. Achim Schweikard,Floris Ernst, "Medical Robotics", Springer, 2016.
2. Paula Gomes, "Medical robotics Minimally invasive surgery", Woodhead, 2013.

REFERENCES:

1. Jaydev P Desai, Rajni V Patel, Antoine Ferreira; Sunil Kumar Agrawal, "The Encyclopedia of Medical Robotics", World Scientific Publishing Co. Pvt. Ltd, 2019.
2. Jocelyne Troccaz , "Medical Robotics", John Wiley & Sons Incorporated, 2013.
3. Vanja Bonzovic , "Medical Robotics", I-tech Education publishing, Austria, 2008.
4. Farid Gharagozloo "Robotic Surgery", Springer, 2nd Edition, 2022.

RA23005	HUMANOID ROBOTICS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

- Understand the historical development and characteristics of humanoid robots.
- Apply kinematic principles to analyze and solve robotic motion problems.
- Explore the concepts of Zero Moment Point (ZMP) and dynamics in humanoid robots.
- Develop walking patterns for biped robots and analyze their stability.
- Implement walking pattern generation techniques using ZMP-based approaches and stabilizing control.

UNIT – I INTRODUCTION 9

Historical development of Humanoids, Human Likeness of a Humanoid Robot, Trade-Offs in Humanoid Robot Design, Human-Friendly Humanoid Robot Design, characteristics of humanoid robots.

UNIT – II KINEMATICS 9

Kinematic structure, forward and inverse kinematic problems, differential kinematics, Twist, Spatial Velocity, and Spatial Transform, Inverse Differential Kinematic Relations. Differential kinematics at singular configurations- Gait Analysis.

UNIT – III ZERO MOMENT POINT AND DYNAMICS 9

ZMP Overview,2D Analysis,3D Analysis, Measurement of ZMP, General Discussion- ZMP of Each Foot, ZMP for Both Feet Contact, Dynamics of Humanoid Robots, Humanoid Robot Motion and Ground Reaction Force , Momentum, Angular Momentum and Inertia Tensor of Rigid Body, Calculation of Robot's Center of Mass, Link Speed, Angular Velocity and Robot's Momentum.

UNIT – IV BIPED WALKING 9

Two Dimensional Walking Pattern Generation, Two Dimensional Inverted Pendulum, Behavior of Linear Inverted Pendulum, Orbital Energy, Support Leg Exchange, Planning a Simple Biped Gait, Extension to a Walk on Uneven Terrain.

UNIT – V WALKING PATTERN GENERATION AND CASE STUDIES 9

ZMP Based Walking Pattern Generation, Cart-Table Model, Off-Line Walking Pattern Generation, Stabilizer, Principles of Stabilizing Control, Stabilizing Control of Honda Humanoid Robot, Advanced Stabilizers- Assessment of various Humanoid robotic models

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO 1: Describe the historical development and key characteristics of humanoid robots.
CO 2: Solve forward and inverse kinematic problems in humanoid robot motion.
CO 3: Analyze the ZMP and dynamics of humanoid robots in both 2D and 3D scenarios.
CO 4: Design and generate walking patterns for biped robots considering stability and terrain variations.
CO 5: Implement stabilizing control techniques for stable walking of humanoid robots.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	1	-	-	-	-	-	1	-	1	2	2	3
CO2	2	3	1	1	-	-	-	-	-	1	-	1	2	2	3
CO3	2	2	1	1	-	-	-	-	-	1	-	1	2	2	3
CO4	2	1	3	1	-	-	-	-	-	1	-	1	2	2	3
CO5	2	1	1	1	-	-	-	-	-	1	-	1	2	2	3
CO/PO & PSO Average	**2**	**1.6**	**1.5**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**2**	**3**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Dragomir N. Nenchev, Atsushi Konno, “Humanoid Robots Modeling and Control”, Butterworth Heinemann, 2019
2. Shuuji K, Hirohisa H, Kensuke H, Kazuhito, Springer-Verlag GmbH ”Introduction to Humanoid Robotics”, Springer, London, 2014.
3. Goswami Ambarish, VadakkepatPrahlad, "Humanoid Robotics: A Reference", Springer, 2019.
4. J. Craig, "Introduction to Robotics: Mechanics and Control", Fourth Edition, Pearson, 2022

REFERENCES:

1. A. Goswami, P. Vadakkepat (Eds.), “Humanoid Robotics: A Reference”, Springer, Netherlands, Dordrecht, 2018
2. J K. Harada, E. Yoshida, K. Yokoi (Eds.), “Motion Planning for Humanoid Robots”, Springer, London, 2010.
3. Lorenzo Sciavicco and Bruno Siciliano, "Modelling and Control of Robot Manipulators", second edition, Springer, 2001.
4. Jean-Claude Latombe, "Robot Motion Planning", Kluwer Academy Publishers, 2004

RA23006	AGRICULTURAL ROBOTICS AND AUTOMATION	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

- Understand the historical development and significance of mechanized agriculture.
- Identify and describe the various farming operations and related machines used in agriculture.
- Analyze the principles and techniques of precision agriculture, including sensor applications and GPS technologies.
- Evaluate traction and testing methods in agriculture, including hitching principles and traction models.
- Examine soil tillage and weed management practices, including tillage equipment and weed control strategies.

UNIT-I INTRODUCTION 9

History of Mechanized Agriculture - Farming Operations and Related Machines - Tillage, Planting Cultivation, and Harvesting, Agricultural Automation - Agricultural Vehicle Robot.

UNIT-II PRECISION AGRICULTURE 9

Precision Agriculture -Global Positioning System (GPS) - GPS for civilian use, Differential GPS, Carrier-phase GPS, Real-time kinematic GPS, Military Grade GPS, Geographic Information System, Variable Rate Applications and Controller Area Networks- NMEA Protocol- Geographic Information System and mapping software, yield mapping systems, Crop production modeling, Variable Rate Applications and Controller Area Networks.

UNIT-III SOIL TILLAGE AND WEED MANAGEMENT 9

Tillage Methods and Equipment, Mechanics of Tillage Tools, Performance of Tillage Implements, Hitching of Tillage Implements, Weed Management - Conventional Cropping Systems, Tools, Crop Rotation, Mechanical Cultivation.

UNIT-IV ROBOTS AND MACHINERIES 9

Agricultural robots - types- function - application. Future trends in automation in agriculture

Screw Conveyors, Pneumatic Conveyors, Bucket Elevators, Forage Blowers, Sugar cane Harvester and Miscellaneous Conveyors, Machinery Selection - Field Capacity and Efficiency, Draft and Power Requirements, Machinery Costs.

UNIT-V AUTOMATION OF AGRICULTURE OPERATION 9

Automation of agricultural operations using IoT based systems - different sensors - Temperature and humidity sensor - Soil Moisture Sensor - Water Level Depth Detector Smart Irrigation System-AutomationinGreenhouse–Drones.CaseStudy-Automationofgreenhouse- farm operations, unmanned ground and aerial vehicles.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected

CO 1: Explain the historical evolution and importance of mechanized agriculture.

CO 2: Identify and differentiate farming operations and related machines used in different agricultural processes.

CO 3: Apply precision agriculture techniques, including sensor utilization and GPS technologies.

CO 4: Assess and analyze traction and testing methods for efficient agricultural operations.

CO 5: Evaluate soil tillage practices and weed management strategies for optimal crop production.

Mapping of COs with POs and PSOs

COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	1	-	1	1	-	-	1	-	1	1	1	1
CO2	1	2	-	1	-	-	-	1	-	1	-	1	1	1	1
CO3	2	2	1	1	-	1	-	-	-	1	-	1	1	1	1
CO4	2	2	-	1	-	1	-	-	-	1	-	1	1	1	1
CO5	2	2	1	1	-	1	-	-	-	1	-	1	1	1	1
CO/PO & PSO Average	**1.8**	**2**	**1**	**1**	**-**	**1**	**1**	**1**	**-**	**1**	**-**	**1**	**1**	**1**	**1**

1 – Slight, 2 – Moderate, 3 – Substantial

TEXT BOOKS:

1. Ajit K. Srivastava, Carroll E. Goering, Roger P. Rohrbach, Dennis R. Buckmaster, "Engineering Principles of Agricultural Machines", ASABE Publication, 2012.
2. Myer Kutz , "Handbook of Farm, Dairy and Food Machinery Engineering", Academic Press, 2019.

REFERENCES:

1. Qin Zhang, Francis J. Pierce, "Agricultural Automation Fundamentals and Practices", CRC Press, 2016.
2. Stephen L Young, Francis J. Pierce, "Automation: The Future of Weed Control in Cropping Systems", Springer, Dordrecht Heidelberg New York London, 2014.
3. R.A. Kepner, Roy Bainer, E.L. Barger, "Principles of Farm Machinery", 3rd Edition, CBS Publishers, New Delhi, 2005.
4. Guangnan Chen, "Advances in Agricultural Machinery and Technologies", 1st Edition, CRC Press, 2021.
5. Choudhury, A., Biswas, A., Singh, T.P. and Ghosh, S.K. eds., 2022. Smart Agriculture Automation Using Advanced Technologies: Data Analytics and Machine Learning, Cloud Architecture, Automation and IoT, Springer.
6. Young, S.L. and Pierce, F.J. eds., 2013. Automation: The future of weed control in cropping systems. Springer Science & Business Media.
7. Billingsley, J., 2019. Robotics and automation for improving agriculture. Burleigh Dodds Science Publishing Limited

VERTICAL 2: INDUSTRIAL AUTOMATION TECHNOLOGIES

RA23007	VIRTUAL INSTRUMENTATION	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

- Understand the history, principles, and advantages of Virtual Instrumentation.
- Develop proficiency in using LabVIEW software for creating, editing, and debugging Virtual Instruments.
- Gain knowledge and skills in data acquisition and control using Virtual Instruments.
- Explore different instrument interfaces and their applications in Virtual Instrumentation.
- Apply Virtual Instrumentation techniques in biomedical engineering for various applications.

UNIT – I INTRODUCTION 9

History of Virtual Instrumentation (VI), advantages, block diagram and architecture of a virtual instrument, Programming paradigms – Virtual Instrumentation – Lab VIEW software – Lab VIEW basics – Lab VIEW environment.

UNIT – II VI USING LABVIEW 9

Creating, Editing and debugging a VI in Lab VIEW – Creating a sub VI – Loops and charts – Case and sequence structures – File I/O – VI customization.

UNIT – III DATA ACQUISITION AND CONTROL IN VI 9

Plug-in DAQ boards – Organization of the DAQ VI System – Performing analog input and analog output – Scanning multiple analog channels – Driving the digital I/Os – Buffered data acquisition

– Simple problems.

UNIT – IV INSTRUMENT INTERFACES 9

Current loop, RS 232C/RS 485, GPIB, System basics, Interface basics: USB, PCMCIA, networking basics for office & industrial application VISA & IVI, image acquisition & processing, Motion Control. ADC, DAC, DIO, DMM, waveform generator.

UNIT – V CASE STUDIES 9

Data Acquisition by LabVIEW and NI Hardware – Temperature, Load, Strain, Accelerometer, Optical sensors - Current trends Voltage types

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Explain the historical development and benefits of Virtual Instrumentation.

CO2: Utilize LabVIEW software to create, edit, and debug Virtual Instruments effectively.

CO3: Perform data acquisition and control tasks using Virtual Instruments in different scenarios.

CO4: Apply various instrument interfaces, such as current loop, RS 232C/RS 485, and USB, for specific purposes in Virtual Instrumentation.

CO5: Design and implement Virtual Instrumentation applications in biomedical engineering, including ECG, EMG, and virtual prototyping, considering the specific requirements and challenges of the field.

Mapping of COs with POs and PSOs															
COs/ POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	-	-	-	-	-	-	1	-	1	1	2	1
CO2	2	1	1	-	1	-	-	-	-	1	-	1	1	2	1
CO3	2	2	2	-	1	-	-	-	-	1	-	1	1	2	1
CO4	2	2	2	1	1	-	-	-	-	1	-	1	1	2	1
CO5	2	2	2	1	1	-	-	-	-	1	-	1	1	2	1
CO/PO & PSO Average	**2**	**1.6**	**1.7**	**1**	**1**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**1**	**2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Gary Johnson, “LABVIEW Graphical Programming”, McGraw Hill, 5th edition, 2019.
2. Lisa K. Wells and Jeffrey Travis, “LABVIEW for Everyone”, PHI, 3rd edition 2006.
3. Skolkoff, “Basic concepts of LABVIEW 4”, PHI, 1998.
4. Jerome, Jovitha, “Virtual Instrumentation and LABVIEW”, PHI Learning, New Delhi, 1st Edition, 2010.
5. Sanjay Gupta and Joseph John, “Virtual Instrumentation using Lab VIEW”, Tata Mc Graw – Hill Publishing Company Limited, New Delhi, 1st Edition, 2010.

REFERENCES:

1. Kevin James, “PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control”, Newnes, 2003.
2. S. Gupta, J.P. Gupta, “PC Interfacing for Data Acquisition and Process Control”, ISA, 2nd Edition, 1994.
3. Technical Manuals for DAS Modules of Advantech and National Instruments.
4. Jon B. Olansen, Eric Rosow, “Virtual Bio-Instrumentation: Biomedical, Clinical, and Healthcare Applications in Lab VIEW” Pearson Education, 2001.

RA23008	INDUSTRIAL NETWORK PROTOCOLS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

- Analyze the characteristics and functionalities of wired and wireless networks.
- Evaluate the advantages and disadvantages of different communication protocols.
- Apply networking concepts to design and implement industrial wired and wireless networks.
- Critically assess the performance and reliability of communication protocols in real-world scenarios.
- Create innovative solutions using communication protocols for automation applications.

UNIT – I WIRED PROTOCOLS 9

Comparison of Wired and Wireless Networks - Serial Communication Protocols - RS232-UART- SPI - I2C- RS485 –UNI/O Bus -1 Wire -Camera Link - Parallel Communication -PPI - Wishbone Bus – AMBA – JTAG - Fireware IEEE 1394 Bus - Ethernet Overview.

UNIT – II WIRELESS PROTOCOLS 9

Network Topologies - Wireless Local Area Networks (WLAN) - Wireless Personal Area Networks (WPAN) - Wimedia – Wimax - RF – Bluetooth- Wi-Fi – Zigbee – Wireless Industrial Automation Protocols- NFC

UNIT – III INDUSTRIAL AND AUTONOMOUS SYSTEMS - WIRED NETWORKS 9

Overview of Industrial Wired Networks – Terminal Bus- Modbus - HART Network -Mechatrolink- II – EtherCAT- Sercos II/III – CAN- Canopen - Modbus IDA—Modbus TCP IP-PROFINET-PROFIBUS-Ethernet/IP- Ethernet Power link- AG Automation and Drives (AS-I) – MQTT– OPC DA/UA. – Gateway-Converters

UNIT – IV INDUSTRIAL WIRELESS NETWORKS 9

Overview of Industrial Wireless Networks - IWLAN - ISA100 Standards – Remote Networks- Controller-Based Networks - Wireless HART Technology - 4G/5G for Automation – RFID Tags - Reader.

UNIT – V APPLICATION OF COMMUNICATION PROTOCOLS 9

Wired Machine Networking of Sub-elements and Machines - Wireless Machine Networking of Subelements and Machines-Gateway, Converters, Switches – Networking of Industry -Data security Protocols- Communication Network Layout Design- Networking for TIA- Cloud Computing – IOT - Case Studies in Automation Applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Demonstrate a thorough understanding of wired and wireless network principles.

CO2: Evaluate and compare different communication protocols based on their features.

CO3: Design and implement industrial wired and wireless networks to meet specific requirements.

CO4: Analyze and troubleshoot networking issues in industrial and autonomous systems.

CO5: Develop effective communication strategies using protocols for automation applications.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	-	-	-	-	-	-	1	-	1	1	2	1
CO2	2	1	1	-	1	-	-	-	-	1	-	1	1	2	1
CO3	2	2	2	-	1	-	-	-	-	1	-	1	1	2	1
CO4	2	2	2	1	1	-	-	-	-	1	-	1	1	2	1
CO5	2	2	2	1	1	-	-	-	-	1	-	1	1	2	1
CO/PO & PSO Average	**2**	**1.6**	**1.75**	**1**	**1**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**1**	**2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. BorkoFurht, “Encyclopaedia of Wireless and Mobile Communications - Three Volume Set”, CRC Press, 2nd edition 2013.
2. Dick Caro, “Wireless Networks for Industrial Automation”,4th edition 2014.

REFERENCES:

1. MMC-SD SERCOS Drive, “G&L Motion Control”, Hardware Manual, 2005.
2. Olaf Pfeiffer, Andrew Ayre and Christian Keydel, “Embedded Networking with CAN and CANopen”, Copperhill Technologies Corporation, 2016.
3. Richard Zurawski, “Industrial Communication Technology”, CRC Press, 2017.
4. Siemens IK, “Industrial Ethernet: IEEE 802.3”, 2005.
5. Wolfram Behardt and Jorg Wollert, “The wireless B: Evolution and Communication”, Stetue Germany, 2016.

RA23009	FACTORY AUTOMATION ARCHITECTURE	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

- Gain the components and advantages of Totally Integrated Automation systems.
- Knowledge the role and necessity of Human Machine Interface (HMI) systems.
- Examine the architecture and functionality of Supervisory Control and Data Acquisition (SCADA) systems.
- Compare and contrast different communication protocols used in SCADA systems.
- Demonstrate an understanding of the architecture and applications of Distributed Control Systems (DCS).

UNIT – I ARCHITECTURE 9

Need, components of TIA systems, advantages, Programmable Automation Controllers (PAC), Vertical Integration structure.

UNIT – II HUMAN MACHINE INTERFACE (HMI) 9

Necessity and Role in Industrial Automation, Need for HMI systems. Types of HMI- Text display- Operator panels - Touch panels - Panel PCs - Integrated displays (PLC & HMI).

UNIT – III SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) 9

Overview – Developer and runtime packages – architecture – Tools – Tag – Internal &External graphics, Alarm logging – Tag logging – structured tags– Trends – history– Report generation, VB & C Scripts for SCADA application.

UNIT – IV COMMUNICATION PROTOCOLS OF SCADA 9

Proprietary and open Protocols – OLE/OPC- UPC UA/DA – DDE – Server/Client Configuration– Messaging – Recipe – User administration – Interfacing of SCADA with PLC, drive, and other field device.

UNIT – V DISTRIBUTED CONTROL SYSTEMS (DCS) 9

DCS – architecture – local control unit- programming language – communication facilities – operator interface – engineering interfaces. APPLICATIONS OF PLC & DCS: Case studies of Machine automation, Process automation, Introduction to SCADA Comparison between SCADA and DCS.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO 1: Apply analytical skills to assess the advantages and components of TIA systems.

CO 2: Justify the importance and relevance of HMI systems in industrial automation.

CO 3: Create graphical displays and reports using SCADA systems.

CO 4: Evaluate and select appropriate communication protocols for SCADA system integration.
CO 5: Design and implement control strategies using Distributed Control Systems (DCS) in various applications.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	-	-	-	-	-	-	1	-	1	2	2	2
CO2	2	1	1	-	1	-	-	-	-	1	-	1	2	2	2
CO3	2	2	2	1	1	-	-	-	-	1	-	1	2	2	2
CO4	2	2	2	1	1	-	-	-	-	1	-	1	2	2	2
CO5	2	2	3	1	1	-	-	-	-	1	-	1	2	2	2
CO/PO & PSO Average	**2**	**1.6**	**2**	**1**	**1**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**2**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. John. W. Webb& Ronald A. Reis, “Programmable logic controllers: Principles and Applications”, Prentice Hall India, 2009.
2. Michael P. Lukas, “Distributed Control systems”, “Van Nostrand Reinfold Company”2002.

REFERENCES:

1. Win C C Software Manual, Siemens, 2003
2. RS VIEW 32 Software Manual, Allen Bradly, 2005
3. CIMPLICITY SCADA Packages Manual, Fanuc India Ltd, 2004.
4. Programming Guideline for S7-1200/S7-1500 STEP 7 and STEP 7 Safety in TIA Portal, 2017

RA23010	BUILDING AUTOMATION	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

- Understand the concepts and principles of intelligent buildings and their evolution.
- Train the working principles and components of HVAC systems.
- Analyze and evaluate energy management systems and their impact on energy consumption.
- Demonstrate knowledge of safety systems and their components in building automation.
- Estimate the integration of different systems in intelligent buildings and assess their benefits.

UNIT – I INTRODUCTION 9

Intelligent Buildings - Definitions of intelligent building, Intelligent architecture and structure, Facilities management vs. intelligent buildings, Technology systems and evolution of intelligent buildings Features, Characteristics, Drawbacks of Building Automation system. Various Systems of Building Automation – Building Management System, Energy Management System, Security System, Safety System, Video Management System.

UNIT – II HVAC SYSTEM 9

Introduction, HVAC, Sensors & Transducers – Temperature, Pressure, Level, Flow, RH. Meaning of Analog & Digital Signals, Valves and Actuators, Valve & Actuator Selection, Various Controllers, Concept of Controller IOs, Std Signals, Signal Compatibility between Controller & Field Devices. AHU – Concept, Components, Working Principle. AC Plant Room – Concept, Components, Refrigeration Cycle Working Principle, Chiller Sequencing, AC Plant Sequencing. Feedback Control Loops, Heat – Types, Heat Transfer Principles, Measurement of Heat Transfer. Psychrometry –Concept, ASHRAE Psychrometric Chart, Meaning of Various Terms – DBT, WBT, ST, RH, DPT, Sensible & Latent Cooling & Heating, Numericals. Job IO Summary Calculation, Controller Sizing, AI to DI Conversion, Cable Selection, Earthing – Meaning, Importance, Panel Earthing, EMI & Tackling EMI. Logic Examples, CL Programming.

UNIT – III ENERGY MANAGEMENT SYSTEM 9

Concept, Energy Meters, Types, Meter Networking, Monitoring Energy Parameters, Analysis of Power Quality – Instantaneous Power, Active Power, Reactive Power, Power Factor, Voltage, Current. Effect of Power Quality on Energy Consumption, Energy Reports, Energy Conservation, Energy Audits, Methodologies to save Energy Saving-Solar Energy System in Building automation

UNIT – IV SAFETY SYSTEM 9

Introduction, Fire –Meaning, Fire Development Stages, Fire Sensors & Detectors, Detector Placement, Detectors Required for Various Applications. Fire Extinguishing Principles, Fire Extinguishers & Its Classification. Fire Alarm System – Controllers, Components, Features, Concept of Fire Loop & Fire Devices, 2-Wire & 4-Wire Loops, Working Principle, System Description, Pre-alarm, Alarm, Trouble, Fault, Differences, Cable Selection, Installation Guidelines Best Installation Practices, Logic Example. NFPA and IS2189 Stds, System Programming.

UNIT – V INTEGRATED SYSTEMS 9

Introduction, Integration of Building Management System, Energy Management System, Safety System, Security Systems & Video Management, Benefits of Integrated Systems, Challenges, Future Prospects of Integrated Systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Describe the characteristics and drawbacks of building automation systems in intelligent buildings.
CO2: Apply knowledge of HVAC systems, including sensors, controllers, and feedback control loops.
CO3: Analyze power quality parameters and their effect on energy consumption in energy management systems.
CO4: Evaluate the components and working principles of safety systems, such as fire sensors and detectors.
CO5: Discuss the integration of various systems in intelligent buildings and evaluate the challenges and future prospects.

Mapping of COs with POs and PSOs

COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	-	1	-	-	-	-	1	-	1	2	2	2
CO2	2	2	-	-	1	-	-	-	-	1	-	1	2	2	2
CO3	2	2	-	1	1	-	-	-	-	1	-	1	2	2	2
CO4	2	2	1	1	1	-	-	-	-	1	-	1	2	2	2
CO5	2	2	1	1	1	-	-	-	-	1	-	1	2	2	2
CO/PO & PSO Average	**2**	**1.8**	**1**	**1**	**1**	-	-	-	-	**1**	**-**	**1**	**2**	**2**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Shengwei Wang, Intelligent Buildings and Building Automation, 2009
2. Reinhold A. Carlson Robert A. Di Giandomenico, ‗Understanding Building Automation Systems: Direct Digital Control, Energy Management, Life Safety, Security Access Control, Lighting, Building‘,1st edition (R.S. Means Company Ltd), (1991).

REFERENCES:

1. Roger W. Haines, "HVAC system Design Handbook", fifth edition
2. National Joint Apprenticeship & Training Committee, Building Automation System Integration With Open Protocols: System Integration With Open Protocols
3. John I. Levenhagen and Donald H. Spethmann, HVAC Controls and Systems (Mechanical Engineering), 1992.
4. James E.Brumbaugh, "HVAC fundamentals", vol: 1 to 3.

EI23C01	ADVANCED TOPICS IN PID CONTROL	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

- To provide an overview of the features associated with Industrial type PID controller.
- To make the students understand the various PID Controller Design methods and about PID
- stabilization for Linear Time-invariant models.
- To develop the skills needed to design adaptive and non-linear PID control schemes.
- 4. To provide basic knowledge about Fractional-order systems and Fractional-order-controller and to lay
  the foundation for the systematic approach to Design controller for fractional order systems.

UNIT-I INTRODUCTION 9

Evolution of PID controller – PID Controller Structures – PID Implementation Issues – Tuning of PID Controller using Classical Approaches.

UNIT-II PID CONTROLLER DESIGN 9

PID Controller Design Techniques: Pole placement, Lamda Tuning, Direct Synthesis, Gain Margin &Phase Margin and Optimization methods - Auto-Tuning.

UNIT-III PID STABILIZATION 9

Stabilization of Linear Time-invariant Plants using P/PI/ PID controllers – Optimal Design using PIDControllers – Robust and Non-fragile PID Controller Design.

UNIT-IV ADAPTIVE/NON-LINEAR PID CONTROL SCHEMES 9

Gain Scheduled PID Controller - Self-tuning PI/PID Controller – PID Types Fuzzy Logic Controller – Predictive PID Control.

UNIT-V INTRODUCTION TO FRACTIONAL ORDER SYSTEM AND FRACTIONAL ORDER PID CONTROLLER 9

Fractional-order Calculus and Its Computations – Frequency and Time Domain Analysis of Fractional-Order Systems - Filter Approximations to Fractional-Order Differentiations –Model reduction Techniques for Fractional Order Systems – Fractional Order PI/PID Controller Design.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Determine the advanced features supported by the Industrial Type PID Controller.

CO2: Design & implement a P/PI/PID Controllers for a given process and validate through simulations

CO3: Design and implement optimal/ robust PID controller for a given process and validate through simulations.

CO4: Design and implement adaptive PID controllers and PID types Fuzzy Logic Controller for a given process and validate through simulations.

CO5: Analyze various PID control schemes and recommend the right control strategy for a given application in accordance with the industrial requirement.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	-	1	-	-	-	-	1	-	1	2	2	2
CO2	2	2	-	-	1	-	-	-	-	1	-	1	2	2	2
CO3	2	2	-	1	1	-	-	-	-	1	-	1	2	2	2
CO4	2	2	1	1	1	-	-	-	-	1	-	1	2	2	2
CO5	2	2	1	1	1	-	-	-	-	1	-	1	2	2	2
CO/PO & PSO Average	**2**	**1.8**	**1**	**1**	**1**	-	-	-	-	**1**	**-**	**1**	**2**	**2**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS:

1. Karl J. Astrom and Tore Haggland, “Advanced PID Control”, ISA Publications, 2005.
2. Aniruddha Datta, Ming-Tzu Ho, and Shankar P. Bhattacharyya, “Structure and Synthesis of PID Controllers”, Advances in Industrial Control, Springer Verlag London, 2000.

REFERENCES:

1. Antonio Visioli, “Practical PID Control” Springer- Verlag London, 2006
2. Aidan O' Dwyer, “Handbook of PI and PID Controller Tuning Rules”, Imperial College Press, 2009
3. Xue, D., Chen, Y.Q., and Atherton, D.P., "Linear Feedback Control Analysis and Design with MATLAB, Advances in Design and Control", Society for Industrial and Applied Mathematics, 2008

RA23C01	ENGINEERING DATA ANALYTICS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

- The main learning objective of this course is to prepare the students to:
- Master data analytics using Microsoft Excel, from fundamental concepts and descriptive statistics to advanced statistical analysis, data visualization, and big data techniques

UNIT – I INTRODUCTION TO DATA ANALYTICS 9

Introduction to data analytics: concepts, importance, and applications -Introduction to Microsoft Excel: basic operations, functions, and data manipulation- Data types and formats in Excel - importing data into Excel: text files, CSV, databases. Data cleaning techniques: handling missing data, duplicate records, and outliers. Text functions and data transformation, Database Functions, Web Functions

UNIT – II DESCRIPTIVE STATISTICS 9

Calculating descriptive statistics: mean, median, mode, variance, standard deviation – ANOVA, MANOVA, T-test, Statistical Distributions - Statistical Analysis Functions in excel

UNIT – III DATA VISUALIZATION AND REPORTING 9

Creating and interpreting charts and graphs: histograms, bar charts, scatter plots.Advanced charting techniques: sparklines, trendlines, and conditional formatting. Creating interactive dashboards in Excel - introduction to Excel VBA for automation in data analysis tasks - PivotTables and PivotCharts for data summarization and visualization - Excel's built-in data analysis tools: Solver, Data Tables, Scenario Manager -Power Query for data transformation and integration

UNIT – IV ADVANCED STATISTICAL ANALYSIS 9

Multivariate statistical techniques: factor analysis, cluster analysis - Time series analysis and forecasting methods -Bayesian statistics and its applications.

UNIT – V BIG DATA ANALYTICS 9

Introduction to big data concepts and technologies (Hadoop, Spark) - Data mining in large-scale datasets - Real-time analytics and streaming data processing - Data Visualization and Communication - Advanced data visualization techniques: interactive dashboards, geospatial visualization.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Understand foundational concepts and importance of data analytics
CO2: Proficiency in data manipulation and cleaning techniques using Excel
CO3: Apply descriptive statistical techniques and interpret results using Excel
CO4: Design and create effective data visualizations and reports in Excel
CO5: Apply advanced statistical techniques and tools for data analysis in Excel

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
	1	1	2	1	2	-	-	-		1	-	1	1	1	2
	2	2	2	1	2	-	-	-	-	1	-	1	1	1	2
	1	1	3	1	2	-	-	-	-	1	-	1	1	1	2
	2	2	2	2	3	-	-	-	-	1	-	1	1	1	2
	1	1	2	1	2	-	-	-	-	1	-	1	1	1	2
/PO & PSO Average	**1.6**	**1.4**	**2.2**	**1.2**	**2.2**	**-**	**-**		**-**	**1**	**-**	**1**	**1**	**1**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Michael Alexander and Richard Kusleika, Excel 2019 Bible, 2019, 5th EditionWiley.

REFERENCES:

1. Michael Alexander and Richard Kusleika, Excel 2019 Power Programming with VBA, Willey.
2. Gordon S. Linoff, Data Analysis Using SQL and Excel, 2016, Willey.
3. Denise Etheridge, Excel Data Analysis, Visual publisher; 3rd edition, 2 July 2010.
4. Frank J. Ohlhorst, "Big Data Analytics: Turning Big Data into Big Money, 2015,Wiley and SAS Business Series

VERTICAL 3: INTELLIGENT SYSTEMS

RA23011	PROGRAMMING FOR ROBOTICS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

- Understand computational thinking principles to identify and analyze computational problems.
- Learn the algorithms using appropriate building blocks and problem-solving strategies.
- Utilize different data types, expressions, and statements in Python programming.
- Implement control flow structures, functions, and string manipulation techniques.
- Manage and manipulate data using lists, tuples, dictionaries, and advanced list processing.

UNIT – I COMPUTATIONAL THINKING AND PROBLEM SOLVING 9

Fundamentals of Computing – Identification of Computational Problems -Algorithms, building blocks of algorithms (statements, state, control flow, functions), notation (pseudo code, flow chart, programming language), algorithmic problem solving, simple strategies for developing algorithms (iteration, recursion). Illustrative problems: find minimum in a list, insert a card in a list of sorted cards, guess an integer number in a range, Towers of Hanoi.

UNIT – II DATA TYPES, EXPRESSIONS, STATEMENTS 9

Python interpreter and interactive mode,debugging; values and types: int, float, boolean,string, and list; variables, expressions, statements, tuple assignment, precedence of operators, comments; Illustrative programs: exchange the values of two variables, circulate the values of n variables, distance between two points.

UNIT – III CONTROL FLOW, FUNCTIONS, STRINGS 9

Conditionals: Boolean values and operators, conditional (if), alternative (if-else), chained conditional (if-elif-else); Iteration: state, while, for, break, continue, pass; Fruitful functions: return values, parameters, local and global scope, function composition, recursion; Strings:
string slices,immutability, string functions and
methods, string module; Lists as arrays. Illustrative programs: square root, gcd, exponentiation, sum an array of numbers, linear search, binary search.

UNIT – IV LISTS, TUPLES, DICTIONARIES 9

Lists: list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, list parameters; Tuples: tuple assignment, tuple as return value; Dictionaries: operations and methods; advanced list processing - list comprehension; Illustrative programs: simple sorting, histogram, Students marks statement, Retail bill preparation.

UNIT – V FILES, MODULES, PACKAGES 9

Files and exception: text files, reading and writing files, format operator; command line arguments, errors and exceptions, handling exceptions, modules, packages; Illustrative programs: word count, copy file, Voter's age validation, Marks range validation (0-100) – python based machine learning and deep learning platforms.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Demonstrate proficiency in identifying and analyzing computational problems using computational thinking techniques.
CO2: Design and implement algorithms using appropriate building blocks and problem-solving strategies.
CO3: Utilize Python programming language effectively for data types, expressions, and statements.
CO4: Apply control flow structures, functions, and string manipulation techniques in programming solutions.
CO5: Represent lists, tuples, dictionaries, and advanced list processing to manage and manipulate data efficiently.

Mapping of COs with POs and PSOs

COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	1	1	-	-	-	-	1	-	1	1	2	1
CO2	2	1	3	1	1	-	-	-	-	1	-	1	1	2	1
CO3	1	1	-	1	1	-	-	-	-	1	-	1	1	2	1
CO4	1	1	-	1	1	-	-	-	-	1	-	1	1	2	1
CO5	1	1	-	1	1	-	-	-	-	1	-	1	1	2	1
CO/PO & PSO Average	**1.4**	**1**	**3**	**1**	**1**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**1**	**2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Allen B. Downey, “Think Python: How to Think like a Computer Scientist”, 2nd Edition, O’Reilly Publishers, 2016.
2. Karl Beecher, “Computational Thinking: A Beginner's Guide to Problem Solving and programming”, 1st Edition, BCS Learning & Development Limited, 2017.

REFERENCES:

1. Paul Deitel and Harvey Deitel, “Python for Programmers”, Pearson Education, 1st Edition, 2021.
2. G Venkatesh and Madhavan Mukund, “Computational Thinking: A Primer for Programmers and Data Scientists”, 1st Edition, Notion Press, 2021.
3. John V Guttag, &Quot;Introduction to Computation and Programming Using Python: With Applications to Computational Modeling and Understanding Data‘‘, Third Edition, MIT Press 2021
4. Eric Matthes, “Python Crash Course, A Hands - on Project Based Introduction to Programming”, 2nd Edition, No Starch Press, 2019.
5. https://www.python.org/
6. Martin C. Brown, “Python: The Complete Reference”, 4th Edition, Mc-Graw Hill, 2018.

RA23012	MEDICAL MECHATRONICS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

- Understand the fundamental concepts of bio-medical instrumentation and measurement.
- Identify and analyze different types of transducers used in bio-medical instrumentation.
- Apply signal conditioning techniques for amplification and processing of bio-medical signals.
- Explain the principles and techniques used in medical support systems.
- Utilize diagnostic instrumentation techniques for analysis and interpretation of bio-medical data.

UNIT – I INTRODUCTION 9

Role of Mechatronics in Medical – Overview of human functional system – cell and origin bioelectric potential-Measurement of blood pressure-invasive and non invasive methods transducers role in measurement–Heart rate – pressure-temperature- Heart sound – Pulmonary function measurements

UNIT – II ASSISTING AND THERAPEUTIC EQUIPMENTS 9

Pacemakers – Defibrillators – Ventilators – Nerve and muscle stimulators – Diathermy – Heart Lung machine –– Dialyzers – centrifuge- coagulators- aspirator – oximeter – spirometer- Nebulizer – Anesthesia machine-Operating Table – examination couches- infusion systems.

UNIT – III CARDIAC AND REGULATORY ASSIST SYSTEM 9

Defibrillator - Muscle and nerve stimulator, Location for Stimulation -Synchronous Counter pulsation, Assisted through Respiration Right Ventricular Bypass Pump, Left Ventricular Bypass Pump, Open Chest and closed Chest type, Intra-Aortic Balloon Pumping Veno Arterial Pumping, Prosthetic Cardio Valves, Principle and problem, Biomaterials for implantable purposes, its characteristics and testing. Lithotripsy-Indication and Principle of Haemodialysis, Membrane, Dialysate, Different types of haemodialysis, Monitoring Systems, Wearable Artificial Kidney,Implanting Type.

UNIT – IV MEDICAL IMAGING 9

Radio graphic and fluoroscopic techniques –XRay machine- Computer tomography – MRI – FMRIUltrasonography – Endoscopy – Colonoscopy -Thermography – Different types of biotelemetry systems and patient monitoring – PET- Introduction to Biometric systems.

UNIT – V SENSORY ASSIST DEVICES AND AUTOMATED ANALYSER 9

Types of deafness, hearing aids, application of DSP in hearing aids- Ear irrigator- Voice synthesizer, speech trainer. Ultra sonic and laser canes, Intra ocular lens, Braille Reader, Tactile devices for visually challenged, ophthalmoscopy Text voice converter, screen readers and automated analyser and medical equipment's.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO 1: Demonstrate knowledge of cell structure and the measurement of bioelectric potentials.

CO2: Apply transducer principles to select appropriate sensors for bio-medical instrumentation.

CO3: Design and implement signal conditioning circuits for bio-medical signals.

CO4: Analyze and interpret bio-medical measurements using medical support equipment and techniques.
CO5: Utilize diagnostic instrumentation tools for the analysis and interpretation of bio-medical data.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	1	-	1	-	-	-	1	-	1	1	2	2
CO2	2	1	1	1	-	1	-	-	-	1	-	1	1	2	2
CO3	2	1	3	1	-	1	-	1	-	1	-	1	1	2	2
CO4	2	1	1	1	-	1	-	1	-	1	-	1	1	2	2
CO5	2	1	1	1	-	1	-	1	-	1	-	1	1	2	2
CO/PO & PSO Average	**2**	**1**	**1.5**	**1**	**-**	**1**	**-**	**1**	**-**	**1**	**-**	**1**	**1**	**2**	**2**

TEXT BOOKS

1. Arumugam M., “Bio Medical Instrumentation”, Anuradha agencies Pub., 2003
2. Cromwell, Weibell and Pfeiffer, “Biomedical Instrumentation and Measurements”, Printice Hall of india, 2nd Edition, 2018.
3. Siamak Najarian“Mechatronics in Medicine – A Bio medical Engg approach", McGraw – Hill Education, 1st Edition, 2011.

REFERENCES:

1. R.S.Khandpur, “Hand Book of Bio-Medical instrumentation”, Tata McGraw Hill Publishing Co Ltd., 2003.
2. Leslie Cromwell, Fred J.Weibell, Erich A.Pfeiffer, “Bio-Medical Instrumentation and Measurements”, II edition, Pearson Education, 2002 / PHI.
2. M.Arumugam, “Bio-Medical Instrumentation”, Anuradha Agencies, 2003.
3. Geddes LA and Baker L.E Principals of Applied Biomedical Instrumentation, John Wiley and sons Newyork 1975.
4. Albert M Cook and Webster J G – Therapeutic medical devices Prentice Hall Nee York 1982.
5. Alfred Horowitz, “MRI Physics for Radiologists – A Visual Approach’, Second edition Springer Verlag Network, 1991.
6. John L.Semmlow,”Biosignal and Biomedical Image Processing Matlab Based applications” Marcel Dekker Inc.,New York,2004.
7. Jerry L.Prince and Jnathan M.Links,” Medical Imaging Signals and Systems”- Pearson Education Inc. 2006
8. Kolff W.J., Artificial Organs, John Wiley and Sons, New York, 1979.
9. Andreas.F.Von racum, Hand book of bio material evaluation, Mc-Millan publishers, 1980.

RA23013	CLOUD POINT DATA PROCESSING	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

- Introduce the principles and techniques of LiDAR
- Understand geometric representation and mesh reconstruction
- Apply segmentation methods to extract meaningful regions from images.
- Implement feature extraction techniques for image enhancement.
- Demonstrate understanding of image processing algorithms and their applications.

UNIT I INTRODUCTION TO LIDAR 9

Introduction to LiDAR Technology – Principles of LiDAR operation – Data acquisition methods – Overview of LiDAR applications in various industries – Methodologies for analyzing LiDAR data

UNIT – II GEOMETRIC REPRESENTATION AND MESH RECONSTRUCTION 9

Polygon Mesh Reconstruction – Surface representation – Triangulation from LiDAR points – Delaunay triangulation, Alpha shapes methods – voxelization

UNIT – III SEGMENTATION 9

Bounding Box calculation – Point Cloud segmentation – Region growing – Clustering algorithms – DBSCAN, Meanshift – Surface fitting - RANSAC

UNIT – IV FEATURE EXTRACTION 9

Extracting features – edges, corners, keypoints from LiDAR data – Harris corner detection, SIFT?SURF keypoints, Deep Learning-based approaches – Convolutional Neural Networks – Prediction and classification of objects from LiDAR data

UNIT – V CASE STUDIES 9

Application of Image processing in Autonomous driving, Urban Planning, Environmental monitoring – LiDAR based object shape and size estimation

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:
CO1: Demonstrate proficiency in applying geometric transformations to manipulate images.
CO2: Evaluate and select appropriate feature detection methods for specific applications.
CO3: Implement computational photography techniques to enhance image quality.
CO4: Develop and evaluate image recognition systems for object, face, and category recognition.
CO5:Design an image recognition for given application.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	1	-	-	-	-	-	1	-	1	2	1	1
CO2	2	2	3	1	-	-	-	-	-	1	-	1	2	1	1
CO3	2	2	-	1	-	-	-	-	-	1	-	1	2	1	1
CO4	2	2	1	1	-	-	-	-	-	1	-	1	2	1	1
CO5	2	2	3	1	-	-	-	-	-	1	-	1	2	1	1
CO/PO & PSO Average	**2**	**2**	**2.3**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer, 2010.
2. Hartley R, Zisserman A, "Multiple View Geometry in Computer Vision", Cambridge University Press, 2004.

REFERENCES:

1. Forsyth D A, Ponce J, “Computer Vision: A Modern Approach”, 2nd Edition Bostan Pearson, 2015
2. Duda R O, Hart P E, Stork D G, "Pattern Classification", Wiley, 2001.
3. Richard Sc "Computer Vision: Algorithms and Applications", Springer, 2010.
4. Simon J.D.Prince "Computer Vision: Models, Learning and Inference", Cambridge University Press, New York, 2014.

RA23014	WEARABLE DEVICES	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

- Define the concepts and components of wearable systems and sensors.
- Analyze the challenges and drawbacks of conventional wearable monitoring systems.
- Evaluate different types of sensors used in wearable systems.
- Apply signal processing techniques for data acquisition and energy harvesting in wearables.
- Assess the applications and benefits of wearable systems in healthcare.

UNIT – I INTRODUCTION TO WEARABLE SYSTEMS AND SENSORS 9

Wearable Systems- Introduction, Need for Wearable Systems, Drawbacks of Conventional Systems for Wearable Monitoring, Applications of Wearable Systems, Types of Wearable Systems, Components of wearable Systems. Sensors for wearable systems-Inertia movement sensors, Respiration activity sensor, Impedance plethysmography, Wearable ground reaction force sensor.

UNIT – II SIGNAL PROCESSING AND ENERGY HARVESTING FOR WEARABLE DEVICES 9

Wearability issues -physical shape and placement of sensor, Technical challenges - sensor design, signal acquisition, sampling frequency for reduced energy consumption, Rejection of irrelevant information. Power Requirements- Solar cell, Vibration based, Thermal based, Human body as a heat source for power generation, Hybrid thermoelectric photovoltaic energy harvests, Thermopiles- SAR

UNIT – III WIRELESS HEALTH SYSTEMS 9

Need for wireless monitoring, Definition of Body area network, BAN and Healthcare, Technical Challenges- System security and reliability, BAN Architecture – Introduction, Wireless communication Techniques.

UNIT – IV SMART TEXTILE 9

Introduction to smart textile- Passive smart textile, active smart textile. Fabrication Techniques- Conductive Fibres, Treated Conductive Fibres, Conductive Fabrics, conductive Inks.Case study- smart fabric for monitoring biological parameters - ECG, respiration.

UNIT – V APPLICATIONS OF WEARABLE SYSTEMS 9

Medical Diagnostics, Medical Monitoring-Patients with chronic disease, Hospital patients, Elderly patients, neural recording, Gait analysis, Sports Medicine, Smart Bag

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Explain the key features and components of wearable systems and sensors.
CO2: Evaluate the limitations and advantages of conventional and wearable monitoring systems.
CO3: Analyze and select appropriate sensors for specific wearable applications.
CO4: Implement signal processing and energy harvesting techniques for wearable devices.
CO5: Apply wearable systems for medical diagnostics, monitoring, and healthcare applications.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	-	-	-	-	-	-	1	-	1	1	1	1
CO2	2	1	-	1	-	-	-	-	-	1	-	1	1	1	1
CO3	2	3	-	1	1	1	-	1	-	1	-	1	1	1	1
CO4	2	1	1	1	-	-	-	1	-	1	-	1	1	1	1
CO5	2	1	1	1	-	1	-	1	-	1	-	1	1	2	1
CO/PO & PSO Average	**2**	**1.5**	**1**	**1**	**1**	**1**	**-**	**1**	**-**	**1**	**-**	**1**	**1**	**1.2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Annalisa Bonfiglio and Danilo De Rossi, “Wearable Monitoring Systems”, Springer, 2011
2. Zhang and Yuan-Ting, “Wearable Medical Sensors and Systems”, Springer, 2023

REFERENCES:

1. Sandeep K.S, Gupta, Tridib Mukherjee and Krishna Kumar Venkatasubramanian, “Body Area Networks Safety, Security, and Sustainability”, Cambridge University Press, 2013.
2. Guang-Zhong Yang, “Body Sensor Networks”, Springer, 2nd Edition, 2016.
3. Edward Sazonov and Micheal R Neuman, “Wearable Sensors: Fundamentals, Implementation and Applications”, Elsevier, 2015
4. Mehmet R. Yuce and JamilY.Khan, “Wireless Body Area Networks Technology, Implementation applications”,Pan Stanford Publishing Pte.Ltd, Singapore, 2012

RA23015	COMPUTATIONAL METHOD AND ALGORITHMS	L	T	P	TCP
	Common To Industrial	3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

- To articulate the C / C++ syntax.
- To use of algorithm design methods for heuristic design.
- To compare various data structures and its applications.
- To analysis of the complexity of Algorithms.
- To use of search procedure for IE applications.

UNIT – I REVIEW OF A LANGUAGE 9

Review of C/C++- writing and debugging large programs – Controlling numerical errors.

UNIT – II ALGORITHM DESIGN METHODS 9

Greedy–Divide and conquer–Backtracking–Branch & bound–Heuristics-Metaheuristics

UNIT – III BASIC TOOLS 9

Structured approach–Networks–Trees–Data structures

UNIT – IV COMPUTATIONALPERFORMANCE 9

Time complexity–Space complexity– Algorithm complexity

UNIT – V APPLICATIONS 9

Sorting–Searching-Networks–Scheduling–Optimization models–IE applications

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1. Use a structured language for program, debug and obtain expected output.
CO2. Choose and apply available algorithm design methods for problems.
CO3. Choose appropriate data structure for data representation, storage and organization.
CO4. Analyze the time complexity of algorithm.
CO5. Choose appropriate search and sort procedure in IE applications.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	1	-	-	-	1	-	-	-	-	-	-	1			
CO2	1	2	3	1	1	-	-	-	-	-	-	1			
CO3	1	2	3	1	1	-	-	-	-	-	-	1			
CO4	1	2	2	3	1	-	-	-	-	-	-	1			
CO5	1	2	2	3	1	-	-	-	-	-	-	1			
CO/PO & PSO Average	**1**	**2**	**2.5**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**1**			
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Panneerselvam.R," Design and Analysis of Algorithms", Prentice Hall of India,2016.

REFERENCES:

1. Dromey,R.G., "How to solve it with computers?",PHI, 2002.
2. Goodman S F and HeadtruemuST , "Introduction to design of algorithms", McGraw Hill,2002.
3. Sahni, "Data Structures, algorithms and applications in C++", McGraw Hill, 2003.
4. Anany Levitin, "Introduction to the Design and Analysis of Algorithms", Pearson, 2017.

RA23016	COMPUTER VISION AND DEEP LEARNING	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

- Understand the principles of image formation and camera calibration.
- Learn reconstruct 3D structure and motion from image data.
- Apply active vision techniques and robotic vision systems.
- Familiar the fundamentals of neural networks and their applications in computer vision.
- Interpret the deep learning techniques for image analysis and recognition.

UNIT – I IMAGE FORMATION AND CAMERA CALIBRATION 9

Basics: Sampling Theorem – Numerical Differentiation – Singular Value Decomposition Introduction to Vision, Terminologies of Fields, Comparison of Biological and Computer Vision, Projective Geometry Basics, Modelling of Geometric Image Formation, Modelling of Camera Distortion, Camera Calibration, Methods of Camera Calibration, Estimation of Projection Matrix, Experimental Performance Assessment in Computer Vision.

UNIT – II 3-D STRUCTURE AND MOTION 9

Computational Stereopsis – Geometry, Parameters – Correspondence Problem, Epipolar Geometry, Essential Matrix and Fundamental Matrix, Eight Point Algorithm – Reconstruction by Triangulation, Visual Motion – Motion Field of Rigid Objects – Optical Flow – Estimation of Motion Field – 3D Structure and Motion from Sparse and Dense Motion Fields – Motion Based Segmentation – Image Processing.

UNIT – III ACTIVE AND ROBOT VISION 9

LIDAR - Construction, Working Principle, Specifications and Selection Criteria. Point Cloud Data Processing. Visual Tracking – Kalman Filtering – Visual SLAM, Solutions, Visual Servoing, Types and Architecture.

UNIT – IV INTRODUCTION TO CNN 9

Convolutional Neural Networks - Convolution, Pooling, Activation Functions, Loss Function, Initialization, Dropout, Batch Normalization, Deep Learning Hardware - CPU, GPU and TPU -Tuning Neural Networks, Best Practices, Training Neural Networks, Update Rules, Ensembles, Data Augmentation,

UNIT – V DEEP LEARNING 9

Transfer Learning, Popular CNN Architectures for Image Classification – Alexnet, VGG, Resnet, , Inception, CNN Architectures for Object Detection – RCNN and Types – YOLO - Semantic Segmentation - FCN, Instance Segmentation - Mask RCNN – Deep Learning frameworks- performance metrics-case studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Understand the knowledge of image formation, camera distortion, and calibration techniques.
CO2: Apply computational stereopsis and epipolar geometry for 3D reconstruction.

CO3: Model visual tracking, visual SLAM, and visual servoing methods.

CO4: Acquire the basics of neural networks, backpropagation, and deep learning in computer vision.

CO5: Utilize convolutional neural networks and deep learning frameworks for image classification and object detection.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	1	1	-	-	-	-	1	-	1	2	2	2
CO2	2	2	-	1	1	-	-	-	-	1	-	1	2	2	2
CO3	2	2	-	1	1	-	-	-	-	1	-	1	2	2	2
CO4	2	2	-	1	1	-	-	-	-	1	-	1	2	3	2
CO5	2	1	1	1	2	-	-	-	-	1	-	1	2	3	2
CO/PO & PSO Average	**2**	**1.7**	**1**	**1**	**1.2**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**2.4**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. BoguslawCyganek, J. Paul Siebert, “An Introduction to 3D Computer Vision Techniques and Algorithms”, 2nd edition, John Willey, 2017.
2. Davies E.R, “Computer and Machine Vision: Theory, Algorithm, Practicalities”, 4th edition Academic Press, Elsevier, Waltham 2012.
3. Emanuele Trucco, Alessandro Verri, “Introductory Techniques for 3D Computer Vision”, Prentice Hall, South Asia, 2006.

REFERENCES:

1. Rafael C. Gonzales, Richard.E.Woods, “Digital Image Processing”, 3rd edition, Gatesmark Publishing, Tenessee 2020.
2. Emanuele Trucco, Alessandro Verri, “Introductory Techniques for 3D Computer Vision”, Prentice Hall, 1998.
3. Ian Goodfellow and YoshuaBengio and Aaron Courville, “Deep Learning”, First Edition, MIT Press, 2018.
4. Forsyth and Ponce, “Computer Vision: A Modern Approach”, 2nd edition Pearson, Harlow Uk 2015.

VERTICAL 4: SMART MOBILITY SYSTEMS

RA23017	ARCHITECTURE OF ELECTRIC AND HYBRID VEHICLES	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

- Analyze the design considerations and requirements for electric vehicles.
- Evaluate different energy sources and their suitability for electric vehicles.
- Compare and contrast various motors and drives used in electric vehicles.
- Examine power converters and controllers for efficient operation of electric vehicles.
- Apply knowledge of hybrid and electric vehicle components and configurations.

UNIT – I DESIGN CONSIDERATIONS FOR ELECTRIC VEHICLES 9

Need for Electric vehicle- Comparative study of diesel, petrol, hybrid and electric Vehicles. Advantages and Limitations of hybrid and electric Vehicles - Architectureof hybrid and electric Vehicles - Design requirement for electric vehicles- Range, maximum velocity, acceleration, power requirement, mass of the vehicle. Various Resistance- Transmission efficiency- Electric vehicle chassis and Body Design, Electric Vehicle Recharging and Refuelling Systems.

UNIT – II ENERGY SOURCES 9

Battery Parameters - Different types of batteries – Lead Acid- Nickel Metal Hydride - Lithium ion- Sodium based- Metal Air. Battery Modelling - Equivalent circuits, Battery charging- Quick Charging devices. Fuel Cell- Fuel cell Characteristics- Fuel cell types-Half reactions of fuel cell. Ultra capacitors. Battery Management System- charging stations and standards

UNIT – III MOTORS AND DRIVES 9

Types of Motors- DC motors- AC motors, PMSM motors, BLDC motors, Switched reluctance motors working principle, construction and characteristics.

UNIT – IV POWER CONVERTERS AND CONTROLLERS 9

Solid state Switching elements and characteristics – BJT, MOSFET, IGBT, SCR and TRIAC - Power Converters – rectifiers, inverters and converters - Motor Drives - DC, AC motor, PMSM motors, BLDC motors, Switched reluctance motors – four quadrant operations –operating modes.

UNIT – V HYBRID AND ELECTRIC VEHICLES 9

Main components and working principles of a hybrid and electric vehicles, Different configurations of hybrid and electric vehicles. Power Split devices for Hybrid Vehicles - Operation modes - Control Strategies for Hybrid Vehicle - Economy of hybrid Vehicles - Case study on specification of electric and hybrid vehicles.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

1. Demonstrate a comprehensive understanding of the design considerations for electric vehicles.
2. Evaluate the advantages and limitations of different energy sources for electric vehicles.
3. Apply principles of motors and drives to analyze their functionality in electric vehicles.
4. Design and implement power converters and controllers for efficient electric vehicle operation.
5. Analyze and evaluate hybrid and electric vehicle systems for optimal performance.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	-	-	-	-	-	-	1	-	1	1	1	1
CO2	2	2	1	-	-	-	-	-	-	1	-	1	1	1	1
CO3	2	1	-	-	-	-	-	-	-	1	-	1	1	1	1
CO4	2	1	3	-	-	-	-	-	-	1	-	1	1	1	1
CO5	2	2	1	-	-	-	-	-	-	1	-	1	1	1	1
CO/PO & PSO Average	**2**	**1.4**	**1.6**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**1**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Iqbal Husain, " Electric and Hybrid Vehicles-Design Fundamentals", CRC Press,2nd edition, 2010
2. Mehrdad Ehsani, Modern Electric, Hybrid Electric and Fuel Cell Vehicles", CRCPress,3rd edition, 2018.

REFERENCES:

1. James Larminie and John Lowry, "Electric Vehicle Technology Explained " John Wiley & Sons,2nd edition 2012
2. Lino Guzzella, " Vehicle Propulsion System" Springer Publications,2005
3. Ron HodKinson, "Light Weight Electric/ Hybrid Vehicle Design", Butterworth Heinemann Publication,2005.

RA23018	AUTOMOTIVE MECHATRONICS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

- Understand the evolution of electronics in automobiles and the impact of emission laws.
- Explain the working principles and design of charging systems, ignition systems, and fuel control systems in automobiles.
- Analyze the function and characteristics of sensors and actuators used in automotive systems.
- Evaluate different engine control subsystems and their control modes in modern automobiles.
- Discuss the operation and role of chassis and safety systems in vehicles.

UNIT – I INTRODUCTION 9

Evolution of electronics in automobiles – emission laws – introduction to Euro I, Euro II, Euro III, Euro IV, Euro V standards – Equivalent Bharat Standards. Charging systems: Working and design of charging circuit diagram – Alternators – Requirements of starting system - Starter motors and starter circuits.

UNIT – II IGNITION AND INJECTION SYSTEMS 9

Ignition systems: Ignition fundamentals - Electronic ignition systems - Programmed Ignition – Distribution less ignition - Direct ignition – Spark Plugs. Electronic fuel Control: Basics of combustion – Engine fuelling and exhaust emissions – Electronic control of carburetion – Petrol fuel injection – Diesel fuel injection.

UNIT – III SENSOR AND ACTUATORS IN AUTOMOTIVES 9

Working principle and characteristics of Airflow rate, Engine crankshaft angular position, Hall effect, Throttle angle, temperature, exhaust gas oxygen sensors – study of fuel injector, exhaust gas recirculation actuators, stepper motor actuator, and vacuum operated actuator.

UNIT – IV ENGINE CONTROL SYSTEMS 9

Control modes for fuel control-engine control subsystems – ignition control methodologies – different ECU’s used in the engine management – block diagram of the engine management system. In vehicle networks: CAN standard, format of CAN standard – diagnostics systems in modern automobiles.

UNIT – V CHASSIS AND SAFETY SYSTEMS 9

Traction control system – Cruise control system – electronic control of automatic transmission –antilock braking system – electronic suspension system – working of airbag and role of MEMS in airbag systems – centralized door locking system – climate control of cars.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Demonstrate knowledge of the evolution of electronics in automobiles and the importance of emission laws.

CO2: Apply principles of charging systems, ignition systems, and fuel control systems to analyze and design automotive circuits.
CO3: Evaluate the performance and characteristics of sensors and actuators in automotive applications.
CO4: Analyze engine control subsystems and their modes of operation in the management of fuel and ignition.
CO5: Explain the function and operation of chassis and safety systems in vehicles, including traction control, cruise control, braking systems, and airbag systems.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	-	-	-	-	-	-	1	-	1	2	1	2
CO2	2	1	2	-	-	-	-	-	-	1	-	1	2	1	2
CO3	2	1	2	-	-	-	-	-	-	1	-	1	2	1	2
CO4	2	1	2	-	-	-	-	-	-	1	-	1	2	1	2
CO5	2	2	1	-	-	-	-	-	-	1	-	1	2	1	2
CO/PO & PSO Average	**2**	**1.2**	**1.7**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**1**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Ribbens, "Understanding Automotive Electronics", 8th Edition, Elsevier, Indian Reprint, 2017.

REFERENCES:

1. Barry Hollembeak, “Automotive Electricity, Electronics & Computer Controls”, Delmar Publishers, 7th edition, 2019.
2. Richard K. Dupuy “Fuel System and Emission controls”, Check Chart Publication,4th edition, 2000.
3. Ronald. K. Jurgon, “Automotive Electronics Handbook”, McGraw-Hill, 1999.
4. Tom Denton, “Automobile Electrical and Electronics Systems”, Edward Arnold Publishers, 2000.

RA23019	AUTOMOTIVE SYSTEM MODELLING AND SIMULATION	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

- Analyze the design principles and material selection for cylinders, pistons, and connecting rods.
- Evaluate the performance and functionality of crankshafts, valves, clutches, gears, vehicle frames, and suspension systems.
- Apply design techniques to develop efficient and reliable components such as clutch assemblies, gearboxes, and axles.
- Create innovative designs for vehicle components and systems, considering factors like loads, stresses, and optimization.
- Understand the principles and concepts underlying the design of engine components, vehicle frames, and suspension systems.

UNIT – I DESIGN OF CYLINDER, PISTON AND CONNECTING ROD 9

Choice of material for cylinder and piston, design of cylinder, design of piston, piston pin, piston rings and piston assembly. Material for connecting rod, design of connecting rod assembly. Case study on piston for car with Modelling and simulation.

UNIT – II DESIGN OF CRANK SHAFT AND VALVES 9

Material for crankshaft, design of crankshaft under bending and twisting. Design aspects of intake & exhaust manifolds, inlet & exhaust valves, valve springs, tappets and valve train. Design of cam& camshaft. Design of rocker arm. Cam profile generation. 3D Engine simulation: Introduction to thermal and flow analysis in engine cylinder, modeling of cylinder and piston for combustion analysis.

UNIT – III DESIGN OF CLUTCHES AND GEARS 9

Design of single plate clutch, multiplate clutch and cone clutch assembly. Torque capacity of clutch. Design of clutch components. Gear train calculations, layout of gearboxes. Calculation of bearing loads and selection of bearings. Design of three speed and four speed gearboxes. Modelling and simulation: braking system.

UNIT – IV DESIGN OF VEHICLE FRAME AND SUSPENSION 9

Study of loads-moments and stresses on frame members. Design of frame for passenger and commercial vehicle - Design of leaf Springs-Coil springs and torsion bar springs. Case study on development of frame for ATV. Modelling and simulation of suspension system.

UNIT – V DESIGN OF FRONT AND REAR AXLE 9

Design of propeller shaft. Design details of final drive gearing. Design details of full floating, semi-floating and three quarter floating rear shafts and rear axle housings. Analysis of loads-moments and stresses at different sections of front axle. Determination of optimum dimensions and proportions for

steering linkages, Design of front axle beam. Modelling and simulation of steering system, transmission system.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Analyze the behavior and characteristics of cylinders, pistons, connecting rods, crankshafts, valves, and clutches in various operating conditions.
CO2: Evaluate the performance, reliability, and efficiency of gears, vehicle frames, suspension systems, and axles.
CO3: Apply design principles and techniques to develop functional and optimized components for automotive applications.
CO4: Create detailed designs for components such as crankshafts, valves, gearboxes, vehicle frames, and axles.
CO5: Understand the fundamental principles and theories of vehicle component design and their interactions within the overall system.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	3	3	1						1	-	1			
CO2	2	2	3	1						1	-	1			
CO3	2	2	3	1						1	-	1			
CO4	2	2	3	1						1	-	1			
CO5	2	2	3	1						1	-	1			
CO/PO & PSO Average	**2**	**2.2**	**3**							**1**	**-**	**1**			
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Giancarlo Genta, Lorenzo Morello, “The Automotive Chassis Volume 1, Components Design”, Springer International Edition, 2nd edition,2020
2. Khurmi. R.S. & Gupta. J.K., "A text book of Machine Design", Eurasia Publishing House (Pvt) Ltd, 25th edition, 2022.
3. Alec Stokes, “Manual gearbox design”, Butterworth-Heinemann 1992.

REFERENCES:

1. “Design Data Hand Book”, PSG College of Technology, 2020- Coimbatore.
2. Dean Averns, "Automobile Chassis Design", Il life Book Co., 2001.
3. Kolchin-Demidov , “Design of Automotive Engines”-Mir Publishers (1984)
4. Lukin P G G and Rodionov V, “Automobile Chassis Design and Calculations”, Mir Publishers, Moscow, 1989.
5. Robert C. Juvinall and Kurt M. Marshek, “Fundamentals of Machine component Design”, 6th Edition, Wiley, 2017.

RA23020	ADVANCED DRIVER ASSISTANCE SYSTEMS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

- Understand the fundamental concepts and components of automotive systems.
- Identify and explain the functions and operation of various automotive sensors.
- Evaluate the principles and applications of driver assistance technology.
- Analyze different ADAS techniques and their role in enhancing vehicle safety.
- Examine the advancements in ADAS display and impaired driver technology.

UNIT – I AUTOMOTIVE FUNDAMENTALS 9

PowerSystem-RunningSystem-ComfortSystem–EngineComponents–Drivetrain–suspensionsystem, ABS, Steering System- Legislation- Standards

UNIT – II AUTOMOTIVE SENSORS 9

Knock sensors, oxygen sensors, crank shaft angular position sensor, temperature sensor, speed sensor, Pressure sensor, Mass air flow sensor, Manifold Absolute Pressure sensors, Crash sensors, Coolant level Sensors, Brake fluid level sensors - operation, Types, characteristics, advantage and application, radar, Ultrasonic Sonar Systems, LIDAR Sensor Technology and systems, Camera

UNIT – III OVERVIEW OF DRIVER ASSISTANCE TECHNOLOGY 9

Basics of Theory of Operation, Applications, Integration of ADAS Technology into Vehicle Electronics, System Examples, Role of Sensor Data Fusion. Vehicle Prognostics Technology

UNIT – IV ADAS TECHNIQUES 9

Advanced Driver Assistance Systems - Lane Departure (LDW), Active Cruise Control (ACC), Blind Spot Detection, Parking Assist, Autonomous Emergency Braking (AEB), Night Vision, Traffic Sign Recognition (TSR), Intelligent High beam Assistant (IHC), Tire Pressure Monitoring (TPMS), Front Collision Warning System (FCWS), Front Vehicle Departure Warning (FVDW), Adaptive Lighting, Driver Drowsiness Detection, Hill Decent Control, Rear Cross Traffic

UNIT – V ADAS DISPLAY & IMPAIRED DRIVER TECHNOLOGY 9

Center Console Technology, Gauge Cluster Technology, Heads-Up Display Technology, and Warning Technology – Driver Notification. Impaired Driver Technology -Driver Impairment Sensor Technology, Sensor Technology for Driver Impairment Detection, Transfer of Control Technology.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Demonstrate knowledge of automotive fundamentals and their interconnections.
CO2: Apply sensor technology to monitor and control automotive systems effectively.
CO3: Assess the integration and benefits of driver assistance technology in vehicles.
CO4: Evaluate the effectiveness and limitations of different ADAS techniques.
CO5: Analyze the impact and potential of ADAS display and impaired driver technology.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	-	1	1	-	1	-	1	-	1	2	2	1
CO2	2	-	-	-	1	1	-	1	-	1	-	1	2	1	1
CO3	2	1	-	-	1	1	-	1	-	1	-	1	2	2	1
CO4	2	2	-	-	1	1	-	1	-	1	-	1	2	1	1
CO5	2	2	-	-	1	1	-	1	-	1	-	1	1	1	1
CO/PO & PSO Average	**2**	**1.6**	**-**	**-**	**1**	**1**	**-**	**1**	**-**	**1**	**-**	**1**	**1.8**	**1.4**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. TomDenton,“AutomobileElectricalandElectronicsystems,Roultedge”,Taylor&Francis Group,5thEdition,2018.
2. William B Ribbens, “Understanding Automotive Electronic: An Engineering Perspective”, Elsevier Science, 8thEdition, 2017.

REFERENCES:

1. Intelligent Transportation Systems and Connected and Automated Vehicles”, Transportation Research Board, 2016.
2. Radovan Miucic, “Connected Vehicles: Intelligent Transportation Systems”, Springer, 2019.

AU23C03	SPECIAL PURPOSE VEHICLES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. Enhance the knowledge of the students about the various equipment's used in earthmoving, applications.
2. Understand the construction and working of the vehicle for constructional application
3. Describe the working nature of farm equipment's based on their application.
4. Discriminate the various industrial vehicles based on the purpose.
5. Acquire the knowledge on the functioning of military vehicle

UNIT - I	EARTH MOVING EQUIPMENTS	9

Construction layout, capacity and applications of dumpers, articulated haulers, front-end loaders, backhoe loaders, bulldozers, scrappers, motor graders, skid-steer loaders, excavator, hydraulic shovels, bucket conveyors, surface miners– highwall Miners.

UNIT - II	CONSTRUCTIONAL EQUIPMENTS	9

Construction layout, capacity and applications of cranes–types, Articulated Trucks, Concrete Ready mixer, Trenchers, Asphalt Pavers, Road Reclaimers, Compactors–types, Draglines, Drillers, Bore well machine.

UNIT - III	FARM EQUIPMEMTS	9

Classification of tractors – Main components of tractor. Working attachment of tractors – Auxiliary equipment –-Top lifting harvesters. General description, working, specification and functions- Paddy harvesting machines, Sugarcane harvesting, Feller bunchers, Forest machines.

UNIT - IV	INDUSTRIAL VEHICLES	9

Constructional features, capacity and working of forklifts, Utility vehicles, towing vehicles, man-lift chassis, scissor lift trucks, material handlers, reclaimers, Street sweepers

UNIT - V	MILITARY AND COMBAT VEHICLES	9

Special features and constructional details of Main Battle tank, gun carriers, transport vehicles, Armored vehicle – launched bridge, Amphibious bridging vehicle, Communication vehicles.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, the students will be able to

CO1	Demonstrate their understanding about the operation of the various special purpose vehicle
CO2	Understand the construction layout of earthmoving equipment's.
CO3	Have the ability to apply the knowledge to design a new concept for construction application.
CO4	Demonstrate their skill in developing modern techniques for future farming vehicles
CO5	Distinguish the various military vehicles and infer their particular technology.

TEXT BOOKS:

1. Abrosimov. K. Branberg. A. and Katayer. K., "Road making Machinery", MIR Publishers, Moscow,1971.
2. V. Rodichev and G. Rodicheva, Tractor and Automobiles, MIR Publishers,1987.
3. Wong. J. T. "Theory of Ground vehicles ", John Wiley & Sons, New York,1987.

REFERENCES:

1. Beleman and M. Moskovin, Farm tractors, MIR, Publishers Moscow.
2. Bart H Vanderveen, Tanks and Transport vehicles, Frederic Warne and Co ltd., London.
3. Kolchin, A., and V. Demidov, Design of Automotive Engines for Tractor, MIR Publishers,1972.
4. Peurifoy R.L “Construction Planning, Equipment and Methods”, Tata McGraw-Hill, New Delhi,2002.
5. Wong J “Terra mechanics and Off-Road Vehicle Engineering”, Butterworth-Heinemann,2009.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	2	2	2	2	2	1	2	2	2	1	3	3	2
2	3	2	2	2	2	2	1	2	2	2	1	3	3	2
3	3	2	2	2	2	2	1	2	2	2	1	3	3	2
4	3	2	2	2	2	2	1	2	2	2	1	3	3	2
5	3	2	2	2	2	2	1	2	2	2	1	3	3	2
Avg	**3**	**2**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**1**	**3**	**3**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

RA23021	AIRCRAFT MECHATRONICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

- Understand the principles and terminology used in aircraft aerodynamics.
- Describe the working principles and components of aircraft propulsion systems.
- Analyze the materials and structural arrangements used in aircraft construction.
- Explain the functioning and control systems of primary flight controls.
- Apply mechatronics principles and technologies in aviation applications.

UNIT – I AIRCRAFT AERODYNAMICS 9

Nomenclature used in Aerodynamics, different parts of airplane- Wing as lifting surface, Types of wing plan forms, Aerodynamic features like Aerofoil pressure distribution- Aerodynamic forces and moments Lift and Drag- Drag polar, L/D ratio, high lift devices, Airplane performance like Thrust/Power available, climb and glide - maximum range and endurance, take off and landings.

UNIT – II AIRCRAFT PROPULSION 9

Requirement of power- various means of producing power - Brief description of thermodynamics of engines - Piston engines, Jet engines - Airplane Structure, Materials and Production - Structural arrangement of earlier airplane- developments leading to all metal aircraft - Strength to weight ratio choice of aircraft materials for different parts.

UNIT – III AIRCRAFT MATERIALS 9

Detailed description of wing - tail and fuselage joints - Stress-Strain diagrams, Plane and Space, Mechanical properties of materials - Materials for different components - use of composites - Aircraft production methods and equipment.

UNIT – IV PRIMARY FLIGHT CONTROLS 9

Ailerons - Aileron Control System of a Commercial Aircraft - Elevators - Elevator control system of a commercial aircraft – Rudders- Rudder Control System.

UNIT – V APPLICATIONS OF MECHATRONICS IN AVIATION 9

Aileron-Flaps and Actuator drive unit-Pilot Static system-Fly by wire control system-Yaw damper-Primary flight control system-Internal navigation system-Under carriage-Measurement of motor rpm-Measurement of air flow velocity-Altitude measurement sensor-Air speed.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Demonstrate knowledge of aerodynamic nomenclature, wing plan forms, and aerodynamic forces.

CO2: Evaluate different types of aircraft engines and their thermo-dynamics.

CO3: Assess the mechanical properties of aircraft materials and their applications.

CO4: Analyze the control systems and operation of primary flight controls.

CO5: Apply mechatronics concepts to aviation systems and components.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	-	-	-	-	-	-	1	-	1	1	2	2
CO2	2	1	-	-	-	-	-	-	-	1	-	1	1	2	2
CO3	2	1	-	-	-	-	-	-	-	1	-	1	1	2	2
CO4	2	1	-	-	-	-	-	-	-	1	-	1	1	2	2
CO5	2	2	-	-	-	-	-	-	-	1	-	1	1	2	2
CO/PO & PSO Average	**2**	**1.25**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**1**	**2**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Fundamentals of Flight; By Dr. O. P. Sharma and Lalit Gupta.Vol 4. 2014
2. Albert Helfrick.D., "Principles of Avionics", Avionics Communications Inc., 2004

REFERENCES:

1. Middleton, D.H., Ed., "Avionics systems, Longman Scientific and Technical", Longman Group UK Ltd., England, 1989.
2. Pallet. E.H.J., "Aircraft Instruments and Integrated Systems", Pearsons, Indian edition 2011.
3. Spitzer, C.R. "Digital Avionics Systems", Prentice-Hall, Englewood Cliffs, N.J.,U.S.A. 3rd edition, 2015.
4. Spitzer. C.R. "The Avionics Hand Book", CRC Press, 2000

VERTICAL 5: PRODUCTION ENGINEERING AND SYSTEMS

RA23022	CNC MACHINES AND AUTOMATED PRODUCTION SYSTEMS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To understand the constructional features of CNC machining centres and its applications.
2. To write CNC part programming for industrial problems.
3. To apply group technology concepts in a production environment.
4. To illustrate flexible manufacturing systems in a manufacturing industry.
5. To select suitable robot specifications for industrial needs.

UNIT I STRUCTURE OF CNC MACHINE AND CNC MACHINING 9

CNC Machine Building, Structural Details, Configuration and Design, Guide Ways – Friction, Anti Friction and Other Types of Guideways, Elements Used to Convert The Rotary Motion To A Linear Motion – Screw And Nut, Recirculating Ball Screw, Planetary Roller Screw, Recirculating Roller Screw, Rack And Pinion, Spindle Assembly, Torque Transmission Elements – Gears, Timing Belts, Flexible Couplings, Bearings- Maintenance Of CNC Machines. Coordinates, Axes, and Motion - CNC Systems - CNC Controls - Operating a CNC Machine – CNC Milling – Types, Machines axes, Machining centers, CNC Turning – Types, Number of axes, Axes designation -Advantages and Disadvantages of CNC Technology - Applications.

UNIT II CNC PROGRAMMING 9

Coordinate Systems and Reference Points -The Ten Steps of CNC Programming - Structure of A Part Program, G Codes and M Codes, Tool Length Compensation, Cutter Radius and Tool Nose Radius Compensation, Do Loops, Subroutines, Canned Cycles, Mirror Image, Parametric Programming, Machining Cycles, Programming for Machining Centre and Turning Centre for Well Known Controllers, Generation of CNC Codes from CAM Packages.

UNIT III INTRODUCTION TO AUTOMATED PRODUCTION SYSTEMS AND GROUP TECHNOLOGY 9

Automation and types, Automated Manufacturing System, Reasons for Automating, the USA Principle, Strategies for automation and process improvement, automation migration strategies, levels of automations, Types of Automations. Part family, Part classification and coding, production flow analysis – OPITZ classification system, cellular manufacturing, quantitative analysis in cellular manufacturing. Rank Order Clustering Technique (ROC), Holier Method –I, II, Single Linkage Cluster Analysis Technique (SLCA). Application of group technology

UNIT IV FLEXIBLE MANUFACTURING SYSTEMS 9

Types of flexibility, types of FMS, FMS components, FMS Components-Workstations, Material Handling and Storage Systems, Computer Control System, Human Resources, FMS Applications and Benefits., Quantitative analysis of FMS, Sizing the FMS, System performance measure. Automated Material Handling & Storage: Functions, Types, Analysis of material handling equipment, Design of Conveyor & AGV systems. Problems. Development for a total material handling system.

UNIT V INDUSTRIAL ROBOTICS AND MECHATRONICS SYSTEMS 9

Introduction, Robot Anatomy and Related Attributes, Robot Control Systems, End Effectors, Sensors in Robotics, Industrial Robot Applications, Robot Programming overview. Transducers, Sensors and

Actuators: Classification, Principle of Operation, Selection Criteria, Signal Conditioning, Calibration. Industry 4.0.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:
CO1: Describe constructional features of CNC Machine Tools.
CO2: Create CNC manual/automated program for given part drawing.
CO3: Apply group technology and their application in industries.
CO4: Discuss FMS and its components.
CO5: Explain robot application in automated production system

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	-	-	-	-	-	-	1	-	1	1	-	1
CO2	2	1	1	-	1	-	-	-	-	1	-	1	1	-	1
CO3	2	1	1	-	1	-	-	-	-	1	-	1	1	1	1
CO4	2	1	1	-	1	-	-	-	-	1	-	1	1	1	1
CO5	2	1	1	-	1	-	-	-	-	1	-	1	1	1	2
CO/PO & PSO Average	**2**	**1**	**1**	**-**	**1**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**1**	**1**	**1.2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Radhakrishnan P, “Computer Numerical Control (CNC) Machines”, New Age International Publishers, 2020.
2. Shivanand H K, Benal M M and Koti V, “Flexible Manufacturing System”, New Age International, 2016.

REFERENCES:

1. Rao P.N., “CAD/CAM”, 3rd Edition, Tata McGraw-Hill, 2010.
2. Michael Fitzpatrick, “Machining and CNC Technology”, McGraw-Hill, 2013.
3. Graham T. Smith, “CNC Machining Technology, Volume II Cutting, Fluids and Workholding Technologies”, Springer, 1993.
4. Mikell P. Groover, “Automation, Production system and Computer integrated Manufacturing”,
5. Prentice Hall of India Pvt. Ltd., 4th Edition, 2014.
6. Radhakrishnan P, Subramanian S and Raju V, “CAD/CAM/CIM”, New Age International Publishers, 3rd Edition, 2014.

PR23C06	MATERIAL HANDLING AND STORAGE SYSTEMS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

- Understand the fundamental concepts and principles of material handling in industrial settings.
- Identify and classify different types of material handling equipment and their applications.
- Examine the factors that influence the selection of material handling equipment and systems.
- Explore the components and attachments used in material handling, such as hoisting mechanisms and load handling appliances.
- Analyze various material transport machinery and their working principles, including conveyors, elevators, and surface transport equipment.

UNIT – I INTRODUCTION TO MATERIAL HANDLING 9

Types - Types of movements - methods of stacking - loading - unloading - principles - hoisting mechanism- lifting mechanism- travelling - slewing mechanism- cross - traverse mechanism - Factors affecting choice of material handling equipment - method of stacking at initial intermediate - final points- specific load conditions - economics of material handling systems - ISO safety standards and protocols for material handling

UNIT – II COMPONENTS OF MATERIAL HANDLING 9

Flexible hoisting appliances – fastening methods – Load handling attachments – Classification of hooks forged – eye hook – Appliances for suspending hooks – crane grab for unit and piece loads – electric lifting magnet – vacuum lifter – Grabbing attachment for loose materials – crane attachment for handling liquids – Arresting gear – brakes – construction – working – electromagnetic shoe brakes – construction – use – thruster operated shoe brakes – control brakes- NIOSH equations for loading and unloading

UNIT – III MATERIAL TRANSPORT MACHINERY 9

Traction type conveyors – Working – belt conveyors – chain conveyors – bucket elevators- escalators Working of traction less type conveyors – gravity type conveyors, vibrating and oscillating conveyors, screw conveyors – pneumatic – hydraulic conveyors – hoppers – gates and feeders – Surface transport equipment – functions – working of trackless equipment – hand operated trucks – powered trucks – tractors, AGV (Automatic Guided Vehicle) – industrial trailers – functions – working – cross handling equipment – winches – capstans – turntables – transfer tables – monorail conveyors- Anti swaying control

UNIT – IV CRANES, HOISTS AND MONORAILS 9

Jib cranes, wall mounted and travelling type, stability criteria, wheel loads, wheel trucks and bogeys, number of mechanisms in jib crane, jib construction, Harbour cranes, luffing and level luffing cranes, shipyard gantry cranes, portal frames and slewing rings, types of hoists.

UNIT – V STORAGE SYSTEMS 9

Introduction, Types of storage system, Automated Storage and Retrieval systems, carousel storage systems, Large Products Storage System, Pallet Storage Systems Selection, Layout of High Rack Storage

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Demonstrate an understanding of the principles and concepts of material handling and its significance in industrial operations.

CO2: Identify and evaluate appropriate material handling equipment based on specific requirements and load conditions.

CO3: Analyze and compare the characteristics and functionalities of different material transport machinery and conveyance systems.

CO4: Design and analyze the components and attachments used in material handling, ensuring optimal performance and safety.

CO5: Apply knowledge of cranes, hoists, and monorails to design and select suitable lifting solutions for different industrial applications.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	-	-	1	-	-	-	1	-	1	1	-	1
CO2	2	-	-	-	-	1	-	-	-	1	-	1	1	-	2
CO3	2	-	-	-	-	1	-	-	-	1	-	1	1	-	2
CO4	2	-	-	-	-	1	-	-	-	1	-	1	1	-	2
CO5	2	-	-	-	-	1	-	-	-	1	-	1	1	-	2
CO/PO & PSO Average	**2**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**1**	**-**	**1**	**1**	**-**	**1.8**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Allegri S.R., “Materials Handling Principles and Practice”, ED-TECH, 2018.
2. Siddharta Ray, “Introduction to Materials Handling”, New Age International Publishers,2007

REFERENCES:

1. Deshmukh, D. J., “Elements of Mining Technology Vol. 1”, India, Denett& Company, 8th Edition, 2010.
2. Peter Darling, “SME Mining Engineering Handbook”, Society for Mining, Metallurgy, and Exploration, 2011.
3. Syd S. Peng, “Advances in Coal Mine Ground Control”, Elsevier Science, 2017.
4. Walker, S.C., “Mine Winding and Transport”, Elsevier Science, 2012.
5. Fruchtbaum, Jacob, “Bulk Materials Handling Handbook”, Springer, 2013.

RA23023	UNCONVENTIONAL MACHINING PROCESSES	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To make acquainted the various unconventional machining processes and its applications
2. To encourage the students for developing the models (experimental/theoretical) of unconventional machining processes
3. To inculcate specialized knowledge and skill in unconventional machining processes using the principles and methods of engineering analysis and design.
4. To cultivate the ability to develop and implement new improved manufacturing processes resulting in creation and distribution of value in engineering applications.
5. To impart knowledge about the significance of controlling process parameters for the optimal performance for newly developed engineering materials used in industries and research organizations.

UNIT – I ABRASIVE AIDED MACHINING PROCESSES 9

Abrasive machining – water jet machining - ultrasonic machining –Abrasive flow machining -Magnetic Abrasive flow machining, Ice jet machining - construction working principle – steps - types – process parameters – derivations – problems, merits, demerits and applications. Magnetic abrasive polishing

UNIT – II ELECTRICAL AND CHEMICAL AIDED MACHINING PROCESSES 9

Wire cut EDM - Electric discharge machining – Electrochemical machining – chemical machining – Maskants - Electrochemical grinding - construction – principle – types – control - circuits – merits, demerits and applications-Hybrid Machining-Electropolishing- Problems

UNIT – III HIGH ENERGY AIDED MACHINING PROCESSES 9

Laser beam machining – Electron beam machining – Plasma arc machining – Ion beam machining – construction - working principle- types – process parameter – derivations – problems, merits, demerits and applications.

UNIT – IV HYBRID ELECTROCHEMICAL PROCESS 9

Electro chemical grinding – electrochemical honing – electro-chemical super finishing – electrochemical buffing – ultrasonic assisted ECM– laser assisted ECM- construction – principle -merits, demerits and applications.

UNIT – V HYBRID THERMAL PROCESSES 9

Electro erosion dissolution machining – electro discharge grinding – EDM with ultrasonic assistance – abrasive electro discharge machining - construction – principle -merits, demerits and applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

1. Recall the key concepts and terminology related to abrasive machining processes and their applications.

2. Explain the basic principles and working mechanisms of electrical and chemical aided machining processes.
3. Identify and describe the different types of high-energy aided machining processes and their specific applications.
4. Apply the principles and techniques of hybrid electrochemical processes to improve surface finish and dimensional accuracy in machining operations.
5. Compare and contrast the characteristics, advantages, and limitations of various hybrid thermal processes for different machining scenarios.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	2	-	1	1	1	1	-	-	1	-	1	1	1	1
CO2	2	2	-	1	1	1	1	-	-	1	-	1	1	1	1
CO3	2	2	-	1	1	1	1	-	-	1	-	1	1	1	1
CO4	2	2	-	1	1	1	1	-	-	1	-	1	1	1	1
CO5	2	2	-	1	1	1	1	-	-	1	-	1	1	1	1
CO/PO & PSO Average	**2**	**2**	**-**	**1**	**1**	**1**	**1**	**-**	**-**	**1**	**-**	**1**	**1**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Helmi Youssef, Hassan El-Hofy “Non-Traditional and Advanced Machining Technologies: Machine Tools and Operations”, CRC Press, 2021.
2. Angelos P. Markopoulos, J. Paulo Davim "Advanced Machining Processes: innovative" CRC Press, 2019.

REFERENCES:

1. J Paulo Davim, "Modern Machining Technology", Elsevier Science, 2011
2. Mishra, P.K., “Non-Conventional Machining”, Narosa Publications, 2018.
3. Chander Prakash, J. Paulo Davim, Sunpreet Singh, "Advanced Manufacturing and Processing Technology", CRC Press, 1st Edition, 2021.
4. Muslim Mahardika, Andi Sudiarso, "Advanced Machining Processes", UGM PRESS, 2018.
5. Ghosh, A. and Mullik, A., “Manufacturing Science”, East –West private Limited, 2010.

MF23C01	ADDITIVE MANUFACTURING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To familiarize various design considerations, software tools, processes, and techniques to create physical components using AM.
2. To enhance product customization for suitable AM techniques
3. To impart knowledge on Medical and Industrial applications of AM

UNIT I INTRODUCTION 9

Overview – Distinction between traditional manufacturing and AM – Evolution of Additive Manufacturing (AM) - AM Process workflow - Classification – Benefits. AM Standards - AM Considerations-Business and Societal Implications of AM -Economic aspects.

UNIT II DESIGN FOR ADDITIVE MANUFACTURING (DFAM) 9

AM Unique Capabilities- Need for DFAM- Design consideration in AM- Part Consolidation - Topology Optimization- Generative Design- Lightweight Structure - DFAM for Part Quality Improvement. CAD Model Preparation - File formats for AM (STL, PLY, VRML, AMF) - Part Orientation and Support Structure Generation - Model Slicing - Tool Path Generation.

UNIT III PHOTO POLYMERIZATION, MATERIAL EXTRUSION, AND POWDER BED FUSION PROCESSES 9

Photo polymerization: Stereolithography Apparatus (SLA) - Materials - Process - Capabilities - Applications. Digital Light Processing (DLP) - Materials – Process - Capabilities - Applications. Continuous Liquid Interface Production (CLIP) - Materials - Process - Capabilities and Applications. Extrusion Based System: Fused Deposition Modeling (FDM) - Process – Types- Materials - Applications. Powder Bed Fusion: Selective Laser Sintering (SLS): Process – Materials and Application. Multijet fusion. Selective Laser Melting (SLM) and Electron Beam Melting (EBM): Materials – Principle - Process - Capabilities and Applications.

UNIT IV SHEET LAMINATION, DIRECT ENERGY DEPOSITION, BINDER AND MATERIAL JETTING PROCESSES 9

Sheet Lamination Process: Laminated Object Manufacturing (LOM) - Basic Principle- Mechanism: Gluing or Adhesive Bonding – Thermal Bonding- Materials-Application and Limitation. Direct Energy Deposition Process: Laser Engineered Net Shaping (LENS) and Wire Arc Additive Manufacturing (WAAM) - Process -Material Delivery - Process Parameters - Materials -Capabilities – Industrial Applications. Binder and Material Jetting: Three-Dimensional Printing - Materials - Physics of 3DP – Process- Types of printing – Material - Capabilities and Application. Hybrid Additive Manufacturing – Need - Principles - Synergy in Hybrid AM Materials - Part Quality and Process Efficiency.

UNIT V APPLICATION OF AM 9

Rapid tooling - Direct tooling - Indirect tooling – Soft tooling- bridge tooling. Rapid Tooling for Investment Casting, sand casting, Injection molding. Case Studies/Application: Aerospace and automotive industries, Medical and healthcare - Architecture and construction - Food Printing - Printing Electronics - Consumer products and fashion.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course students shall be able to:

CO1: Gain an understanding of Additive Manufacturing and its development and Identify different business opportunities associated with Additive Manufacturing.

CO2: Develop a comprehensive understanding of design considerations specific to Additive Manufacturing and familiarize oneself with a range of software tools used in the design process for Additive Manufacturing.

CO3: Elaborate the photo polymerization, material extrusion processes, powder bed fusion processes and its applications.

CO4: Acquire knowledge on process and applications of sheet lamination, direct energy deposition, Binder and Material Jetting Processes and introduce the concept of hybrid Additive Manufacturing processes that combine multiple techniques to achieve desired outcomes.

CO5: Achieve in-depth knowledge of Rapid Tooling techniques in Additive Manufacturing and explore case studies and industrial applications of AM

CO's- PO's & PSO's MAPPING

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	1	1	1	1	1	1	1	1	1	2	3	1	1	1
2	3	2	2	1	2	1	3	1	1	1	1	3	2	3	2
3	3	1	1	1	1	1	2	1	1	1	1	3	2	2	1
4	3	1	1	1	1	1	2	1	1	1	1	3	2	2	1
5	3	3	2	1	1	1	2	3	1	1	2	3	3	3	3
Avg	3	1.6	1.4	1	1.2	1	2	1.4	1	1	1.4	3	2	2.2	1.6

TEXT BOOKS:

1. Gibson, Ian, David Rosen, Brent Stucker, Mahyar Khorasani, Ian Gibson, David Rosen, Brent Stucker, and Mahyar Khorasani. "Design for additive manufacturing." Additive manufacturing technologies (2021), ISBN : 978-3-030-56126-0.
2. Andreas Gebhardt and Jan-Steffen Hötter "Additive Manufacturing: 3D Printing for Prototyping and Manufacturing", Hanser publications, United States, 2016, ISBN: 978-1-56990-582-1.

REFERENCES:

1. A Practical Guide to Design for Additive Manufacturing, Diegel, Olaf, Axel Nordin, and Damien Motte, Springer, 2020.
2. Additive Manufacturing, Second Edition, Amit Bandyopadhyay Susmita Bose, CRC Press Taylor & Francis Group, 2020, ISBN- 978-1-4822-2360-6.
3. The 3D Printing Handbook: Technologies, Design and Applications, Redwood, Ben, Filemon Schoffer, and Brian Garret, 3D Hubs, 2017.
4. Amit Bandyopadhyay and Susmita Bose, "Additive Manufacturing", Second Edition, CRC Press., United States, 2020, ISBN 9781032238593.
5. Additive Manufacturing: Principles, Technologies and Applications, C.P Paul, A.N Junoop, McGrawHill, 2021.

RA23024	ENGINEERING METROLOGY	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students:

1. To understand the concept of engineering metrology.
2. To familiarize with metrology instruments used for linear and angular measurements.
3. To learn about the surface texture and measuring instruments
4. To explain about the metrology of screw threads and gears
5. To introduce the concepts of Laser and computer applications in metrology.

UNIT – I FUNDAMENTALS OF MEASUREMENT 9

Fundamentals of Engineering metrology –Static characteristics -Precision, Accuracy, Sensitivity, Repeatability, Reproducibility, Linearity- Errors in measurements– Uncertainties in measurements-precautions-Standards-National, Reference, Secondary, and Working Standards-Calibration, Traceability, interchangeability and selective assembly.

UNIT – II LINEAR AND ANGULAR MEASURING INSTRUMENTS 9

Linear measuring instrument-Vernier callipers, micrometres, Slip gauges, dial gauges and surface plates– Concept of comparators - mechanical, electrical, optical and pneumatic comparators – Angular measuring instruments- angle gauges –bevel protractor– Sine bar – Precision spirit level, Autocollimators – Angle dekkor-Alignment telescope – Clinometers.

UNIT – III TOLERANCE ANALYSIS AND MEASUREMENTS OF SCREW THREADS & GEARS 9

Fundamentals of GD&T – Conventional vs Geometric Tolerance, Interpretation of GD&T, Symbols in Engineering Drawings, Datums, Limits, Fits and Tolerances- Problems (using tables); Design of Limit gauges – Process capability, Tolerances Stackup Analysis – Worst Case Analysis and Root Sum of Squares Analysis, Tolerance Charting. Screw thread terminology- Measurements of internal and external screw thread parameters – thread micrometre two and three wire method– Gear terminology - measurement of various elements of gears by pitch circle, constant chord, base tangent and plug method – measurement using rolling gear tester.

UNIT – IV SURFACE TOPOGRAPHY, STRAIGHTNESS, ROUNDNESS MEASUREMENT AND MEASURING INSTRUMENTS 9

Surface finishing – Definitions – types of surface finish –measurement methods-comparison – Profilometer – advanced surface finishing measuring instruments – Straightness and flatness measurement using precision level and autocollimator - Measurement of roundness and camming– Tool makers microscope – Optical and Laser Alignment telescope.

UNIT – V ADVANCES IN METROLOGY AND COMPUTER AIDED METROLOGY 9

Metrology for machine tools-Laser micrometre - Laser interferometer – Applications – Straightness, Alignment, Ball Bar test, Noncontact and in-process inspection using laser – CMM – Types of CMM – Constructional Features – Probes – Accessories – Software – Applications – Multi sensor CMMs – Articulated CMMs – Factors affecting CMM measurement – Machine Vision – machine vision systems –3D Computed Tomography.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

1. Outline the principles of Engineering Metrology.
2. Compare equipment for linear measurements and angular measurements.
3. Apply concepts of Geometric Dimensioning and Tolerancing and select appropriate methodology to measure the parameters of screw threads and gears.
4. Explain various principles in surface topography
5. Summarize the advancements in metrology.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	1	-	-	-	1	-	1	-	1	2	-	1
CO2	2	1	-	1	-	-	-	-	-	1	-	1	1	-	1
CO3	3	1	1	1	-	-	-	1	-	1	-	1	1	-	1
CO4	2	1	-	1	-	-	-	-	-	1	-	1	1	-	1
CO5	2	1	-	1	1	-	-	-	-	1	-	1	1	-	1
CO/PO & PSO Average	**2.2**	**1**	**1**	**1**	**1**	**-**	**-**	**1**	**-**	**1**	**-**	**1**	**1.2**	**-**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Jay L. Bucher, "The Metrology Handbook", ASQ Quality Press,2012.
2. Gupta.I.C., “A text book of Engineering Metrology”, Dhanpat Rai and Sons, 7th edition 2012.

REFERENCES

1. “ASTE Hand book of Industrial Metrology”, Prentice Hall of India Limited 2002.
2. Gayler G.N. and Shotbolt C.R., “Metrology for Engineers”, ELBS 2000.
3. Rajput R.K., “Engineering Metrology and Instrumentation”, Kataria and Sons Publishers, 2013.
4. Raghavendra and L.Krishnamurthy, “Engineering Metrology and Measurements”OUP India,2013.
5. Francis T. Farago and Mark A.Curtis, “Handbook of Dimensional Measurements”, Industrial Press Inc, 2007.

MF23C04 **TOTAL PRODUCTIVE MAINTENANCE** **L T P TCP**
3 0 0 3

COURSE OBJECTIVES:

1. To familiarize students with the major concepts on maintenance concepts followed in industries
2. To introduce the models, tools and techniques used in TPM

UNIT I MAINTENANCE CONCEPTS 9

Introduction - History of TPM - The TPM Paradigm Shift -TPM pillars -Objectives and functions – Productivity, Quality, Reliability and Maintainability (PQRM) - Terotechnology - Reliability Centered Maintenance - Predictive Maintenance - Condition Based Maintenance - maintainability prediction - availability and system effectiveness-maintenance costs - maintenance organization- Benefits of TPM-TPM and Lean- TPM and Six Sigma

UNIT II MAINTENANCE MODELS 9

Minimal repair - As Good As New policy - maintenance types -Autonomous Maintenance- Breakdown Maintenance- -Planned Maintenance-Upstream Maintenance- steps to maintenance excellence. - PM schedules: deviations on both sides of target values - PM schedules: functional characteristics - replacement models.

UNIT III TOTAL PRODUCTIVE MAINTENANCE 9

Zero breakdowns - Zero Defects and TPM - maximizing equipment effectiveness – Autonomous maintenance program - Steps to autonomous maintenance-- - Establishment of basic policies and goals - Formation of master plan - TPM implementation- Difficulty in implementation of TPM. Online Monitoring -Condition monitoring - Infrared Thermography, Oil Analysis, acoustic emissions testing, Motor Current Analysis, Vibration Measurement and Analysis, Wear Debris Monitoring, Visual checks - corrosion control - Maintenance Management Information System - Expert system applications.

UNIT IV MAINTENANCE LOGISTICS 9

Management Decision -The new role for the maintenance department- TPM organization -Creation of Organizations -TPM is a team effort- - TPM small group activities - maintenance staffing methods - Roles and Responsibilities in TPM-The Operators role-The Specialists role-Improvement teams role TPM Education & Training-GEMBA Workshops-Key indicators-Strive workshop and “7S” Initiatives One-Point lessons - -Pre-TPM checklist- maintenance manuals- queuing applications - simulation - Tools management - spare parts management - maintenance planning and scheduling.

UNIT V MEASURING TPM EFFECTIVENESS 9

Definition of losses-Causes of losses-6 Big losses of TPM-Basic quality management tools from TPM- Zero Accident-Definition of zero accidents-Steps in zero accidents-- - The philosophy of setting goals-Types of indicators-Evaluating TPM-Overall Equipment efficiency- Definitions of AR, QR, PR & OEE -OEE Factors-The Role of OEE in Total Productive Maintenance-Calculation of OEE- Improvement in OEE-Direct & Indirect benefits of TPM.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, the students shall be able to:

CO1: Differentiate maintenance methods employed in industries

CO2: Recognize various models used in maintenance

CO3: Gain knowledge on TPM, inspection and monitoring methods used.

CO4: Do maintenance management

CO5: Calculate OEE, understand losses, able to set goal for productivity.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	-	3	3	3	3	1	3	3	3	-	3	3			
CO2	-	3	3	3	3	1	3	3	3	-	3	3			
CO3	1	3	3	3	3	1	3	3	3	-	3	3			
CO4	-	3	3	3	3	3	3	3	3	-	3	3			
CO5	1	3	3	3	3	1	3	3	3	-	3	3			
CO/PO & PSO Average	**1**	**3**	**3**	**3**	**3**	**1**	**3**	**3**	**3**	**-**	**3**	**3**			
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS:

1. Nakajima S., “Introduction to TPM”, Productivity Press, Chennai, 1992.
2. Srivastava S.K., “Maintenance Engineering (Principle, Practices & Management)”, S. Chand Group, 2011.
3. Tina Kanti Agustiady Elizabeth A. Cudney, “Total Productive Maintenance Strategies and Implementation Guide”, CRC Press,2016 ISBN:13: 978-1-4822-5540-9

REFERENCES:

1. Goto F.,“Equipment planning for TPM Maintenance Prevention Design”, Productivity Press., United States,1992.
2. Kelly A., “Maintenance planning and control”, Butterworths, London, 1991.
3. Shirose K., “Total Productive Maintenance for Workshop Leaders”, Productivity Press., United States.
4. Shirose K., “TPM for Operators”, Productivity Press, United States, 1996.
5. Suzuki T., “New Directions for TPM”, Productivity Press, United States,1992
6. Wireman T., “Total Productive Maintenance”, Industrial Press Inc., New york, 2004.

AE23C06	AVIONICS SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

Of this course are

1. To introduce the basic of avionics and its need for civil and military aircrafts.
2. To impart knowledge on different avionic architecture and various avionics data buses.
3. To impart knowledge on different cockpit displays and display technologies.
4. To impart knowledge on different navigation systems and their operating principles.
5. To impart knowledge on air data systems and the functions of autopilot.

UNIT I INTRODUCTION TO AVIONICS 9

Need for avionics in civil and military aircraft and space systems – Integrated avionics and weapon systems – Typical avionics subsystems, design, technologies – Introduction to Digital Computer and memories.

UNIT II DIGITAL AVIONICS ARCHITECTURE AND BUSES 9

Avionics system architecture – System Integration - Data buses – MIL-STD-1553B – ARINC – 429 – ARINC – 629 – ARINC-664 (AFDX), ARINC 825 (CAN)

UNIT III FLIGHT DECKS AND COCKPITS 9

Control and display technologies: CRT, LED, LCD, EL and plasma panel – Touch screen – Direct voice input (DVI) – Civil & Military Cockpits: MFDS, HUD, MFK, HOTAS, ARINC 661, ARINC 717, ARINC 818

UNIT IV INTRODUCTION TO NAVIGATION SYSTEMS 9

Dead Reckoning systems – Inertial sensors – Inertial Navigation Systems (INS) – INS block diagram – Kalman Filter, Radio navigation – Hyperbolic Navigation - ILS, MLS –– Satellite Navigation systems – GPS – Waypoint Navigation.

UNIT V AIR DATA SYSTEMS AND AUTO PILOT 9

Air data quantities – Altitude, Air speed, Vertical speed, Mach number – FMS – Auto pilot – Basic principles, Longitudinal and Lateral auto pilot. Case study- Apollo 11 mission

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will be able to

CO1 Explain the need for avionics in aircrafts and explain the functions of basic aircraft systems.

CO2 Select a suitable avionics architecture based on requirements and explain the functions of a data bus.

CO3 Explain the working of cockpit displays and to distinguish the type of technology used in displays.

CO4 Explain the importance of navigation system and operating principles of different navigation systems.

CO5 Explain the functions of autopilot and compare the different types of air speeds.

TEXTBOOKS:

1. Albert Helfrick.D., Principles of Avionics, Avionics Communications Inc., 7th Edition, 2012.
2. Collinson.R.P.G. Introduction to Avionics, Chapman and Hall, 2003.

REFERENCES:

1. Middleton, D.H., Ed., Avionics systems, Longman Scientific and Technical, Longman Group UK Ltd., England, 1989.
2. Pallet.E.H.J., Aircraft Instruments and Integrated Systems, Longman Scientific, 1992.
3. Spitzer, C.R. Digital Avionics Systems, Prentice-Hall, Englewood Cliffs, N.J., U.S.A. 1993.
4. Spitzer. C.R. The Avionics Hand Book, CRC Press, 2000.

COs	POs												PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	3												2			
2	3		1		1								2	1		
3	3				1					1			2			
4	3				1					1			2			
5	3		1	1	1								2	1		

AE23C04	AIRCRAFT NAVIGATION SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: to impart knowledge on the concept of

1. Different axis systems and co-ordinate transformation techniques

2. Different short range radio navigation systems

3. Different long range radio navigation systems and its integration

4. Various approach and landing aids of aircraft

5. Different functions of FMS and air traffic management

UNIT I INTRODUCTION **9**

Principles of navigation – Different types of Navigation - Design Trade-offs – Evolution of Air navigation - Different co-ordinate frames - Transformation Techniques

UNIT II SHORT RANGE NAV AIDS 9

Non-directional Beacons - Operating Principles of VOR – DME – ADF – TACAN - VORTAC

UNIT III LONG RANGE NAV AIDS 9

Hyperbolic Navigation – Inertial Sensors & INS - GPS - System description – Principle of operation - position and velocity determination - Differential GPS - Integration of GPS and INS

UNIT IV APPROACH AND LANDING SYSTEMS 9

Visual flight Rules– Instrument Landing System - Microwave Landing System - Ground Controlled Approach System - Satellite based Landing system

UNIT V FMS AND AIR TRAFFIC MANAGEMENT 9

Flight Plan and Functions of FMS – ADSB - Collision avoidance systems - Surface movement and surveillance radars - Airfield lighting control and monitoring – METAR weather data

TOTAL : 45

COURSE OUTCOMES: Students will be able to:

CO1 Explain the need for different axis systems and select the suitable system for the given Condition.

CO2 Explain the operating principles of short range navigation systems

CO3 Compare different long range navigation systems.

CO4 Explain the operation of various Automatic Landing systems

CO5 Explain different functions of FMS and air traffic management

TEXTBOOKS:

1. Collinson R.P.G, 'Introduction to Avionics Systems', Springer Publisher, 3rd Edition 2011.
2. David Wyatt, Mike Tooley, 'Aircraft Communications and Navigation Systems', Routledge Publication, 2017.

REFERENCES:

1. Myron Kyton, Walfred Fried, 'Avionics Navigation Systems', John Wiley & Sons, 2009
2. Collinson R.P.G, 'Introduction to Avionics Systems', Springer Publisher, 3rd Edition 2011.
3. Nagaraja, N.S. Elements of Electronic Navigation‖, Tata McGraw-Hill Pub. Co., New Delhi, 2nd edition, 2017.
4. Paul. D. Groves. 'Principles of GNSS, Inertial, and Multi sensor Integrated Navigation Systems', Artech House, 2013.

COs	POs												PSOs			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
1	3	3	2	2	3	3				2		2	3	3		3
2	3	3	3	3	3	3				2		3	3	3		3
3	3	1	3	3	3	2				2		3	3	3		3
4	3	2	2	3	3	2				2		3	3	3		3
5	3	2	2	3	3	2			2	2		3	3	3	2	3

AE23C05	AIRCRAFT SYSTEM MODELING AND SIMULATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

Of this course are

1. To introduce the concepts of aircraft mathematical model and Aircraft Equations of Motion
2. To introduce the probability concepts in simulation
3. To impart practical knowledge on the simulation of aircraft systems
4. To introduce the knowledge about various types of flight simulators
5. To introduce interfacing of Flight simulators with Aero Sim and Aerospace Blockset

UNIT I INTRODUCTION 9

Continuous and discrete systems, Need for System Modelling, Different forces acting on an aircraft – Different Coordinate systems – Methods of Coordinate transformation - Static models, Dynamic models, Principles used in modelling the techniques of simulation

UNIT II AIRCRAFT MODELLING 9

Aircraft Equations of Motion – Aircraft force equations – Moment Equations – Longitudinal and Lateral Directional EOM- Kinematic Equations – Linearizing the EOM – Moment of Inertia Calculation – Representation of aerodynamics data – Use of Look-up table in dynamic modelling – Dynamic modelling of the Quadrotor - Aircraft mathematical model, Analytical modelling of aircraft wing loads, Bending moment model

UNIT III AIRCRAFT SIMULATION REQUIREMENTS 9

Discrete events, Representation of time, Generation of arrival patterns, Simulation Programming tasks, Gathering statistics, Simulation language. Continuous System models, Differential equation, Continuous system simulation language (CSSLs), Motion system, Visual system, Instructor‘s facilities

UNIT IV SIMULATION USING FLIGHT SIMULATORS 9

Historical background – Requirements of a good simulator, Simulator Certification, Interactive systems, Control interface with flight simulator software - AR and VR in simulation, Generation of guidance and control commands – Simulation of an autopilot, autonomous landing systems, Simulation of autonomous flight using Waypoint Navigation

UNIT V FLIGHT SIMULATOR AS A TRAINING DEVICE AND RESEARCH TOOL 9

Introduction, advantage of simulator- Simulators in academic and research – the effectiveness of Simulator, The user‘s role, , Data sources, Validation, in- flight simulators - Interfacing Flight Gear Flight Simulator using AeroSim and Aerospace Blockset

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will be able to

CO1 Explain the equations governing the aircraft dynamics and the process of linearizing them.

CO2 Derive the equations of aircraft wing loads, bending moment model

CO3 Explain the probability concepts in simulation and flight simulators .

CO4 Perform and compare the simulation on different flight simulators

CO5 Demonstrate the concepts and working of a flight simulator.

TEXTBOOKS:

1. Brian L. Stevens, Frank L. Lewis, Eric N. Johnson. 'Aircraft Control and Simulation', John Wiley & Sons, 2016.
2. David Allerton. 'Principles of Flight Simulation', John Wiley & Sons, 2009.
3. Gordon. G., System Simulationǁ, Prentice – Hall Inc., 1992.
4. Nandan K. Sinha, N. Ananthkrishnan, Advanced Flight Dynamics with Elements of Flight Control, CRC Press, 1st Edition, 2017.

REFERENCES:

1. Marcello R. Napolitano. 'Aircraft Dynamics', John Wiley & Sons, 2011.
2. Stables, K.J. and Rolfe, J.M. Flight Simulation, Cambridge University Press, 1986.
3. Thomas R. Yechout, Steven L. Morris, David E. Bossert, Wayne F. Hallgren, James K. Hall— Introduction to Aircraft Flight Mechanics, AIAA Education series, 2014.

COs	POs												PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	3	3	2	2		3					3	3				
2	3	3	2		2		2				3					
3	3	3		3												
4	3	3	2		3		2				3					
5	3	3	2	3	3							3				

AE23C03	AIRCRAFT GUIDANCE AND CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

Of this course are

1. To learn about the operating principle of guidance law and augmentation systems
2. To study about the mathematical modelling of an aircraft system
3. To understand the development of aircraft equations of motion
4. To study longitudinal dynamics and to design the longitudinal autopilot
5. To study lateral dynamics and to design the lateral autopilot and understand the basics of Fly-by-wire control

UNIT I INTRODUCTION 9

Introduction to Guidance and control - Historical background -Need for automatic flight control systems, Stability augmentation systems, control augmentation systems – Flight Guidance Systems

UNIT II MATHEMATICAL MODELLING 9

Coordinate Frames - Coordinate Transformations- Different methods – Velocities in moving axis system – Development of Equations of motion – Linearization – Separations of Equations of motion

UNIT III LONGITUDINAL AUTOPILOT 9

Longitudinal Oscillatory motions - Introduction to Displacement Autopilot - Pitch Orientation Control system - Landing Geometry - Autopilot for Automatic Glide Slope Control system

UNIT IV LATERAL AUTOPILOT 9

Lateral Oscillatory motions – Dampers – Introduction to different methods of co-ordination -Yaw Orientation Control system

UNIT V FLY-BY-WIRE FLIGHT CONTROL SYSTEMS 9

Need for Fly-by-wire flight control systems – Introduction to ACT and CCV concepts - Redundancy Management – C* control law – Introduction to Digital Fly-by-wire and Fly by light concepts.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will be able to

CO1 Define the various guidance schemes and augmentation systems

CO2 Explain the equations governing the aircraft dynamics and the process of linearizing them.

CO3 Analyse the longitudinal oscillatory modes and design the autopilots for longitudinal modes and control of aircrafts

CO4 Analyse the lateral oscillatory modes and design the autopilots for lateral modesand control of aircrafts

CO5 Understand and apply the concepts of Fly by wire control systems

TEXTBOOKS:

1. Blake Lock, J.H Automatic control of Aircraft and missiles, John Wiley Sons, New York, 1990.
2. Collinson R.P.G, 'Introduction to Avionics', Chapman and Hall, India, 1996.
3. Nandan K. Sinha, N. Ananthkrishnan, Advanced Flight Dynamics with Elements of Flight Control, CRC Press, 1st Edition, 2017.
4. Nandan K. Sinha, N. Ananthkrishnan, "Elementary Flight Dynamics with an Introduction to Bifurcation and Continuation Methods, CRC Press, 2nd Edition, 2021

REFERENCES:

1. Michael V. Cook 'Flight Dynamics Principles: A Linear Systems Approach to Aircraft Stability and Control', Elsevier, 2013.
2. Nelson R.C, 'Flight stability & Automatic Control', McGraw Hill, 1989.

COs	POs												PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	3	3	2			3			2	2	3		3	3	2	
2	3	3								2	3		3	3	2	
3	3	3		3		3							3	3	2	
4	3	3	2		3	3				2	3		3	3	2	
5	3	3	2	3	3								2	3	3	

AE23C02	AIR TRAFFIC CONTROL AND PLANNING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

Of this course are

1. To introduce the basic of air traffic control.
2. To impart knowledge about air traffic systems.
3. To gain more knowledge on flight information systems.
4. To learn about aerodrome data.
5. To gain knowledge on navigation systems.

UNIT I BASIC CONCEPTS 9

Objectives of air traffic control systems - Parts of ATC services – Scope and Provision of ATCs – VFR & IFR operations – Classification of ATS air spaces – Various kinds of separation – Altimeter setting procedures – Establishment, designation and identification of units providing ATS – Division of responsibility of control.

UNIT II AIR TRAFFIC SYSTEMS 9

Area control service, assignment of cruising levels - minimum flight altitude - ATS routes and significant points – RNAV and RNP – Vertical, lateral and longitudinal separations based on time / distance –ATC clearances – Flight plans – position report- AI's role in Air Traffic Control

UNIT III FLIGHT INFORMATION SYSTEMS 9

Radar service, Basic radar terminology – Identification procedures using primary / secondary radar performance checks – use of radar in area and approach control services – assurance control and co-ordination between radar / non radar control – emergencies – Flight information and advisory service – Alerting service – Co-ordination and emergency procedures – Rules of the air. Estimated Time of Arrival at Terminal Airspace Boundary (ETA_TAB) and Estimated Landing Time (ELDT)

UNIT IV AERODROME DATA 9

Aerodrome data - Basic terminology – Aerodrome reference code – Aerodrome reference point – Aerodrome elevation – Aerodrome reference temperature – Instrument runway, physical Characteristics; length of primary / secondary runway – Width of runways – Minimum distance between parallel runways etc. – obstacles restriction.

UNIT V NAVIGATION AND OTHER SERVICES 9

Visual aids for navigation Wind direction indicator – Landing direction indicator – Location and characteristics of signal area – Markings, general requirements – Various markings – Lights, general requirements – Aerodrome beacon, identification beacon – Simple approach lighting system and various lighting systems – VASI & PAPI - Visual aids for denoting obstacles; object to be marked and lighter – Emergency and other services.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will be able to

CO1 Classify the requirement of air traffic control systems and types of air traffic control system.
CO2 Explain in flight information systems and rules of air traffic systems.
CO3 Explore the emergency procedure and air rules followed by air traffic control

systems.

CO4 Describe the aerodrome data.

CO5 Gain the information of navigation and emergency procedures in the air traffic control systems.

TEXTBOOKS:

1. AIP (India) Vol. I & II, “The English Book Store”, 17-1, Connaught Place, New Delhi.
2. “Aircraft Manual (India) Volume I”, Latest Edition – The English Book Store, 17-1, Connaught Place, New Delhi.

REFERENCES:

1. “PANS – RAC – ICAO DOC 4444”, Latest Edition, The English Book Store, 17-1, Connaught Place, New Delhi.
2. Michael S. Nolan., “Fundamentals of Air Traffic Control”, Cengage Learning.
3. Wells .A-Airport Planning and Management, 4th Edition- McGraw-Hill, London-2000.
4. P S Senguttuvaan., “Fundamentals of Air Transport Management”, McGraw-Hill, 2003.

COs	POs												PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	3					1	1					1	2			
2	3					1	1					1	2			
3	3					1		1				1	2			
4	3					1				1		1	2	1		
5	3					1	1	1		1		1	2	1		

RA23C03	VIBRATION ANALYSIS AND CONTROL	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

1. Analyze the fundamental principles and mathematical models of vibration.
2. Evaluate the response of single and multi-degree freedom systems to various excitations.
3. Apply vibration isolation methods and techniques for vibration and noise control.
4. Design and implement experimental methods for vibration analysis and measurement.
5. Interpret and analyze vibration data to identify system characteristics and behavior.

UNIT – I FUNDAMENTALS OF VIBRATION 9

Introduction -Sources of Vibration-Mathematical Models- Displacement, velocity and AccelerationReviewof Single Degree Freedom Systems -Vibration isolation Vibrometers and accelerometers - Response to Arbitrary and non- harmonic Excitations – Transient Vibration –Impulse loadsCritical Speed of Shaft-Rotor systems.

UNIT – II TWO DEGREE FREEDOM SYSTEM 9

Introduction-Free Vibration of Undamped and Damped - Forced Vibration With Harmonic Excitation System –Coordinate Couplings And Principal Coordinates.

UNIT – III MULTI-DEGREE FREEDOM SYSTEM AND CONTINUOUS SYSTEM 9

Multi Degree Freedom System –Influence Coefficients and stiffness coefficients- Flexibility Matrix and Stiffness Matrix – Eigen Values and Eigen Vectors-Matrix Iteration Method –Approximate Methods: Dunkerley, Rayleigh's, and Holzer Method -Geared Systems-Eigen Values &Eigenvectors for large system of equations using sub space, Lanczos method - Continuous System: Vibration of String, Shafts and Beams.

UNIT – IV VIBRATION AND NOISE CONTROL 9

Specification of Vibration Limits – Vibration severity standards- Vibration as condition Monitoring Tool-Vibration Isolation methods - Dynamic Vibration Absorber - Static and Dynamic Balancing machines – Field balancing - Major sources of noise – Noise survey techniques – Measurement technique for vehicular noise – Road vehicle noise standards – Industrial noise sources – Control Strategies – Noise control at the source and along the path – use of acoustic barriers – Noise control at the receiver.

UNIT – V EXPERIMENTAL METHODS IN VIBRATION ANALYSIS 9

Vibration Analysis Overview - Experimental Methods in Vibration Analysis-Vibration Measuring Instruments - Selection of Sensors- Accelerometer Mountings. -Vibration Exciters-Mechanical, Hydraulic, Electromagnetic and Electrodynamics –Frequency Measuring Instruments-. System Identification from Frequency Response -Testing for resonance and mode shapes.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO: 1. Demonstrate a comprehensive understanding of the fundamental concepts and mathematical models of vibration.
CO: 2. Apply mathematical techniques to analyze the response of single and multi-degree freedom systems.
CO: 3. Evaluate and select appropriate vibration isolation methods for specific applications.
CO: 4. Design and conduct experiments using vibration measuring instruments and sensors.
CO: 5. Analyze and interpret vibration data to identify system parameters and behavior.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	2	1	2	1	-	-	-	1	-	1	2	2	1
CO2	2	3	3	3	1	2	-	-	-	1	-	1	2	2	1
CO3	2	2	2	2	3	1	-	-	-	1	-	1	1	2	1
CO4	1	2	2	2	2	2	-	-	-	1	-	1	2	2	1
CO5	2	3	2	2	2	1	-	-	-	1	-	1	1	2	1
CO/PO & PSO Average	**2**	**2.4**	**2.2**	**2**	**2**	**1.4**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. William T. Thomson, “Theory of Vibration with Applications”, Taylor & Francis, 2003.
2. V.P. Singh, Mechanical Vibrations, Dhanpat Rai & Co, 2016.

REFERENCES:

1. Graham Kelly. Sand Shashidhar K. Kudari, “Mechanical Vibrations”, Tata McGraw –Hill Publishing Com. Ltd., 2007.
2. Singiresu S. Rao,” Mechanical Vibrations,” Pearson Education Incorporated, 2017.
3. Ramamurti. V, “Mechanical Vibration Practice with Basic Theory”, Narosa Publishing House, 2000

RA23026	QUANTITATIVE TECHNIQUES IN MANAGEMENT	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To familiarize the students with concepts of Linear Programming
2. To introduce the replacement models to students
3. To enable the students to utilize the queuing models for application to waiting line problems.
4. To stress importance of inventory management and their use in industry.
5. To familiarize project network and decision tree problems to students so that they can use them in project management.

UNIT I LINEAR PROGRAMMING 9

Problem formulation - Graphical method – simplex method- Big M method- Two Phase Method–Dual Simplex method- Special cases of LP– transportation model- assignment model –applications.

UNIT II REPLACEMENT MODELS AND GAME THEORY 9

Basic replacement model – individual replacement and group replacement problems –applications – game theory – terminology – decision criteria – solution to a 2 x 2 and 2 x n games – applications of LP in game theory – applications.

UNIT III QUEUING MODELS AND SIMULATION 9

Elements of queue – queue discipline – Poisson arrival and exponential service – Queue Models - queue length –waiting time – steady state conditions – applications – concept of simulation – Monte Carlo method – applications-Scheduling – priority rules -sequencing – methods of sequencing – Johnson's rule – Heuristic approach, line balancing –applications.

UNIT IV INVENTORY MANAGEMENT 9

Inventory – Purpose – Economic Order Quantity – Quantity Discount Model – Material Requirement Planning –Q System-P system- Finite Replenishment– ABC Analysis.

UNIT V PROJECT NETWORK ANALYSIS AND DECISION TREE ANALYSIS 9

Network – CPM/PERT – Project time estimation – critical path – crashing of network, Decision tree analysis – applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

1. Use the simplex method to solve problems in industry
2. Identify a suitable replacement model so that replacement of equipment's can be done optimally
3. Utilize the knowledge on queuing models and sequencing in production systems
4. Identify inventory model for a specific industry
5. Select a suitable project network technique for project management

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	-	1	-	-	-	-	-	1	-	1	1	1	1
CO2	3	2	-	1	-	-	1	-	-	1	-	1	1	1	1
CO3	3	2	-	1	-	-	-	-	-	1	-	1	1	1	1
CO4	3	2	-	2	-	1	1	-	-	1	1	1	1	2	1
CO5	3	2	1	2	-	-	-	-	-	1	1	1	1	2	1
CO/PO & PSO Average	**3**	**2**	**1**	**1.4**	**-**	**1**	**1**	**-**	**-**	**1**	**1**	**1**	**1**	**1.4**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Hamdy A.Taha, “Operations Research – An Introduction”, Prentice Hall of India, 11th edition2022.
2. Panneerselvam R., “Operation Research”, Prentice Hall of India, 3rd edition, 2023.

REFERENCES

1. Guptha.P.K. and Man-Mohan, “Problems in Operations Research”, Sultan chand and Sons,2014.
2. Monks. J.G, “Operations Management theory and Practice”, McGraw Hill, 2nd edition 1996.
3. Ravindran, Philips and Sojberg, “Operations Research Principles and Practice”, John Wileyand Sons, Singapore, 2nd edition, 2007.
4. Sharma J.K., “Operations Research Theory and Applications”, Macmillan India Ltd., 5thedition, 2012.
5. Kothari D P,Awari G K, “Quantitative Techniques in Business, Management and Finance”,CRC Press, Taylor and Francis Group, 2016.

RA23027	DESIGN OF EXPERIMENTS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To familiarize the concepts of Single Factor Experiment and Post hoc tests
2. To illustrate understanding of Factorial experiments
3. To enable students with the extensions of Factorial experiments and Response Surface Methods
4. To provide students with an understanding of Taguchi method for parameter Optimization
5. To provide students with understanding of Shainin DOE

UNIT I SINGLE FACTOR EXPERIMENTS 9

Introduction to Hypothesis testing – Experimentation – Need, Conventional test strategies, terminology, basic principles of design – steps in experimentation – Completely Randomized Design-effect of coding the observations- model adequacy checking - estimation of model parameters, residuals analysis- treatment comparison methods – Duncan's multiple range test, Newman-Keuel's test, Fisher's LSD test, Tukey's test- Testing using contrasts-Randomized Block Design – Latin Square Design- Graeco Latin Square Design – Applications.

UNIT II FACTORIAL DESIGNS 9

Main and Interaction effects - Two and three factor full factorial designs- Fixed effects and random effects model – Rule for sum of squares and Expected Mean Squares - 2^K Design with two and three factors– Yate's Algorithm – Fitting regression model– Randomized Block Factorial Design-Introduction to MANOVA & ANCOVA.

UNIT III SPECIAL FACTORIAL DESIGNS & RESPONSE SURFACE METHODS 9

Blocking and Confounding in 2^K Designs- blocking in replicated design – 2^K Factorial Design in two blocks– Complete and partial confounding – Confounding 2^K Design in four blocks – Two level Fractional Factorial Designs - Construction of one-half and one-quarter fraction of 2^K Design - Introduction to Response Surface Methods- Designs for fitting First –order Model -Central Composite Design – Box- Behnken Designs.

UNIT IV TAGUCHI DESIGN OF EXPERIMENTS 9

Taguchi's Quality Loss Function- Philosophy- Design of Experiments using Orthogonal Arrays, Data analysis from Orthogonal experiments - Response Graph Method- ANOVA- Attribute data analysis-Robust design- noise factors, Signal to Noise ratios, Inner/outer OA design- case studies.

UNIT V SHAININ DESIGN OF EXPERIMENTS 9

Basics of Shainin DOE - Comparison between Taguchi DOE Vs Shainin DOE methods - Problem Solving Algorithm - Problem Identification Tools- Shainin Design of Experiments Tools - Case studies

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1. Understand the fundamental principles of Classical Design of Experiments

CO2. Apply single factor experiment for process parameter understanding and optimization.
CO3. Apply Factorial Design principles for understanding of process parameters and its optimization
CO4. Gain knowledge on Taguchi's approach to experimental design for attaining robustness.
CO5. Apply Response Surface Method and Shainin DOE to evaluate quality

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	2	-	1	2	-	-	-	-	-	3	1	1	2	1
CO2	2	3	3	2	2	-	-	-	-	-	3	1	1	2	1
CO3	2	3	3	3	2	-	-	-	-	-	3	1	1	2	1
CO4	2	3	3	2	2	-	-	-	-	-	3	1	1	2	1
CO5	2	3	3	2	2	-	-	-	-	-	3	1	1	2	1
CO/PO & PSO Average	**2**	**2.8**	**3**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**3**	**1**	**1**	**2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Krishnaiah K, and Shahabudeen P, "Applied Design of Experiments and Taguchi Methods", PHI,1 st Edition, 2011.

REFERENCES

1. Douglas C. Montgomery, "Design and Analysis of Experiments", John Wiley &sons,Inc Hoboken,10th edition,2021 .
2. Krishnaiah K, Applied Statistical Quality Control and Improvement,1 st Edition,2014.
3. Box, G. E., Hunter,W.G., Hunter, J.S., Hunter,W.G., "Statistics for Experimenters: Design, Innovation, and Discovery", 2nd Edition, Wiley, 2005.
4. Phillip J. Ross, "Taguchi Techniques for Quality Engineering", Tata McGraw-Hill, 2005.

RA23028	ENGINEERING MANAGEMENT	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students:

1. To familiarize students about the concepts of inventory management.
2. To introduce the students about Production Management Techniques such as work study, Plant location, Layout, Materials handling.
3. To illustrate to the students the importance of financial management.
4. To introduce Profit Planning and management as a concept to plan for profit.
5. To familiarize the students, HR and Marketing concepts and techniques.

UNIT – I INVENTORY MANAGEMENT 9

Inventory – Purpose – Economic Order Quantity – Quantity Discount Model – MaterialRequirement Planning –Q System-P system- Finite Replenishment– ABC Analysis.

UNIT – II PRODUCTION MANAGEMENT 9

Work Study – Method Study – Steps in method study – Motion economy – Principles – Workmeasurement – Stop watch – Time study – Work sampling – Plant location decision making – Plant layout – Principles types- Selection – Material handling – Principles – Selection – Plantlayout, location techniques-Aggregate Planning.

UNIT – III FINANCIAL MANAGEMENT 9

Financial Accounting- Income statement-Balance sheet- Assets- types- Liabilities- Consumersequity- Sources of finance- Capital budgeting- Working Capital Management- Inventory Pricing.

UNIT – IV PROFIT AND LOSS MANAGEMENT 9

Break Even Analysis – Profit planning – Angle of incidence – Margin of safety – Multi productbreak even analysis – Effect of variation in selling price, Fixed cost and Variable cost on breakeven quantity, angle of incidence and margin of safety.

UNIT – V HUMAN RESOURCE AND MARKETING MANAGEMENT 9

Human resource management – Organization- Recruitment- Selection – Training andDevelopment- Communication – Motivation – Trade union – Industrial relations – Marketing –Organization – Difference between marketing and selling – Sales promotion- Distributionchannels- Advertisement – Publicity – Packaging – Market research.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

1. Design a suitable inventory system for a given situation.
2. Interpret work study and its methods todevelop layout and materials handling systems.
3. Prepare financial statements such as balance sheet, income statements.
4. Apply concepts of Break Even Analysis for profit planning.

5. Develop marketing and human resource skills.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	2	2	2	3	1	2	1	1	1	2	3	3	3	1
CO2	2	2	2	2	3	1	2	1	1	1	2	3	3	3	1
CO3	2	2	2	2	3	1	2	1	1	1	2	3	3	3	1
CO4	2	2	2	2	3	1	2	1	1	1	2	3	3	3	1
CO5	2	2	2	2	3	1	2	1	1	1	2	3	3	3	1
CO/PO & PSO Average	**2**	**2**	**2**	**2**	**3**	**1**	**2**	**1**	**1**	**1**	**2**	**3**	**3**	**3**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Kesavan. R, Elanchezhian.C, and SundarSelwyn. T, “Engineering Management”,Eswar Press, 2009.
2. Panneerselvam.R, “Production and Operations Management”, Prentice Hall of India, 3rd edition, 2012.

REFERENCES:

1. Aswathappa, “Human Resources Management”, McGraw Hill, 2018.
2. Chary S.N, “Production and Operation Management”, Tata McGraw Hill, 4th Edition, 2012.
3. Philips Kotler, “Marketing Management”, Pearson Education, 16th Edition, 2022.
4. Prasanna Chandra,”Financial Management”, McGraw Hill, 2018.
5. MartlandTelsand, “Industrial Engineering and Production Management”, S.Chand, 2006.

RA23029	SUPPLY CHAIN MANAGEMENT	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To describe the role and drivers of supply chain management in achieving competitiveness.
2. To explain about supply chain network design and inventory.
3. To illustrate about the issues related to logistics in supply chain.
4. To appraise about sourcing and coordination in supply chain.
5. To apply information technology concepts in supply chain.

UNIT – I INTRODUCTION **9**

Role of Logistics and Supply chain Management: Scope and Importance - Evolution of Supply Chain – Examples of supply Chains - Decision Phases in Supply Chain - Competitive and Supply chain Strategies – Drivers of Supply Chain Performance and Obstacles – Supply Chain Performance Measures – Enhancing Supply Chain Performance Measures-Challenges in maintaining Supply Chain in India.

UNIT – II NETWORK DESIGN AND IVENTORY **9**

Role of Distribution in Supply Chain – Factors influencing Distribution network design – Design options for Distribution Network- Distribution Network in Practice - Role of network Design in Supply Chain – Framework for network Decisions. Managing inventories in Supply Chain: Single stage inventory control, inventory control policies, impact of service level on safety stock.

UNIT – III LOGISTICS IN SUPPLY CHAIN **9**

Role of transportation in supply chain – Factors affecting transportations decision – Design option for transportation network – Tailored transportation – Vehicle Routing and scheduling in transportation - 3PL-4PL- Global Logistics - Reverse Logistics; Reasons, Activities and issues-Closed Loop Supply Chain

UNIT – IV SOURCING AND COORDINATION **9**

Role of transportation in supply chain – Supplier selection – Design collaboration – Sourcing planning and analysis – Types of supply chain contracts and its types – Supply chain co-ordination – Bull Whip Effect – Effect of lack of co-ordination in supply chain and obstacles – Remedial measures to overcome Bull Whip Effect - Building strategic partnerships and trust within a supply chain.

UNIT – V IT AND EMERGING CONCEPTS IN SUPPLY CHAIN **9**

The role IT in supply chain-The supply chain IT framework - Customer Relationship Management – Internal Supply Chain Management – Supplier Relationship Management – Future of IT in supply chain – E-Business in Supply Chain- Introduction to Warehouse Management, Risks in Supply Chain, Lean Supply Chains, Sustainable supply Chains – Block Chain and its applications in Supply Chain.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

1. Understand the scope of Supply Chain Management (SCM) and the drivers of supply chain performance.
2. Design suitable Supply Chain network and inventory for a given situation
3. Solve the issues related to Logistics in SCM
4. Understand sourcing, coordination and current issues in SCM
5. Appraise about the applications of IT in SCM and apply SCM concepts in selected enterprise

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	1	2	1	-	-	-	-	-	-	-	-	-	1	1	1
CO2	3	3	1	1	1	-	-	-	-	-	-	-	1	2	2
CO3	3	3	1	1	1	-	-	-	-	-	-	-	1	2	2
CO4	3	3	1	1	1	-	-	-	-	-	-	-	1	2	2
CO5	3	3	1	1	3	-	-	-	-	-	-	-	1	1	2
CO/PO & PSO Average	**2.6**	**2.8**	**1**	**1**	**1.5**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**1.6**	**1.8**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Sunil Chopra, Peter Meindl and D.V. Kalra, “Supply Chain Management: Strategy, Planning,and Operation", Pearson Education,7th edition 2020.
2. Mason Harris, “Global Logistics and Supply Chain Management”, WILLFORD Press, 2020

REFERENCES:

1. Ravi Ravindran A, Donald P. Warsing, Jr, “Supply Chain Engineering: Models and Applications”, CRC Press, 2023.
2. Srinivasan G.S, “Quantitative models in Operations and Supply Chain Management”, PHI, 2010.
3. Thomas E. Vollmann, William Lee Berry, David Clay Whybark and F. Robert Jacobs, “Manufacturing Planning and Control Systems for Supply Chain Management”, McGraw Hill., 2014.
4. Joseph J, Massie, “Essentials of Management”, Prentice Hall of India Pvt. Ltd., 1985
5. Donald J. Bowersox, David J. Closs, M. Bixby Cooper, John C. Bowersox, “Supply Chain Logistics Management”, McGraw Hill, 2023

IE23C02	FUNDAMENTALS OF LEAN SIX SIGMA	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To know the basis of lean and Six Sigma.
2. To analyse the process of integrating Lean and six sigma
3. To identify and select the resources required for LSS Projects and selection of projects including Team building.
4. To infer the DMAIC process and study the various tools for undertaking LSS projects.
5. To relate how to institutionalize the LSS efforts.

UNIT I INTRODUCTION TO LEAN AND SIX SIGMA 9

Introduction to Lean- Definition, Purpose, Features of Lean; Top seven wastes, need for Lean management, the philosophy of lean management, Creating a lean enterprise, Elements of Lean, Lean principles, the lean metric, Hidden time traps. Introduction to quality, Definition of six sigma, origin of six sigma, Six sigma concept and Critical success factors for six sigma: Case analysis.

UNIT II INTEGRATION OF LEAN AND SIX SIGMA 9

Evolution of lean six sigma, the synergy of Lean and six sigma, Definition of lean six sigma, the principles of lean six sigma, Scope for lean six sigma, Features of lean six sigma. The laws of lean six sigma, Key elements of LSS, the LSS model and the benefits of lean six sigma. Initiation - Top management commitment – Infrastructure and deployment planning, Process focus, organizational structures, Measures – Rewards and recognition, Infrastructure tools, structure of transforming event and Launch preparation; Case study presentations.

UNIT III PROJECT SELECTION AND TEAM BUILDING 9

Resource and project selection, Selection of Black belts, Training of Black belts and Champions, Identification of potential projects, top down (Balanced score card) and Bottom up approach – Methods of selecting projects – Benefit/Effort graph, Process mapping, value stream mapping, Predicting and improving team performance, Nine team roles and Team leadership; Case study presentations.

UNIT IV THE DMAIC PROCESS AND TOOLS 9

The DMAIC process – Toll gate reviews; The DMAIC tools; Define tools – Project definition form, SIPOC diagram; Measure tools – Process mapping, Lead time/cycle time, Pareto chart, Cause and Effect matrix, FMEA: Idea – generating and organizing tools – Brainstorming, Nominal group technique and Multi-voting and Cause and effect diagram, Data collection and accuracy tools- Check sheet, Gauge R&R; Understanding and eliminating variation- run charts; control charts and process capability analysis: Analyze tools - Scatter plots, ANOVA, Regression analysis, Time trap analysis; Improve tools – Mistake proofing, Set up time reduction (SMED), TPM, DOE and the pull system; Control tools – statistical process control.

UNIT V INSTITUTIONALIZING AND DESIGN FOR LSS 9

Institutionalizing lean six sigma – improving design velocity, creating cycle time base line, valuing projects, gating the projects, reducing product line complexity, Design for lean six sigma, QFD, Theory of Inventive Problem solving (TRIZ), Robust design; Case study presentations.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1. Understand what is Lean and Six sigma and their importance in the globalized competitive world.
CO2. Understand the importance of integrating Lean and Six sigma and also the process of their integration.
CO3. Plan the Resources required to undertake the LSS projects and also acquire how to select the suitable projects and the teams.
CO4. Apply DMAIC methodology to execute LSS projects and in this regard they will be acquainted with various LSS tools.
CO5. Understand the process of institutionalizing the LSS effort and also understand the Design for LSS.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	3	3	3	1	1	-	-	-	-	2	1	-	1
CO2	3	3	3	3	3	2	2	-	-	-	-	3	1	-	1
CO3	3	3	3	3	3	2	2	-	-	-	-	2	1	-	1
CO4	3	3	3	3	3	2	2	-	-	-	-	2	1	-	1
CO5	3	3	3	3	3	3	3	-	-	-	-	3	1	-	1
CO/PO & PSO Average	**3**	**3**	**3**	**3**	**3**	**2**	**2**	-	-	-	-	**2.4**	**1**	**-**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Michael L.George, David Rownalds, Bill Kastle, What is Lean Six Sigma, McGraw – Hill 2003
2. James P. Womack, Daniel T.Jones, Lean Thinking, Free Press Business, 2003

REFERENCES

1. Thomas Pyzdek, The Six Sigma Handbook, McGraw-Hill,2000.
2. Fred Soleimannejed, Six Sigma, Basic Steps and Implementation, AuthorHouse, 2004.
3. Forrest W. Breyfogle, III, James M. Cupello, Becki Meadows, Managing Six Sigma:A Practical Guide to Understanding, Assessing, and Implementing the Strategy That Yields Bottom-Line Success, John Wiley & Sons, 2000.

IE23C05	ENGINEERING ECONOMICS AND COSTING	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To understand the concept of Engineering Economics and gaining knowledge to implement various micro economics concept in real life.
2. To gain knowledge in the field of macro-economics to enable the students to have better understanding of various components of macro-economics.
3. To understand the different procedures of pricing.
4. To gain knowledge in the field of costing.
5. To analyze the various methods of costing in detail.

UNIT I INTRODUCTION TO MANAGERIAL ECONOMICS AND DEMAND ANALYSIS 9

Definition of Managerial Economics - Nature and scope of Managerial Economics - Managerial Economics and other disciplines. Objectives of the firm - Factors influencing Managerial decisions, Demand Analysis – Defining demand, Types of demand and Determinants of demand, Elasticity of Demand and Supply.

UNIT II PRODUCTION AND COST ANALYSIS 9

Production Analysis – Production function, Returns to a factor, Returns to scale, ISO quants and least cost combination of inputs. Cost Analysis – Cost concepts, Determinants of cost, Short-run cost-output Relationship, Long-run cost output relationship, Economies and Diseconomies of scale and Estimating Cost-Output Relationship.

UNIT III PRICING 9

Determinants of Price – Pricing under different objectives – Pricing under different market structures – Price discrimination – Pricing of Joint products – Pricing methods in practice.

UNIT IV COSTING 9

Objectives, Functions, Importance of Costing – Cost Accounting – Classification of costs – Elements of cost – Estimation in Material cost, Labour cost and overheads – Allocation of overheads.

UNIT V COSTING METHODS AND CONTROL 9

Job costing – Operating costing – Process costing, Budgetary control.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1. Summarize principles of micro economics and demand forecasting.
CO2. Recognize the concepts in production and detailed cost analysis.
CO3. Infer the principles of pricing methodologies.
CO4. Examine the basics of costing for all type of industry.
CO5. Distinguish cost analysis using different methods of costing.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	-	-	-	-	-	-	-	-	3	2	1	-	1
CO2	3	2	-	-	-	-	-	-	-	-	-	2	1	-	1
CO3	-	-	-	-	-	-	2	-	-	-	1	-	1	-	1
CO4	-	-	2	-	-	-	-	2	-	-	3	-	1	-	1
CO5	2	-	-	-	-	-	-	-	-	-	2	-	1	-	1
CO/PO & PSO Average	**2.6**	**2**	**2**	**-**	**-**	**-**	**2**	**2**		**-**	**1.8**	**2**	**1**	**-**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Yogesh Maheshwari, “Managerial Economics”, Third edition, PHI 2012.
2. Jawaharlal, Cost Accounting, Tata McGraw Hill, 2013

REFERENCES

1. Mote V L, Samuel Paul and G.S.Gupta, “Managerial Economics – concepts and cases”,McGraw Hill Education (India), 2011.
2. Paneerselvam R, “Engineering Economics”, PHI, 2013.
3. Ramachandra Aryasri A and Ramana Murthy V V, “Engineering Economics and Financial Accounting”, McGraw Hill Education (India), New Delhi, 2004.
4. Nag A, “Macro Economics for Management Students” MacMillan India Ltd., New Delhi, 2005.

RA23030	INTEGRATED PRODUCT DEVELOPMENT	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

1. Understand the fundamental concepts and principles of product development.
2. Apply product development methodologies and techniques in practical scenarios.
3. Analyze and evaluate global trends and their impact on product decisions.
4. Create effective product designs and prototypes using appropriate tools and techniques.
5. Evaluate the sustainability and end-of-life support considerations in product development.

UNIT – I FUNDAMENTALS OF PRODUCT DEVELOPMENT 9

Global Trends Analysis and Product decision - Social Trends - Technical Trends-Economic Trends - Environmental Trends - Political/Policy Trends - Introduction to Product Development Methodologies and Management - Overview of Products and services - Types of Product Development - Overview of Product Development methodologies- Product Life Cycle – Product Development Planning and Management.

UNIT – II REQUIREMENTS AND SYSTEM DESIGN 9

Requirement Engineering - Types of Requirements - Requirement Engineering -traceability Matrix and Analysis - Requirement Management - System Design &Modeling -Introduction to System Modeling - System Optimization - System Specification - Sub-System design - Interface Design.

UNIT – III DESIGN AND TESTING 9

Conceptualization - Industrial Design and User Interface Design - Introduction to Concept generation Techniques – Challenges in Integration of Engineering Disciplines – Concept Screening & Evaluation - Detailed Design - Component Design and Verification –Mechanical, Electronics and Software Subsystems - High Level Design/Low Level Design of S/W Program - Types of Prototypes, S/W Testing- Hardware Schematic, Component design, Layout and Hardware Testing – Prototyping - Introduction to Rapid Prototyping and Rapid Manufacturing - System Integration, Testing, Certification and Documentation.

UNIT – IV SUSTENANCE ENGINEERING AND END-OF-LIFE (EOL) SUPPORT 9

Introduction to Product verification processes and stages - Introduction to Product Validation processes and stages - Product Testing Standards and Certification - Product Documentation - Sustenance **-** Maintenance and Repair – Enhancements - Product EOL **–** Obsolescence Management – Configuration Management - EOL Disposal

UNIT – V BUSINESS DYNAMICS – ENGINEERING SERVICES INDUSTRY 9

The industry - Engineering Services Industry - Product Development in Industry versus Academia –The IPD Essentials - Introduction to Vertical Specific Product Development processes - Manufacturing/Purchase and Assembly of Systems - Integration of Mechanical, Embedded and Software Systems – Product Development Trade-offs - Intellectual Property Rights and Confidentiality – Security and Configuration Management.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO 1: Demonstrate a comprehensive understanding of product development principles and methodologies.

CO 2: Apply product development techniques to solve real-world problems and challenges.

CO 3: Analyze global trends and make informed product decisions based on their implications.

CO 4: Create innovative product designs and prototypes using various tools and technologies.

CO 5: Evaluate the sustainability and end-of-life support strategies in product development.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	-	-	-	1	1	-	1	-	1	1	1	1
CO2	2	1	1	1	-	-	-	-	-	1	-	1	1	1	1
CO3	2	2	1	1	-	-	-	1	-	1	-	1	1	1	1
CO4	2	1	2	1	-	-	-	1	-	1	-	1	1	1	1
CO5	2	2	1	1	-	-	-	1	-	1	-	1	1	1	1
CO/PO & PSO Average	**2**	**1.5**	**1.2**	**1**	**-**	**-**	**1**	**1**	**-**	**1**	**-**	**1**	**1**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Book specially prepared by NASSCOM as per the MoU.
   Karl T Ulrich and Stephen D Eppinger, "Product Design and Development", Tata McGraw Hill, Fifth Edition, 2020.
2. John W Newstorm and Keith Davis, "Organizational Behavior", Tata McGraw Hill, Eleventh Edition.

REFERENCES:

1. Hiriyappa B, “Corporate Strategy – Managing the Business”, Author House, 2013.
2. Peter F Drucker, “People and Performance”, Butterworth – Heinemann [Elsevier], Oxford, 2007.
3. Vinod Kumar Garg and Venkita Krishnan N K, “Enterprise Resource Planning – Concepts”, Second Edition, Prentice Hall, 2004.
4. Mark S Sanders and Ernest J McCormick, "Human Factors in Engineering and Design", McGraw Hill Education, Seventh Edition, 20131. Hiriyappa B, “Corporate Strategy – Managing the Business”, Author House, 2015.

PR23C02	COMPOSITE MATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To introduce the concept of composites and various types of composites.
2. To familiarize about the types of fibres and matrix materials
3. To analyze different polymer matrix composites processing methods and their applications
4. To expose the students to the various metal matrix composite processing methods
5. To analyze the processing techniques of various ceramic matrix composites.

UNIT – I INTRODUCTION TO COMPOSITES 9

Definition and fundamentals of composites– Types - need for composites – enhancement of properties - commonly used reinforcement and matrix constituents, general characteristics, rule of the mixture – Theory of composites – Mechanical behaviour – Stress-strain relationships – Thermal properties. Applications of various types of composites. Fibres – Types, Fabrication, Structure, properties and applications – Glass, Boron, carbon, polyethylene, Kevlar, Aramid, Alumina, SiC, Si3, N4, B4C, ceramic and metallic fibres whiskers – Matrix materials structure – Polymers – metals and ceramics – Physical and chemical properties - Fiber surface treatments

UNIT – II POLYMER MATRIX COMPOSITES 9

Open mould process, bag moulding, Hand layup and spray up techniques, filament winding, compression and transfer moulding, BMC and SMC – pultrusion – centrifugal casting – injection moulding – structure, properties and application of PMC's – Carbon Matrix Composites – Interfaces – Properties – recycling of PMC.

UNIT – III METAL MATRIX COMPOSITES 9

Processing of MMCs: Types, Important metallic materials, Processing – solid state, Liquid state, deposition, in-situ fabrication methods. Interfaces – diffusion bonding – powder metallurgy technique – Machining - properties - Applications.

UNIT – IV CERAMIC MATRIX COMPOSITES 9

Ceramic matrix materials – Need for CMC Ceramic matrix - Various types of Ceramic Matrix composites - Processing – Hot pressing, liquid infiltration techniques Lanxide process, In-situ, sol-gel, chemical reaction techniques - CVD, CVI process. Interface in CMCs. Thermal shock resistance - Applications, Properties, Surface treatment.

UNIT – V TESTING AND CHARECTERIZATION 9

Testing of composites: Mechanical testing of composites, tensile testing, compressive testing, Hardness testing, Impact testing, Intra-laminar shear testing, Inter-laminar shear testing, Fracture testing, wear testing, Fatigue testing.Thermal properties of composites – Thermal expansion – Specific heat – Phase transformations – Thermal conductivity – Thermal conductance of an Interface – Evaluating the thermal conduction – uses.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

1. Acquire Knowledge about various composites and their properties
2. Classify fiber and matrix materials and select for its applications.
3. Discuss various polymer matrix composites, processing methods.
4. Analyze the various processing methods of metal matrix composites.
5. Interpret the various processing techniques of ceramic matrix composites.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	-	-	-	-	-	-	1	-	1	1	-	1
CO2	2	-	-	1	-	-	1	-	-	1	-	1	2	-	2
CO3	2	-	-	1	-	-	1	-	-	1	-	1	2	-	2
CO4	2	-	-	1	-	-	-	-	-	1	-	1	2	-	2
CO5	2	-	-	1	-	-	-	-	-	1	-	1	2	-	2
CO/PO & PSO Average	2.0	1.0	-	1.0	-	-	1.0	-	-	1.0	-	1.0	1.8	-	1.8
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Hall, Wayne., Javanbakht, Zia, “Design and Manufacture of Fibre - Reinforced Composites”, Springer, 2021.
2. Krishan K Chawla, “Composite materials science and engineering”, Springer, 3rd Edition, 2021.

REFERENCES

1. Kenneth, Budinski.G and Michael K. Budinski, “Engineering Materials”, Prentice Hall of India pvt ltd., 4th Indian reprint, 2010
2. Mathews F.L. and Rawlings R.D., “Composite materials, Engineering and Science”, Chapman. Woodhead Publishing, 1999.
3. Strong. B, “Fundamentals of composite manufacturing”, SME, 2008
4. Sharma. S.C, “Composite materials”, Narosa publications, 2000
5. Weatherhead R.G., “FRP technology”, Applied Science Publishers Limited, 2012.

PR23C08	PROCESS PLANNING AND COST ESTIMATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To select the process, equipment and tools for process planning
2. To explain the concept of cost estimation and its elements.
3. To compute the overhead and depreciation cost.
4. To learn to estimate production cost for casting, forging and welding processes.
5. To calculate the machining time and cost for various machining operations.

UNIT – I INTRODUCTION TO PROCESS PLANNING **9**

Drawing interpretation –Material selection process and methods – Selection of Production Processes from Tables – Factors to be considered in selecting: Processes; Process Sequencing; Operation Sequencing; Equipment & Tool Selection; Tool Holding Devices; Measuring Instruments –Computer Aided Process Planning – Retrieval / Variance CAPP and Generative CAPP - Case Study in Process Planning.

UNIT – II COST ESTIMATION **9**

Concept and Purpose of Estimating, Functions of Estimating Department, Concept of Costing, Costing versus Estimating, Types of Estimates, Importance of Estimates, Estimating Procedure, Cost Estimators and their Qualifications, Principal Constituents in a Cost Estimate – Elements of Cost – Introduction, Material Cost, Labour Cost, Expenses and Cost of Product (Ladder Cost).

UNIT – III ESTIMATION OF OVERHEADS AND DEPRECIATION **9**

Overhead, Allocation or Distribution of Overhead Cost , Depreciation and Methods to Calculate it, Interest on Capital, Idleness Costs, Repair and Maintenance Cost

UNIT – IV ESTIMATION OF CASTING, FORGING AND WELDING COSTS **9**

Estimation of cost for Casting processes, Welding processes and Forging processes.

UNIT – V ESTIMATION OF MACHINING COST **9**

Estimation of Machining Time and Cost – Drilling, Milling, Shaping Planning, Grinding operations.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

1. Select the process, equipment and tools for various process planning
2. Apply the various elements of cost and its types for product costing.
3. Determine the overhead and depreciation cost for industrial products.
4. Estimate production cost for casting, forging and welding processes.
5. Evaluate the machining time and cost for various machining operations.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	1	-	1	-	-	-	-	-	1	-	1	1	1	1
CO2	3	1	-	1	-	-	-	-	-	1	-	1	1	1	1
CO3	3	1	-	1	-	-	-	-	-	1	-	1	1	1	1
CO4	3	1	-	1	-	-	-	-	-	1	-	1	1	1	1
CO5	3	1	-	1	-	-	-	-	-	1	-	1	1	1	1
CO/PO & PSO Average	3.0	1.0	-	1.0	-	-	-	-	-	1.0	-	1.0	1	1	1
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Panneer Selvam, Sivasankaran P, "Process planning and Cost Estimation", Prentice-Hall of India, 2016
2. S.C.Sharma, T.R.Banga, "Mechanical Estimating and Costing", Khanna Publishers, 2011.

REFERENCES

1. Chitale A.V. and Gupta R.C., “Product Design and Manufacturing”, 2nd Edition, PHI, 2002.
2. Ostwalal P.F. and Munez J., “Manufacturing Processes and Systems”, John Wiley, 9th Edition, 1998.Russell R.S and Tailor B.W, “Operations Management”, PHI, 4th Edition, 2003.
3. Mikell P. Groover, “Automation, Production, Systems and Computer Integrated Manufacturing”, Pearson Education, 2001.
4. K.C. Jain & L.N. Aggarwal, “Production Planning Control and Industrial Management”, Khanna Publishers, 1990.

ME23C09	FINITE ELEMENT ANALYSIS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

1. Apply mathematical modeling techniques to solve engineering field problems.
2. Analyze and solve one-dimensional problems using the finite element method.
3. Formulate and solve two-dimensional scalar variable problems in engineering.
4. Determine solutions for two-dimensional vector variable problems in elasticity.
5. Utilize isoparametric formulation and advanced techniques in engineering analysis.

UNIT I INTRODUCTION 9

Historical Background – Mathematical Modeling of field problems in Engineering –Governing Equations – Discrete and continuous models – Boundary, Initial and Eigen Value problems– Weighted Residual Methods – Variational Formulation of Boundary Value Problems – Ritz Technique – Basic concepts of the Finite Element Method.

UNIT II ONE-DIMENSIONAL PROBLEMS 9

One Dimensional Second Order Equations – Discretization – Element types- Linear and Higher order Elements – Derivation of Shape functions and Stiffness matrices and force vectors-Assembly of Matrices - Solution of problems from solid mechanics including thermal stresses-heat transfer. Natural frequencies of longitudinal vibration and mode shapes. Fourth Order Beam Equation – Transverse deflections and Transverse Natural frequencies of beams.

UNIT III TWO-DIMENSIONAL SCALAR VARIABLE PROBLEMS 9

Second Order 2D Equations involving Scalar Variable Functions – Variational formulation –Finite Element formulation – Triangular elements and Quadrilateral elements- Shape functions and element matrices and vectors. Application to Field Problems - Thermal problems – Torsion of Non-circular shafts.

UNIT IV TWO-DIMENSIONAL VECTOR VARIABLE PROBLEMS 9

Equations of elasticity – Plane stress, plane strain and axisymmetric problems – Constitutive

matrices and Strain displacement matrices – Stiffness matrix – Stress calculations - Plate and shell elements.

UNIT V ISOPARAMETRIC FORMULATION AND ADVANCED TOPICS 9

Natural co-ordinate systems – Isoparametric elements – Shape functions for isoparametric elements– One and two dimensions – Serendipity elements – Numerical integration - Meshing techniques - Introduction to Analysis Software-Introduction to Non-Linearity.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1 Develop mathematical models for Boundary Value Problems and their numerical solution
CO2 Formulate the Finite Element methodology to solve the one-dimensional problems.
CO3 Estimate field variables for two-dimensional scalar variable problems
CO4 Determine field variables for two-dimensional vector variable problems

CO5 Apply the Iso-parametric transformation and use the numerical integration technique for engineering problems.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	2	2	2	-	-	1	-	-	2	1	2	-	2
CO2	3	3	3	3	2	-	-	1	-	-	1	2	2	-	2
CO3	3	3	3	2	3	-	-	1	-	-	2	2	2	-	2
CO4	3	3	3	3	2	-	-	1	-	-	1	2	2	-	2
CO5	3	3	2	2	3	-	-	1	-	-	2	1	2	-	2
CO/PO & PSO Average	**3**	**3**	**2.6**	**2.4**	**2.4**	**-**	**-**		**-**	**-**	**1.6**	**1.6**	**2**	**-**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Rao, S.S., “The Finite Element Method in Engineering”, 6th Edition, ButterworthHeinemann, 2018.

REFERENCES:

1. David Hutton, “Fundamentals of Finite Element Analysis”, Tata McGrawHill, 2005
2. Dhanaraj. R and Prabhakaran Nair. K, “Finite Element Analysis”, Oxford Publications, 2015.
3. Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt, “Concepts and Applications of Finite Element Analysis”, 4th Edition, Wiley Student Edition, 2004.
4. Seshu.P, “Text Book of Finite Element Analysis”, PHI Learning Pvt. Ltd., NewDelhi, 2012.
5. Tirupathi R. Chandrupatla and Ashok D. Belegundu, “Introduction to Finite Elements in Engineering”, International Edition, Pearson Education Limited, 2014.
6. Bathe K. J, “Finite Element Procedures in engineering analysis” 1996

RA23031	STATISTICAL QUALITY CONTROL AND RELIABILITY	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

1. Understand the principles and concepts of statistical process control (SPC) and its application in quality control.
2. Learn about acceptance sampling techniques and their role in determining product quality.
3. Gain knowledge of experimental design and Taguchi methods for optimizing process parameters and improving product quality.
4. Explore reliability analysis techniques and methods for predicting and improving product reliability.
5. Develop skills in analyzing failure data and selecting appropriate statistical distributions for reliability analysis.

UNIT – I STATISTICAL PROCESS CONTROL 9

Quality control – Definition – Quality Assurance Variation in process – Factors – control charts – variables XR and Xσ, - Attributes P, C and U-Chart Establishing and interpreting control charts process capability – Quality rating – Short run SPC.

UNIT – II ACCEPTANCE SAMPLING 9

Lot by lot sampling types – probability of acceptance in single, double, multiple sampling plans – OC curves – Producer's risk and consumer's risk. AQL, LTPD, AOQ, AOQL, Concepts Design of sampling plan – single, double, multiple- standard sampling plans for AQL and LTPD – Use of standard sampling plans – Sequential sampling plan.

UNIT – III EXPERIMENTAL DESIGN AND TAGUCHI METHODS 9

Fundamentals – fractional, factorial experiments – random design, Latin square design – Taguchi method –Quality Loss function – experiments – S/N ratio and performance measure – Orthogonal array.

UNIT – IV RELIABILITY AND ITS PREDICTION 9

Life testing – Failure characteristics – Meantime to failure – maintainability and availability –reliability – system reliability – OC curves – reliability improvement techniques – Reliability testing techniques – Pareto analysis. MTBF, MTTF, MTTR – System reliability – OC curve Availability and Maintainability – Reliability Improvement techniques.

UNIT – V FAILURE DATA ANALYSIS 9

Real time distribution, exponential, normal, log normal, gamma and Weibull – reliability data requirements – Graphical evaluation.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

1. Apply statistical process control techniques to monitor and control process variation, and interpret control charts effectively.
2. Design and implement acceptance sampling plans based on given quality requirements and understand the associated risks.
3. Design and conduct experiments using factorial and fractional factorial designs, and apply Taguchi methods to optimize process parameters.
4. Analyze reliability data, calculate reliability metrics, and evaluate the performance and availability of systems.
5. Perform failure data analysis and select appropriate statistical distributions for reliability modeling.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	-	1	-	1	-	1	-	1	-	1	1	1	2
CO2	3	2	-	1	-	1	-	1	-	1	-	1	1	1	2
CO3	3	2	-	1	-	-	-	-	-	1	-	1	1	1	2
CO4	3	2	-	1	-	-	-	-	-	1	-	1	1	1	2
CO5	3	2	-	1	-	1	-	-	-	1	-	1	1	1	2
CO/PO & PSO Average	**3**	**2**	**-**	**1**	**-**	**1**	**-**	**1**	**-**	**1**	**-**	**1**	**1**	**1**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1.Modares, “Reliability and Risk Analysis”, Marcel Decker Inc. 4th edition, 2014.
2. Besterfield D.H., “Quality Control”, Prentice Hall, 3rd edition 2011.

REFERENCES

1. Amitava Mitra, “Fundamentals of Quality Control and Improvement”, Pearson Education Asia,5th edition,2021.
2. Manohar Mahajan, “Statistical Quality Control”, Dhanpat Rai and Sons, 2007.
3. Sharma S.C., “Inspection Quality Control and Reliability”, Khanna Publishers, 1998.
4. Ross, S.M., “Introduction to Probability and Statistics for Engineers and Scientists”, Elsevier, 6th Edition, 2021.
5. Krishnaiah K., “Applied Statistical Quality Control and Improvement”, PHI, 2014

RA23032	ADVANCED CONTROLLERS AND FPGA	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

- To impart knowledge in the area of real time embedded system.
- To understand the ARM & FPGA Processor, high level language descriptions of software for embedded system.

UNIT – I INTRODUCTION TO EMBEDDED SYSTEMS AND ARM 9 CORE 9

Definitions – Brief overview of micro-controllers - DSPs,-Typical classifications –Memory Devices and application scenarios of embedded systems. Introduction about ARM 9 Processor-DSP Processor-Sharc Processor - Internal Architecture – Modes of Operations – instruction set – Pipelining – AMBA – Applications and futures.

UNIT – II PROGRAMMING OF ARM PROCESSOR 9

Programming of C – ARM Compiler - introduction to linker – librarian –image conversion utility and supporting libraries.

UNIT – III INTRODUCTION TO FPGA 9

FPGA & CPLD Architectures - FPGA Programming Technologies- FPGA Logic Cell Structures FPGA Programmable Interconnect and I/O Ports - FPGA Implementation of Combinational Circuits - FPGA Sequential Circuits - Timing Issues in FPGA Synchronous Circuits

UNIT – IV PROGRAMMING OF FPGA 9

Introduction to Verilog HDL and FPGA Design flow with using Verilog HDL - FPGA Arithmetic Circuits - FPGAs in DSP Applications - Design of SDRAM & Halftone Pixel Converter - Programming FPGAs. Introduction to DSP processor - TMS320C54x and TMS320C6x architecture

UNIT – V APPLICATIONS OF ARM 9 AND FPGA CONTROLLERS 9

Specific examples of time-critical and safety-critical embedded systems - applications in automation- automotive – aerospace - medical and manufacturing.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Develop the controller for the real time application.
CO2: Gather the knowledge for the effective use of advanced controllers and its programming in real time product development.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	-	1	-	1	-	1	-	1	-	1	1	1	2
CO2	3	2	-	1	-	1	-	1	-	1	-	1	1	1	2
CO3	3	2	-	1	-	-	-	-	-	1	-	1	1	1	2
CO4	3	2	-	1	-	-	-	-	-	1	-	1	1	1	2
CO5	3	2	-	1	-	1	-	-	-	1	-	1	1	1	2
CO/PO & PSO Average	**3**	**2**	**-**	**1**	**-**	**1**	**-**	**1**	**-**	**1**	**-**	**1**	**1**	**1**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial															

REFERENCES

1. Wayne Wolf, “Computers as Components – Principles of Embedded Computing System Design”, Morgan Kaufmann Publishers 2009.
2. Ball S.R., “Embedded microprocessor Systems – Real World Design”, Prentice Hall, 2006. 3. C.M. Krishna, Kang G. Shin, “Real Time systems”, McGraw Hill, 2009.
3. Frank Vahid and Tony Givagis, “Embedded System Design”. Wiley, 2001.
4. Tim Wilmshurst, “An Introduction to the Design of Small – Scale Embedded Systems”, Palgrave Macmillan, 2011.
5. Steve Kilts, “Advanced FPGA Design,” Wiley Inter-Science, Wiley-IEEE Press, 2007.
6. P. Chu, “FPGA Prototyping by Verilog Examples,” Wiley, 2008

RA23033	BIOLOGICALLY INSPIRED ROBOTICS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To introduce the fundamental concepts of Bio-inspired robots
2. To familiarize the design and working of bio-inspired sensors
3. To learn the various bio-inspired actuation mechanisms
4. To illustrate various bio-inspired architectures
5. To learn various case studies on bio-inspired robots

UNIT – I INTRODUCTION 9

Bio inspired robot – Definition, History, Significance, Examples, Applications – Bio inspired Morphologies – Introduction to Robot design, robot control, actuation and sensing - Soft robotics

UNIT – II BIO-INSPIRED SENSORS 9

Biological sensory systems – Construction and working of bio-inspired sensors - Vision sensors, Audition sensors, Touch sensors, Smell sensors, Taste sensors, Internal sensors

UNIT – III BIO-INSPIRED ACTUATION 9

Analysis of biological locomotion – types of locomotion – walking, crawling, swimming, flying – Actuation mechanisms – Grasping, Drilling

UNIT – IV BIO-INSPIRED CONTROL ARCHITECTURES 9

Behaviour based robotics – Learning robots – Evolving robots – Collective robots (SWARM)

UNIT – V CASE STUDIES 9

Robotic fish for pollution control – Snake like robot – Humanoid Robot Neck – Octopus robot - case studies of successful bio inspired designs

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Identify the terminologies of bio-inspired robots

CO2: Describe the fundamental concepts of bio-inspired robots, sensors, actuations and architectures

CO3: Acquire knowledge on working of bio-inspired robots, sensors, actuations and architectures

CO4: Apply the concepts of sensors, actuations and architectures to design an bio-inspired robot

CO5: Select a suitable bio-inspired robot for various applications

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	1	-	-	-	-	-	1	-	1	2	2	1
CO2	2	1	-	1	-	-	-	-	-	1	-	1	2	2	1
CO3	2	1	-	1	-	-	-	-	-	1	-	1	2	2	1
CO4	2	1	-	1	-	-	-	-	-	1	-	1	2	2	1
CO5	2	1	-	1	-	-	-	-	-	1	-	1	2	2	1
CO/PO & PSO Average	**2**	**1**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Toshio Fukuda, Fei Chen and Qing Shi, Bio-Inspired Robotics, MDPI, 2018
2. Yunhui Liu and Dong Sun, “Biologically Inspired Robotics”, CRC Press, Taylor & Francis Group, 2012

REFERENCES:

1. Barbara Webb, Thomas R. Consi, “Biorobotics: Methods and Applications”, MIT Press; 1st edition, 2001
2. Chandra Mouli Pandey, Bansi Dhar Malhotra, “Biosensors: Fundamentals and Applications”, De Gruyter, 2019
3. Azar Ahmad Taher, “Control Systems Design of Bio-Robotics and Bio-mechatronics with Advanced Applications”, Academic Press, 2019

RA23034	LINEAR INTEGRATED CIRCUITS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To introduce the basic building blocks of linear integrated circuits
2. To learn the linear and non-linear applications of operational amplifiers
3. To introduce the theory and applications of analog multipliers and PLL
4. To learn the theory of ADC and DAC
5. To introduce the concepts of waveform generation and introduce some special function ICs

UNIT – I BASICS OF OPERATIONAL AMPLIFIERS 9

Current mirror and current sources, Current sources as active loads, Voltage sources, Voltage References, BJT Differential amplifier with active loads, Basic information about op-amps – Ideal Operational Amplifier – General operational amplifier stages -and internal circuit diagrams of IC 741, DC and AC performance characteristics, slew rate, Open and closed loop configurations –JFET Operational Amplifiers – LF155 and TL082.

UNIT – II APPLICATIONS OF OPERATIONAL AMPLIFIERS 9

Sign Changer, Scale Changer, Phase Shift Circuits, Voltage Follower, V-to-I and I-to-V converters, adder, subtractor, Instrumentation amplifier, Integrator, Differentiator, Logarithmic amplifier, Antilogarithmic amplifier, Comparators, Schmitt trigger, Precision rectifier, peak detector, clipper and clamper, Low-pass, high-pass and band-pass Butterworth filters.

UNIT – III ANALOG MULTIPLIER AND PLL 9

Analog Multiplier using Emitter Coupled Transistor Pair – Gilbert Multiplier cell – Variable transconductance technique, analog multiplier ICs and their applications, Operation of the basi PLL, Closed loop analysis, Voltage controlled oscillator, Monolithic PLL IC 565, application of PL for AM detection, FM detection, FSK modulation and demodulation and Frequency synthesizing and clock synchronization.

UNIT – IV ANALOG TO DIGITAL AND DIGITAL TO ANALOG CONVERTERS 9

Analog and Digital Data Conversions, D/A converter – specifications – weighted resistor type, R-2 Ladder type, Voltage Mode and Current-Mode R – 2R Ladder types – switches for D/A converters high speed sample-and-hold circuits, A/D Converters – specifications – Flash type – Successive Approximation type – Single Slope type – Dual Slope type – A/D Converter using Voltage-to-Time Conversion – Over-sampling A/D Converters, Sigma – Delta converters.

UNIT – V WAVEFORM GENERATORS AND SPECIAL FUNCTION ICS 9

Sine-wave generators, Multivibrators and Triangular wave generator, Saw-tooth wave generator,ICL8038 function generator, Timer IC 555, IC Voltage regulators – Three terminal fixed

and adjustable voltage regulators – IC 723 general purpose regulator – Monolithic switching regulator, Low Drop – Out(LDO) Regulators – Switched capacitor filter IC MF10, Frequency to Voltage and Voltage to Frequency converters, Audio Power amplifier, Video Amplifier, Isolation Amplifier, Optocouplers and fibre optic IC.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO 1: Design linear and nonlinear applications of OP – AMPS
CO 2: Design applications using analog multiplier and PLL
CO 3: Design ADC and DAC using OP – AMPS
CO 4: Generate waveforms using OP – AMP Circuits
CO 5: Analyze special function ICs

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	1	1	-	-	1	-	-	-	-	1	1	2	3
CO2	3	2	1	1	-	-	1	-	-	-	-	1	1	2	3
CO3	3	2	1	1	-	-	1	-	-	-	-	1	1	2	3
CO4	3	2	1	1	-	-	1	-	-	-	-	1	1	2	3
CO5	3	2	1	1	-	-	1	-	-	-	-	1	1	2	3
CO/PO & PSO Average	**3**	**2**	**1**	**1**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**2**	**3**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. D.Roy Choudhry, Shail Jain, —Linear Integrated Circuits‖, New Age International Pvt. Ltd., 2018, Fifth Edition. (Unit I – V)
2. Sergio Franco, —Design with Operational Amplifiers and Analog Integrated Circuits‖, 4th Edition, Tata Mc Graw-Hill, 2016 (Unit I – V)

REFERENCES:

1. Ramakant A. Gayakwad, —OP-AMP and Linear ICs‖, 4th Edition, Prentice Hall / Pearson Education, 2015.
2. Robert F.Coughlin, Frederick F.Driscoll, —Operational Amplifiers and Linear Integrated Circuits‖, Sixth Edition, PHI, 2014.
3. B.S.Sonde, —System design using Integrated Circuits‖ , 2nd Edition, New Age Pub, 2001.
4. Gray and Meyer, — Analysis and Design of Analog Integrated Circuits‖, Wiley International, 5th Edition, 2011.

RA23035	DATA STRUCTURES AND OBJECT ORIENTED PROGRAMMING IN C++	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To introduce the relevance of this course to the existing technology through demonstrations, case studies, simulations, contributions of scientist, national / international policies with a futuristic vision along with socio-economic impact and issues
2. This course comprehends the fundamentals of object oriented programming, particularly in C++, which are then used to implement data structures. This also gives an idea of linear and non-linear data structures and their applications.

UNIT I DATA ABSTRACTION & OVERLOADING 9

Overview of C++ – Structures – Class Scope and Accessing Class Members – Reference Variables – Initialization – Constructors – Destructors – Member Functions and Classes – Friend Function– Dynamic Memory Allocation – Static Class Members – Container Classes and Integrators–Proxy Classes–Overloading: Function overloading and Operator Overloading.

UNIT II INHERITANCE&POLYMORPHISM 9

BaseClassesandDerivedClasses–ProtectedMembers–
CastingClasspointersandMemberFunctions–Overriding–Public, Protected and Private Inheritance–Constructors and Destructors in derived Classes — Implicit Derived — Class Object to Base — Class Object Conversion —Composition Vs. Inheritance – Virtual functions – This Pointer – Abstract Base Classes and Concrete Classes–Virtual Destructors–Dynamic Binding.

UNIT III LINEARDATASTRUCTURES 9

Asymptotic Notations: Big-Oh, Omega and Theta – Best, Worst and Average case Analysis: Definition and an example–Arrays and its representations– Stacks and Queues–Linked lists– Linked list based implementation of Stacks and Queues –Evaluation of Expressions–Linked list based polynomial addition.

UNIT IV NON-LINEARDATASTRUCTURES 9

Trees–BinaryTrees–Binarytreerepresentationandtraversals–Threadedbinarytrees–Binarytree representation of trees – Application of trees: Set representation and Union-Find operations – Graph and its representations–Graph Traversals–Connected components.

UNIT V SORTING&SEARCHING 9

Insertionsort–Mergesort–Quicksort–Heapsort–LinearSearch–BinarySearch.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Comprehend and appreciate the significance and role of this course in the present contemporary world
CO2: Select suitable data structure for specific Application.
CO3: Compare Linear and nonlinear data structures for different application.
CO4: Perform different searching and sorting techniques.
CO5: Identify connected components in trees.
CO6: Analyze asymptotic notations.

Mapping of COs with POs and PSOs															
COs/ POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	1	-	-	-	-	1	-	1	-	-			
CO2	3	2	1	-	-	-	-	1	-	1	-	-			
CO3	3	2	1	-	-	-	-	1	-	1	-	-			
CO4	3	2	1	-	-	-	-	1	-	1	-	-			
CO5	3	2	1	-	-	-	-	1	-	1	-	-			
CO/PO & PSO Average	**3**	**2**	**1**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**-**	**-**			
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Deitel and Deitel, " C++, How To Program", Fifth Edition, Pearson Education, 2005
2. Ellis Horowitz, Sartaj Sahni and Dinesh Mehta, Fundamentals of Data Structures in C++, 2nd edition, Universities Press Pvt Ltd., Hyderabad, 2007.

REFERENCES:

1. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C++", Third Edition, Addison-Wesley, 2007.
2. Bhushan Trivedi, "Programming with ANSI C++, A Step-By-Step approach", Oxford University Press, 2010.
3. Goodrich, Michael T., Roberto Tamassia, "David Mount. "Data Structures and Algorithms in C++", 7th edition, Wiley. 2004.

PR23C07	HUMAN FACTORS AND WORK DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To understand the concepts of the concept of productivity and its related terms like performance and efficiency.
2. Expose the concepts of method study.
3. Develop skills in work measurement using time study, work sampling, and predetermined time standards.
4. To understand the concepts of production management techniques.
5. To integrate ergonomic principles into workplace design and work processes.

UNIT I PRODUCTIVITY 9

Productivity concepts and definitions, Productivity related terms – Performance, Efficiency, Productivity measurement - Productivity measurement Models – Kendrick -Creamer Model- Carig-Harris Model- APC Model- Total Productivity Model-Techniques for productivity improvement -Work Study - Procedure for work-study - influence of working conditions on work-study.Approaches – (Kurosawa &Goshi structural approach, Alan Lawlor's approach, Gold's approach). Productivity measure – (PPM, TPM, TFP, MFP)

UNIT II METHODS STUDY 9

Methods Engineering- Procedure –Record, Examine & Develop - Flow and Handling of Materials - Tools for Recording the movement of Workers- Methods and Movements at the workplace – Define – Install -Maintain-Motion study - Micromotion Study- Therbligs - SIMO chart- Principles of Motion economy.Recordings- (Charts – outline, flow process, two handed, multiple activity) - (Diagrams – flow, string, cycle graph, chrono cycle graph), recording techniques – (OITDS)

UNIT III WORK MEASUREMENT 9

Purpose of work measurement – Techniques of work measurement- Time study, analytical estimation, historic data- Equipment - selecting and timing the job - performance rating – allowances – Standard time – setting time standard for work with machines - learning effect.Work sampling and Standard Time Determination- Group Timing Technique– Development of Standard data- Synthetic Data- predetermined time standards (PTS), types- use of time standard - Methods-Time Measurement (MTM) - Introduction to MOST technique - Wage incentive plans.

UNIT IV PRODUCTION MANAGEMENT TECHNIQUE 9

Production design – Utilization of Material-Quality Control -Sequential Quality Control, Taguchi approach, Total quality control – Layout handling and process planning – Production planning and control – Continuous production, Intermittent production -Inventory control techniques- Traditional approach, just in time, Maintenance-Work Study.

UNIT V ERGONOMICS 9

Ergonomics – Types, Industrial ergonomics, Musculoskeletal disorders, Anthropometry, Standardization and method of setting standards- Form design and control.One case study on physical, organizational and cognitive.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

1. Analyse and evaluate productivity levels in organizations using appropriate models.
2. Conduct comprehensive methods study, including the recording and analysis of workflows and the application of motion economy principles to enhance efficiency.
3. Apply work measurement techniques to determine standard time and improve work processes
4. Apply production management techniques to achieve efficient utilization of resources and ensure smooth production flow.
5. Design ergonomically sound workplaces that promote worker health, safety, and comfort.

Mapping of COs with POs and PSOs

COs/POs & PSOs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	3	2										3	2	1
CO2	2	3	2										3	2	1
CO3	2	3	2										3	2	1
CO4		3	2						1	1			3	2	1
CO5	2	3	2										3	2	1
CO/PO & PSO Average	2	3	2						1	1			3	2	1
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. ILO, “Introduction to Work Study”, Oxford and IBH publishing, 2008.
2. Barnes, R.M, “Motion and Time Study, Design and measurement of work”, John Wiley sons (Asia), Seventh edition, 2003.

REFERENCES

1. Benjamin W.Niebel, AndrisFreivalds, “Methods, standards and Work Design”, McGraw hill, Eleventh edition, 2002.
2. Maynard H.B, “Industrial Engineering Hand book”, McGraw-Hill, 2008.

IE23C04	PRODUCT LIFE CYCLE MANAGEMENT	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To recognize and appreciate the concept of Production and Operations Management in creating and enhancing a firm's competitive advantages.
2. To describe the concept and contribution of various constituents of Production and Operations Management (both manufacturing and service).
3. To relate the interdependence of the operations function with the other key functional areas of a firm.
4. To teach analytical skills and problem-solving tools to the analysis of the operations problems
5. To apply scheduling and Lean Concepts for improving System Performance.

UNIT I PRODUCT DEVELOPMENT AND PRODUCT LIFECYCLE 9

Product development process and functions, present market constraints, need for collaboration, collaborative product development, use of internet class technologies and data transfer, various developments on internet technology that support product development and its impact on business. Concept of product lifecycle - different phases of product lifecycle and corresponding technologies, its uses and examples.

UNIT II PRODUCT DATA MANAGEMENT (PDM) 9

PDM functions, PDM system and importance, architecture of PDM systems, document management, representation of lifecycle of business objects, concepts on roles, users and project management, system administration, access control and its use in lifecycle

UNIT III AUTOMATING BUSINESS PROCESSES 9

Product Lifecycle Management (PLM) architecture, components of PLM, lifecycle problems to resolve, Workflows - lifecycle and work flow integration, product configuration, bill of materials management, product structure, configuration management and engineering change management. Introduction to Product Manufacturing Information (PMI) and Model Based Definition (MBD)

UNIT IV PRODUCT VISUALISATION 9

Use of CAD neutral approach and visualization techniques in product development, capabilities of PLM visualization software - lightweight representations, markup method, representation information repository, use of visualization in different stages of lifecycle, case studies. Introduction to virtual reality, digital mock-up, virtual testing and validation.

UNIT V INTEGRATION OF PLM WITH OTHER SYSTEMS 9

Benefits of integrating PLM system with other systems, different ways to integrate PLM systems with other systems, integration with CAD and ERP - use of middleware in integrating business applications in product development. PLM software customisation

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1. Appreciate the role of Production and Operations management in enabling and enhancing a firm's competitive advantages in the dynamic business environment.

CO2. Obtain sufficient knowledge and skills to forecast demand for Production and Service Systems.

CO3. To optimize inventory cost

CO4. Formulate and Assess Aggregate Planning strategies and Material Requirement Plan.

CO5. Apply scheduling and Lean Concepts for improving System Performance.

Mapping of COs with POs and PSOs															
COs/ POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	1	2	1	-	-	-	-	-	-	-	-	-	1	-	1
CO2	3	3	1	1	1	-	-	-	-	-	-	-	1	-	1
CO3	3	3	1	1	1	-	-	-	-	-	-	-	1	-	1
CO4	3	3	1	1	1	-	-	-	-	-	-	-	1	-	1
CO5	3	3	1	1	3	-	-	-	-	-	-	-	1	-	1
CO/PO & PSO Average	**2.6**	**3**	**1**	**1**	**1.5**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Michael Grieves, "Product Lifecycle Management", Tata McGraw Hill, 2006
2. Faisal Hogue, "E-Enterprise Business Models Architecture and Components", Cambridge University Press, 2000.

REFERENCES:

1. Alexis Leon, "Enterprise Resource Planning", Tata McGraw Hill, 2002
2. Danier Amor, "The E-Business Revolution", Pearson Education Asia, 2000
3. David Ferry, Larry Whipple, "Building an Intelligent e-Business", Prima Publishing, 2000
4. David Bedworth, Mark Hederson, Phillip Wolfe, "Computer Integrated Design and Manufacturing", McGraw Hill Inc., 1991.

PR23C04	GD&T IN DESIGN AND MANUFACTURING	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. Understand GD & T principles and their importance in interpreting engineering drawing
2. Interpret symbols and terminology used in GD&T for effective communication of geometric properties
3. Apply controls for forms, datums, orientation, position, concentricity, symmetry, runout and profile in GD&T
4. Perform tolerance calculations and analyze worst case scenarios for different GD&T controls
5. Apply GD&T principle in integrated product design and manufacturing processes for improved producibility and process efficiency

UNIT I NEED FOR GD&T AND BASIC CONCEPTS 9

Engineering drawings and tolerancing - Dimensioning, dimensioning standards and rules, Geometric properties of a surface - Coordinate tolerancing system and its shortcomings, Geometric dimensioning and tolerancing system - benefits, Symbols &terms as per ASME Y14.5M, rules and concepts, virtual condition and bonus tolerance

UNIT II FORM, DATUMS, AND ORIENTATION CONTROLS 9

Flatness, Straightness, Circularity and Cylindricity control; Datums - Implied datums, Planar datums, datum targets, FOS datum features, FOS datum features applications RFS, at MMC and LMC, Orientation controls - Perpendicularity, Angularity and parallelism control of axis / midplane;

UNIT III POSITION, CONCENTRICITY, SYMMETRY, RUNOUT AND PROFILE CONTROLS 9

Tolerance of position - Position vs Coordinate conversion, Tolerance of position RFS, at MMC and LMC, TOP calculations, fixed and floating fastener calculations; Runout control - circular, total and runout calculations, Profile control - surface, line, Profile modifiers, Derived element controls - Straightness derived median line, Flatness derived median plane, Concentricity control, Symmetry control

UNIT IV GD&T FOR INTEGRATED PRODUCT DESIGN AND MANUFACTURING - 1 9

Concurrent engineering in Y14.5M, Datum reference frames, Foundation of geometric control: interrelated features, the boundary concept, Taylor’s principle, and refinement of controls; Application considerations, Product and process design - The six step methodology, Developing the tooling and gaging designs needed to create a producible product

UNIT V GD&T FOR INTEGRATED PRODUCT DESIGN AND MANUFACTURING - 2 9

Producibility design cycle, datum - specification, selection, qualification, and identification; Phantom gage dimensioning, Dimensional measurements, Inspection and verification, functional gaging, functional gage tolerancing, functional inspection techniques, functional workholding and fixturing, Implementation and process improvement.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1. Explain why geometric tolerancing is superior to coordinate Tolerancing

CO2. Interpret the symbols and material modifiers used in GD&T.

CO3. Define the key terms used in GD&T

CO4. Interpret applications of datum targets, size datum features, and size datum features.

CO5. Interpret the various types of tolerance (flatness, circularity, cylindricity, straightness, perpendicularity, parallelism, angularity, position, runout, and profile)

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	1	-	-	-	1	-	1	-	1	2	-	1
CO2	2	1	-	1	-	-	-	-	-	1	-	1	1	-	1
CO3	3	1	1	1	-	-	-	1	-	1	-	1	1	-	1
CO4	2	1	-	1	-	-	-	-	-	1	-	1	1	-	1
CO5	2	1	-	1	1	-	-	-	-	1	-	1	1	-	1
CO/PO & PSO Average	**2.2**	**1**	**1**	**1**	**1**	**-**	**-**	**1**	**-**	**1**	**-**	**1**	**1.2**	**-**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Alex Krulikowski, “Fundamentals of Geometric Dimensioning and Tolerancing” 3rd Edition, 2013, Cengage Learning, ISBN: 9781111129828.
2. Bob Campbell, “Integrated Product Design and Manufacturing Using Geometric Dimensioning and Tolerancing”, 2003, Marcel Dekker.

REFERENCES:

1. Georg Henzold, “Geometrical Dimensioning and Tolerancing for Design, Manufacturing and Inspection A Handbook for Geometrical Product Specification Using ISO and ASME Standards”, Butterworth-Heinemann, 3rd Edition, 2021.
2. ASME Y14.5-2018, “Dimensioning and Tolerancing - Engineering Product Definition and Related Documentation Practices”, ASME, 2018.
3. James D. Meadows, “Geometrical Dimensioning and Tolerancing - Application, Analysis and Measurement”, ASME Press, 2009.
4. David A. Madsen and David P. Madsen, “Geometrical Dimensioning and Tolerancing”, 9th Edition, The Goodheart-Willcox Company, Inc., 2013.
5. Gene R. Cogorno, “Geometrical Dimensioning and Tolerancing for Mechanical Design”, McGraw-Hill, 2006.

LIST OF COURSES FOR HONORS DEGREE

RA23036	MULTIBODY DYNAMICS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

1. Understand the fundamental concepts and principles of dynamics in mechanical systems.
2. Apply computational methods for analyzing and solving dynamic problems.
3. Analyze and evaluate nonlinear systems and their stability properties.
4. Characterize and assess the behavior of dynamic systems through system characterization techniques.
5. Design control strategies for nonlinear mechanical systems.

UNIT – I INTRODUCTION TO DYNAMICS 9

Importance of Multibody Dynamics - Particle Mechanics - Rigid Body Mechanics - Deformable Bodies - Constrained Motion- -Kinematics - Rotation - Translation - Velocity- Acceleration Equations – Mechanics of Deformable Bodies - Floating Frame Reference Formulation – Inertia - Generalized Forces - Equation of Motions - Multi Body Systems - Sub Systems - Friction and Spring Nonlinear Model - Nonlinear Dynamic Equations Formulation.

UNIT – II COMPUTATIONAL METHODS FOR DYNAMIC ANALYSIS 9

Jacobian Matrix - Newton-Rasphon Method - Nonlinear Kinematic Constrain Equation – System Mass Matrix - External and Elastic Forces - Acceleration Vector – Lagrangian Multiplier - Langrage's Equation – Kinetic Energy – Hamilton Equation - Hamilton vector Field- Euler - Langrage Equation- Generalized Reaction Forces – State Vector and Equation Formulation -Model Order Reduction- Regressive Dynamics

UNIT – III NONLINEAR SYSTEMS AND CONCEPTS 9

Linear Time Varying and Linearization- model order reduction methods – Input and Output Stability - Lyapunov Stability Analysis – Asymptotic Stability - Popov's and Circle Criterion - Perturbed System – Chaos – Periodic OrbitsIndex theory and Limit Cycle – Center Manifold Theory- Normal Forms- Nonlinear analysisPoincare Maps - Bifurcations – Maps - Vector Fields - Methods – Control System Design using Lyapunov's Direct Method.

UNIT – IV SYSTEM CHARACTERIZATION 9

Stability, Controllability, Observability - Phase Plane Analysis - Phase Portrait - Limit Cycle - Describing Function - Assumption – Limit Cycles.

UNIT – V CONTROL OF NONLINEAR MECHANICAL SYSTEMS 9

Double Inverted Pendulum – Nonlinear Machineries – Robots - Suspension System - Aircraft.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Explain the importance and applications of multibody dynamics in mechanical systems.

CO2: Apply computational methods, such as Jacobian matrix and Lagrange's equations, for dynamic analysis.
CO3: Analyze and predict the stability of nonlinear systems using Lyapunov stability analysis.
CO4: Characterize and assess the stability, controllability, and observability of dynamic systems.
CO5: Design control systems for nonlinear mechanical systems, such as double inverted pendulum or robotic systems.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	-	-	-	-	-	-	1	-	1	1	1	1
CO2	2	1	1	1	2	-	-	-	-	1	-	1	1	1	1
CO3	2	2	1	1	-	-	-	-	-	1	-	1	1	1	1
CO4	2	1	2	1	-	-	-	-	-	1	-	1	1	1	1
CO5	2	1	2	1	-	-	-	-	-	1	-	1	1	1	1
CO/PO & PSO Average	**2**	**1.2**	**1.5**	**1**	**2**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**1**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Ahmed A. Shabana, “Dynamics of Multibody Systems”, Cambridge University Press, 4th edition, 2014.
2. Robert E. Roberson , Richard Schwertassek, Dynamics of Multibody Systems, Springer, 198.

REFERENCES:

1. Brian L. Stevens, Frank L. Lewis, “Aircraft Control and Simulation”, Wiley India Pvt Ltd, 2010.
2. Hasan Khalil, “Nonlinear Systems and Control”, Prentice Hall, 2002.
3. Mahmut Reyhanoglu, “Dynamics and Control of a Class of Under Actuated Mechanical Systems”, IEEE Transactions on Automatic Control, 44(9), 1999.
4. Stephen Wiggins, “Introduction to Applied Nonlinear Dynamics System and Chaos”, SpringerVerlag, 2000.
5. 5.Wei Zhong and Helmut Rock, “Energy and Passivity Based Control of the Double Inverted Pendulum on a Cart”, IEEE, 2001.

RA23037	MODERN CONTROL THEORY	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1. To understand the nature of non-linear systems
2. To analyze the stability of such systems
3. To develop suitable models of non-linear systems and to develop suitable controllers for such systems
4. To understand the chaotic and bifurcation behaviour of non-linear systems
5. To linearize the non- linear systems.

UNIT – I NON-LINEAR SYSTEMS 9

Types of Non-Linearity – Typical Examples – Properties of nonlinear systems – Nonlinear differential equations – Numerical solutions to nonlinear differential equations – Equilibrium points – free and forced responses – Input and output multiplicities.

UNIT – II STABILITY OF NON-LINEAR SYSTEMS 9

BIBO and Asymptotic stability – Phase plane analysis (analytical and graphical methods) – Lyapunov Stability Criteria – Krasovskil's method – Variable Gradient Method – Stability Analysis by Describing function method.

UNIT – III MODELLING AND CONTROL OF NON-LINEAR SYSTEMS 9

Models for Nonlinear systems - Hammerstein and Wiener models - Input signal design for Identification – On-line parameter estimation for nonlinear systems – Nonlinear PID controller - Gain scheduling control – case studies

UNIT – IV CHAOS AND BIFURCATION BEHAVIOR 9

Introduction to Chaos - The Lorenz Equations – Test for chaos - Bifurcation Behavior of ordinary differential equations - Types of Bifurcations - Limit Cycle Behavior and Hopf Bifurcation.

UNIT – V LINEARIZATION 9

Methods of linearization – Taylor's series expansion – Jacobean method - state model for systems – Role of Eigen values and Eigenvectors – State transition matrix and its properties – Controllability and observability – Stabilizability and Detectability.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO 1: Determine the numerical solution for non-linear differential equations

CO 2: Analyze and interpret the stability of the nonlinear systems.

CO 3: Understand the bifurcation behaviour of non-linear systems.

CO 4: Linearize non-linear systems for developing linear control

CO 5: Use appropriate software tools for analysis of non-linear systems

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	-	1	-	-	-	-	1	-	1	2	2	2
CO2	2	2	-	-	1	-	-	-	-	1	-	1	2	2	2
CO3	2	2	-	1	1	-	-	-	-	1	-	1	2	2	2
CO4	2	2	1	1	1	-	-	-	-	1	-	1	2	2	2
CO5	2	2	1	1	1	-	-	-	-	1	-	1	2	2	2
CO/PO & PSO Average	**2**	**1.8**	**1**	**1**	**1**	-	-	-	-	**1**	**-**	**1**	**2**	**2**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Hangos, K.M., Bokor, J., and Szederkrnyi, G., “Analysis and control of Non-linear Process systems”.Springer 2016.
2. Gopal,M., “Digital Control and State Variable Methods: Conventional and Intelligent Control Systems'', Fourth Edition, Tata Mc-Graw Hill, 2012.

REFERENCES:

1. Shankar Sastry, “Nonlinear Systems: Analysis, Stability, and Control”, Springer New York, 2013.
2. Bequette, B.W., “Process Control Modeling, Design and Simulation”, Prentice Hall of India, 2008.
3. Bequette, B.W., “Process Control: Modeling, Design and Simulation”, Prentice Hall International series in Physical and Chemical Engineering Sciences, 2003.
4. Steven E. LeBlanc, and Donald R. Coughanowr, “Process Systems Analysis and Control”, Third Edition, Chemical Engineering series, McGraw-Hill Higher Education, 2009. 110
5. Thompson, J. M. T., and Stewart, H. B.,” Nonlinear Dynamics and Chaos”, John Wiley & Sons, 2002.
6. William S. Levine, “The Control Systems Handbook”, Second Edition: Control System Advanced Methods, Second Edition, CRC Press, 2010.
7. NPTEL Lecture on “Non-linear system Analysis” by Prof. Laxmidhar Behera, IIT Kanpur.

RA23038	DIGITAL SIGNAL PROCESSING	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1. Understand the fundamentals of signals and systems in continuous and discrete time.
2. Apply mathematical and graphical representations to analyze elementary signals.
3. Learn continuous and discrete time signals and systems based on their properties.
4. Conduct continuous and discrete time systems using Fourier and Laplace transforms.
5. Estimate digital filters using various techniques and window functions.

UNIT – I INTRODUCTION TO SIGNALS AND SYSTEMS 9

Elementary signals in continuous and discrete time - graphical and mathematical representation - Elementary operations and classification of continuous and discrete time signals – CT systems and DT systems - Properties of CT systems and DT systems Classification of systems.

UNIT – II ANALYSIS OF CONTINUOUS TIME SIGNALS AND SYSTEMS 9

The continuous time Fourier series - Fourier Transform properties - Laplace transform and properties - Impulse response - convolution integrals - Fourier and Laplace transforms in Analysis of CT systems - Frequency response of systems characterized by differential Equations.

UNIT – III ANALYSIS OF DISCRETE TIME SIGNALS AND SYSTEMS 9

Fourier Transform of discrete time signals (DTFT) Properties of DTFT - Discrete Fourier Transform Fast Fourier Transform (FFT) - Z Transform and Properties – Impulse response - Convolution sum System analysis from difference equation model - Stability of systems.

UNIT – IV DESIGN OF DIGITAL FILTERS 9

Review of design techniques for analog low pass filters - Frequency transformation – IIR filters - Properties - Design of IIR digital filters using bilinear transformation - FIR filters - Characteristics of FIR filters with linear phase - Design of FIR filters using Window functions.

UNIT – V DIGITAL SIGNAL PROCESSORS AND APPLCATIONS 9

Architecture of TMS320C54xx DSP - Addressing Modes - Instructions and Programming - Applications: Signal Compression - Sine wave generators - Noise generators – DTMF Tone Detection - Echo cancellation - Speech enhancement and recognition.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Identify and classify elementary signals in continuous and discrete time.
CO2: Analyze and interpret mathematical and graphical representations of signals and systems.
CO3: Apply Fourier and Laplace transforms to analyze continuous time systems.
CO4: Perform system analysis using discrete time Fourier transform and Z-transform.
CO5: Design and implement digital filters using appropriate techniques and window functions.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	1	-	-	-	-	-	1	-	1	2	1	1
CO2	2	2	3	1	-	-	-	-	-	1	-	1	2	1	1
CO3	2	2	-	1	-	-	-	-	-	1	-	1	2	1	1
CO4	2	2	-	1	-	-	-	-	-	1	-	1	2	1	1
CO5	2	1	2	1	-	-	-	-	-	1	-	1	2	1	1
CO/PO & PSO Average	**2**	**1.75**	**2.5**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Alan V Oppenheim, Alan S Willsky, Hamid Nawab S , "Signals and Systems", 2nd edition, Phi Learning, New Delhi, 2015.
2. John G. Proakis, Dimitris K Manolakis , "Digital Signal Processing, 5th edition, Hoboken,NJ : Pearson Education, New Delhi, 2021

REFERENCES:

1. Lonnie C Ludeman, "Fundamentals of Digital Signal Processing", Wiley & Sons, New Delhi, 2014.
2. Emmanuel C Ifeachor, Barrie W Jervis," Digital Signal Processing", Pearson Education, New Delhi, 2013.
3. Haykin S, Barry Van Veen, "Signals and Systems", John Wiley and sons, New Delhi, 2016.
4. Vinay K Ingle, John G Proakis , "Digital Signal Processing using MATLAB", Cengage Learning, New Delhi, 2017.

PR23C09	CONDITION MONITORING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

1. Understand the importance of machinery maintenance and the different maintenance approaches, including reactive, preventive, and predictive maintenance.
2. Gain knowledge of condition monitoring techniques in manufacturing industries, both online and offline, and their significance in detecting and diagnosing faults.
3. Learn about measurement standards, sources of errors, and calibration in condition monitoring, and become familiar with basic measurement equipment for various parameters such as vibration, force, speed, noise, temperature, laser-based measurements, current, chemical analysis, and ultrasound.
4. Understand the principles of vibration monitoring and its application in detecting and analyzing various faults in machinery, including misalignment, eccentricity, cracked shaft, bowed and bent shaft, unbalanced shaft, bearing defects, and gear faults.
5. Explore the principles of noise monitoring, acoustical terminology, noise sources, sound fields, and techniques for identifying and mitigating noise-related issues in machinery.

UNIT – I CONDITION MONITORING NEED AND TECHNIQUES 9

Introduction to Machinery Maintenance – Reactive maintenance, Preventive maintenance, Predictive maintenance, Condition Monitoring in manufacturing industries – Online and Offline condition monitoring, Measurement Standards-Errors – Calibration – Basic Measurement Equipment – Vibration, Force, Speed, Noise, Temperature, Laser – Based, Current, Chemical, Ultrasound Measurement

UNIT – II VIBRATION AND NOISE MONITORING 9

Vibration Monitoring –Principles of Vibration Monitoring, Misalignment Detection, Eccentricity Detection, Cracked Shaft, Bowed and Bent Shaft, Unbalanced Shaft, Bearing Defects, Gear Fault Noise Monitoring – Acoustical Terminology, Noise Sources, Sound Fields, Noise Source Identification – Applications

UNIT – III ELECTRICAL, THERMAL AND MAGNETIC EMISSION MONITORING 9

Faults in Electric Motor – Motor Current Signature Analysis, Thermography –Thermal Imaging Device – Application of thermography in condition monitoring, Wear Debris Analysis, Eddy Current, Ultrasonic and Radiography methods in condition monitoring – Application

UNIT – IV MACHINE TOOL CONDITION MONITORING 9

Tool Wear-Sensor Fusion in Tool Condition Monitoring – Direct Tool wear measurement – Indirect Tool wear measurement in conventional and unconventional Machining – Application

UNIT – V SIGNAL PROCESSING AND CASE STUDIES 9

Study of periodic and random signals, probability distribution, statistical properties, auto and

cross correlation and power spectral density functions, Time domain and Frequency domain and Time – frequency domain analysis, Intelligent fault detection system using Machine Learning, Case studies

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

1. Recognize the significance of machinery maintenance and the different maintenance approaches, and assess their suitability for specific operational requirements.
2. Apply measurement standards, minimize errors, and perform calibration of measurement equipment for accurate condition monitoring.
3. Utilize various condition monitoring techniques to detect and diagnose faults in machinery, and make informed maintenance decisions.
4. Analyze vibration patterns and characteristics to identify and assess different types of faults, such as misalignment, eccentricity, cracked shaft, unbalanced shaft, bearing defects, and gear faults.
5. Identify noise sources, understand acoustical terminology, and apply noise monitoring techniques to mitigate noise-related issues in machinery.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	1	-	-	-	1	-	-	-	1	1	-	1
CO2	2	-	-	1	-	-	-	-	-	-	-	1	1	-	1
CO3	2	-	-	1	-	-	-	-	-	-	-	1	1	-	1
CO4	2	-	-	1	-	-	-	-	-	-	-	1	1	-	1
CO5	2	-	-	1	-	-	-	-	-	-	-	1	1	-	1
CO/PO & PSO Average	2.0	-	-	1.0	-	-	-	1.0	-	-	-	1.0	1.0	-	1.0
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Davies A, “Handbook of Condition Monitoring: Techniques and Methodology”, Springer, 2012.
2. Nakhaeinejad, Mohsen, and Bukowitz, David O., “Practical Vibration Analysis of Machinery: Case Studies”, CreateSpace Independent Publishing Platform, 2011.
3. Nandi, Asoke K., and Ahmed, Hosameldin., “Condition Monitoring with Vibration Signals”, Wiley, 2020.

REFERENCES

1. Tadeusz Uhl, “Condition Monitoring of Machinery in Non-Stationary Operations: Proceedings of the Second International Conference”, Springer, 2012
2. Clarence W. de Silva, “Vibration Monitoring, Testing, and Instrumentation”, CRC Press, 2007
3. Mohanty, Amiya R., “Machinery Condition Monitoring: Principles and Practices”, CRC Press, 2014.
4. Blitz, J., “Electrical and Magnetic Methods of Non-destructive Testing”, Springer, 2012.
5. Havens, Kirk J, and Sharp, Edward J., “Thermal Imaging Techniques to Survey and Monitor Animals in the Wild: A Methodology”, Elsevier Science, 2015.

RA23039	IMMERSIVE TECHNOLOGIES AND HAPTICS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

1. Define and explain the fundamental concepts and components of haptics technology.
2. Analyze the role and importance of touch in human perception and interaction.
3. Explore and evaluate different types of haptic sensing and their applications.
4. Apply principles of haptic design and psychophysics to create immersive experiences.
5. Investigate and assess the integration of haptics technology with virtual, augmented, and mixed reality environments.

UNIT – I INTRODUCTION TO HAPTICS 8

Definition - Importance of Touch - Tactile Proprioception - Tactual Stereo Genesis - Kinesthetic Interfaces - Tactile Interfaces - Human Haptics - Overview of Existing applications - Basics of Force Feedback Devices - Kinesthetic Vs. Tactile Haptic Devices - Configurations of Kinesthetic Devices -Types of Kinesthetic Devices.

UNIT – II KINESTHETIC HAPTIC DEVICES AND TELEOPERATION 10

Mechatronics in Haptics System - Haptic Kinematics - Haptic Dynamics - Existing Kinesthetic Devices - Haptic Device Static Rendering - Haptic Device Dynamic Rendering - Control of Haptic Devices - Stability Analysis of Haptic Devices - Stability Analysis of the Rendered Model -Passivity of the Rendered Model. Types of Sensors - Measurement of Haptic Parameters - Types of Actuators - Types of Transmission - Admittance Type Kinesthetic Device - Admittance Control - Comparison of Impedance and Admittance Type Devices - Genesis of Tele-Operation - Tele-Operation Controllers -Tele-Operator Transparency - Stability Analysis of Tele-operator - Tracking and Transparency - Surface Haptic - Exogenous Force Inputs.

UNIT – III HUMAN HAPTICS ITS PLATFORM 9

Introduction - Types of Haptic Sensing - Active vs. Passive Touch - Mechanoreception-Mechanoreceptive Afferents - Kinesthetic Sensing - Force Sensing, control, torque Control and Proprioception-Introduction to Psychophysics - Measurement Thresholds - Laws of Psychophysics - Weber's Law - Fechner's Law - Fitt's Law - Psychophysical Methods of Limit, Constant Stimuli and Adjustment - Introduction to Virtual Reality Modelling Language (VRML) – Open Haptic Platform - OpenGL- Virtual Environment Manager - Modelling of Simple Haptic System.

UNIT – IV VIRTUAL AND AUGMENTED REALITY 9

The Reality – Virtuality Continuum - Virtual Reality Definitions - Software, Hardware, Sensation and Perception - Multi-Modal Interaction Challenges - System Architecture of Virtual Reality. Aspects of Geometrical Modelling and Environmental Modelling General Solution for Calculating Geometric &Illumination Consistency in the Augmented Environment. Usability Guidelines - Design and Implementation of an Immersive User Experience - Case Study for VR and AR.

UNIT – V MIXED REALITY 9

System Architecture of a Mixed Reality System - Common Interaction Techniques for Mixed Reality Environments - Common Navigation Techniques - Common Interface for MR - Menu Design Directions - Haptic Control Panel - Performance of an Interaction Techniques, Advanced Interaction Techniques, Design and Implementation of an Immersive User Experience - Case Study for MR.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Demonstrate a clear understanding of the principles and terminology of haptics technology.

CO2: Recognize the significance of touch and its impact on human perception and interaction.

CO3: Differentiate between various haptic sensing techniques and their applications.

CO4: Design and develop haptic systems that effectively engage users in immersive experiences.

CO5: Evaluate the integration of haptics technology in virtual, augmented, and mixed reality environments for enhanced user interaction.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	-	1	-	-	-	-	1	-	1	1	-	1
CO2	2	1	-	1	1	-	-	2	-	1	-	1	1	-	1
CO3	2	2	-	2	1	-	-	2	-	1	-	1	1	-	1
CO4	2	2	2	1	1	-	-	2	-	1	-	1	1	2	1
CO5	2	2	1	1	1	-	-	2	-	1	-	1	1	2	1
CO/PO & PSO Average	**2**	**1.7**	**1.5**	**1.2**	**1**	**-**	**-**	**2**	**-**	**1**	**-**	**1**	**1**	**2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Burdea, G. C. and P. Coffet. “Virtual Reality Technology”, 3rd edition, Wiley-Interscience, Hoboken New Jersey, 2012.
2. Eckehard Steinbach et al, “Haptic Communications”, Vol. 100, 4:937-956, 2012
3. Hannaford B and Okamura A. M “Haptics: Handbook of Robotics”, Springer, pp. 718-735, 2008.

REFERENCES:

1. Kenneth Salisbury, Francois Conti and Federico Barbagli, “Haptic Rendering: IEEE Computer Graphics and Applications”, v24 n2 (200403): 24-32, 2004.
2. Jean-Pierre Bresciani, Knut Drewing and Marc O. Ernst. “Human Haptic Perception and the Design of Haptic-Enhanced Virtual Environments: The Sense of Touch and Its Rendering”,STAR 45, pp. 61–106, 2008.
3. MacLean K. E, “Haptic Interaction Design for Everyday Interfaces: Reviews of Human Factors and Ergonomics”, 4:149-194, 2008.
4. Weir D. W and Colgate J. E “Stability of Haptic Display: Haptic Rendering: Foundations, Algorithms, and Applications”. AK Peters, 2008.
5. Sherman, William R. and Alan B. Craig. “Understanding Virtual Reality – Interface, Application, and Design” 2nd edition, Morgan Kaufmann, Cambridge U.S 2019.
6. Yuichi Ohta, Hideyuki Tamura, “Mixed Reality: Merging Real and Virtual Worlds”, Springer Verlag, Berlin, 2014.

RA23040	BRAIN COMPUTER INTERFACE AND APPLICATIONS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

1. Understand the fundamentals and classification of Brain-Computer Interface (BCI).
2. Explore and analyze different electrophysiological sources used in BCI.
3. Apply feature extraction methods for BCI signal processing.
4. Implement feature translation methods for BCI data analysis.
5. Examine the applications of BCI in functional restoration and control.

UNIT – I INTRODUCTION TO BCI 9

Fundamentals of BCI – Structure of BCI system – Classification of BCI – Invasive, Non-invasive and Partially invasive BCI – EEG signal acquisition - Signal Pre-processing – Artifacts removal.

UNIT – II ELECTROPHYSIOLOGICAL SOURCES 9

Sensorimotor activity – Mu rhythm, Movement Related Potentials – Slow Cortical Potentials-P300 - Visual Evoked Potential - Activity of Neural Cells - Multiple Neuromechanisms.

UNIT – III FEATURE EXTRACTION METHODS 9

Time/Space Methods – Fourier Transform, PSD – Wavelets – Parametric Methods – AR, MA, ARMA models – PCA – Linear and Non-Linear Features.

UNIT – IV FEATURE TRANSLATION METHODS 9

Linear Discriminant Analysis – Support Vector Machines - Regression – Vector Quantization– Gaussian Mixture Modeling – Hidden Markov Modeling – Neural Networks.

UNIT – V APPLICATIONS OF BCI 9

Functional restoration using Neuroprosthesis - Functional Electrical Stimulation, Visual Feedback and control - External device control, Case study: Brain actuated control of mobile Robot.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Demonstrate a comprehensive understanding of the fundamentals and classification of BCI.
CO2: Analyze and interpret electrophysiological sources used in BCI systems.
CO3: Apply feature extraction methods to preprocess and extract relevant information from BCI signals.
CO4: Implement feature translation methods for classification and analysis of BCI data.
CO5: Evaluate the applications of BCI in functional restoration and control through case studies.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	2	-	1	-	-	-	-	-	1	-	1	-	2	2
CO2	2	2	-	1	-	-	-	-	-	1	-	1	-	2	2
CO3	2	2	-	1	-	-	-	-	-	1	-	1	-	2	2
CO4	2	2	-	2	-	-	-	-	-	1	-	1	-	2	2
CO5	2	2	-	2	-	-	-	-	-	1	-	1	-	2	2
CO/PO & PSO Average	**2**	**2**	**-**	**1.4**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**-**	**2**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Bernhard Graimann, Brendan Allison, Gert Pfurtscheller, “Brain-Computer Interfaces: Revolutionizing Human-Computer Interaction”, Springer, 2010.

REFERENCES:

1. R. Spehlmann, “EEG Primer”, Elsevier Biomedical Press, 3rd edition 1999.
2. Arnon Kohen, “Biomedical Signal Processing”, Vol I and II, CRC Press Inc, Boca Rato, Florida, 1986.
3. Bishop C.M., “Neural Networks for Pattern Recognition”, Oxford, Clarendon Press, 1995.

RA23041	BIO-MECHATRONICS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

1. Define the fundamental principles and concepts of bio-mechanics using appropriate terminology.
2. Apply analytical skills to analyze and interpret the mechanics of skeletal and muscular systems.
3. Demonstrate the control mechanisms of biological systems through practical examples and experiments.
4. Evaluate the design and functionality of prosthetic and orthotic devices using critical thinking.
5. Utilize simulation and modeling techniques to understand and predict biomechanical behaviors.

UNIT – I BIO-MECHANICS 9

Introduction to Bio-Mechanics, Relation between Mechanics and Medicine, Newton"s Laws, Stress, Strain, Shear Rate, Viscosity, Visco-Elasticity, Non-Newtonian Viscosity, Soft Tissue Mechanics, Mechanical Properties of Soft Biological Tissues - Bio Fluid Mechanics - Introduction to Biomechatronic Systems

UNIT – II MECHANICS IN SKELETAL AND MUSCULAR SYSTEM 9

Bones, Types and Functions - Axial and Appendicular Skeleton. Joints: Definition, Types and Functions, Mechanical Properties of Bones. Kinetics and Kinematics Relationship of Skeletal and Muscular System.

UNIT – III CONTROL MECHANISM OF BIOLOGICAL SYSTEMS 9

Skeletal Muscles Servo Mechanism, Cardio Vascular Control Mechanism, Respiratory Control Mechanism – Interfacing Techniques with Natural Servo Mechanism.

UNIT – IV PROSTHETIC AND ORTHOTIC DEVICES 9

Analysis of Force in Orthopaedic Implants, Hand and Arm Replacement, Different Types of Models for Externally Powered Limb Prosthetics, Lower Limb, Upper Limb Orthotics, and Material for Prosthetic and Orthotic Devices, Functional Electrical Stimulation, Sensory Assist Devices. Exoskeletons, Exomusculatures, Space Suits, Physical Therapy and Rehabilitation, Wheelchairs and other Mobility Assistance.

UNIT – V SIMULATION AND MODELLING OF BIOMECHATRONICS 9

Physics-Based Modelling and Simulation of Biological Structures - Variables of Interest – Geometry - Introduction to Model the Skeletal System Using Open Source Software – Human Leg Prosthesis And Normal Gait vs. Prosthesis Leg Analysis - Upper Extremity Kinematic Model – Application in Sports, exercise, entertainment.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Understand the fundamental principles and terminology of bio-mechanics.

CO2: Interpret and explain the mechanics of skeletal and muscular systems.

CO3: Apply control mechanisms of biological systems to real-world scenarios.

CO4: Evaluate the design and functionality of prosthetic and orthotic devices.
CO5: Utilize simulation and modelling techniques to predict biomechanical behaviors.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	1	-	-	-	-	-	-	-	-	1	-	1	1	-	-
CO2	1	1	1	1	-	-	-	-	-	1	-	1	1	1	-
CO3	2	1	1	1	-	-	-	-	-	1	-	1	1	2	-
CO4	2	1	2	1	1	-	-	-	-	1	-	1	1	2	1
CO5	2	1	1	1	1	-	-	-	-	1	-	1	1	2	1
CO/PO & PSO Average	**1.6**	**1**	**1.2**	**1**	**1**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**1**	**1.7**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Dawson .D and Right, “Introduction to Bio-mechanics of Joints and Joint Replacement”, Mechanical Engineering Publications Ltd., 1989.

REFERENCES:

1. Fung .Y.C, “Biomechanics: Mechanical Properties in Living Tissues”, Springer, 2nd Edition, 2011.
2. Susan J.Hall, “Basics Bio-Mechanics”, McGraw-Hill, 2002.
3. Gillian Pocock & Christopher D.Richards, “The Human Body”, Oxford University Press, 2009.
4. Jacob Segil, “Handbook of Biomechatronics”, Acadamic Press, 2019.
5. Marko Popovic, “Biomechatronics”, Academic Press, 2019.
6. Ranganathan T S, “Text Book of Human Anatomy” S. Chand and Company, 5th Edition, 2000.
7. Scott L. Delp., “Open Sim: Open-Source Software to Create and Analyze Dynamic Simulations of Movement”, IEEE Transaction on Biomedical Engineering, Vol.54 No.11, 2007.

AE23C07	DRONE TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

Of this course are

1. To make students familiarize about Indian Drone Rules
2. To impart knowledge on UAV and its design aspects
3. To gain knowledge about the Drone operations
4. To impart knowledge on Drone applications
5. To introduce the basic concepts of Drone Data Analysis

UNIT I INDIAN DRONE POLICY, RULES AND REGULATIONS 9

Importance of Drone Rules and Regulation, - Overview of Drone Rules of Various Countries, - Indian Drone Rules History & Evolution, - Indian Drone Rules 2021, - Amendment on Indian Drone Rules, - Drone Training Circulars, - Drone Quality Certification Scheme

UNIT II UAV SYSTEM DESIGN 10

History of Drones, - Classification of UAV, - Introduction to UAS, - Design of the UAV Systems, - Design Standards and Regulatory Aspects, UAV Propulsion System Overview- Avionics Overview, - Types of Payload and its uses

UNIT III DRONE OPERATIONs 7

Introduction to Ground Control Station, - GCS Software Overview, - Flight Modes, - Waypoint Navigation, - Ground Test analysis, - Drone Trouble Shooting, - System in Flight Testing, - Case Studies on various Drone Operations

UNIT IV DRONE APPLICATIONS 7

Drones for Civil Application, - Drones for Disaster Management, - Drones for Defence Applications, - Future of Drones, - Case Studies on Various Real-time Drone Applications,

UNIT V GEOSPATIAL DRONE DATA ANALYSIS 10

Introduction to Photogrammetry and GIS, - , Challenges in Drone Photogrammetry,- Drone Data Capture and Processing Methodology, - Point Cloud, - DSM, - DEM, - DTM, - Orthomosaic, - Analysis of 2D and 3D Data -, Case Study on Drone Data Analysis

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will be able to

CO1 Acquire knowledge on the importance of Drone Rules, Regulations and Quality Policies

CO2 Gain Insights on Drone components, design, design standards and System selection

CO3 Acquire knowledge on Drone operations and its methodologies

CO4 Gain Insights on Drone based Applications and Impacts

CO5 Acquire Knowledge on Drone Data Interpretation and its challenges

TEXTBOOKS:

1. Reg Austin “unmanned aircraft systems UAV design, development and deployment”, Wiley,2010.
2. Drone Rules 2021, Done Amendment Rules, Certification Scheme for Drones, DTC

(https://digitalsky.dgca.gov.in/home)

3. Frazier, A., & Singh, K. (Eds.) “Fundamentals of Capturing and Processing Drone Imagery and Data (1st ed.)”, CRC Press, 2021.

REFERENCES:

1. Daniel Tal, John Altschuld “Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation”, John Wiley & Sons, Inc, 2021
2. “Drone Technology: Future Trends and Practical Applications”, Scrivener Publishing LLC, 2023

COs	POs												PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1				2		3		3	3			3				
2	3	3	2	3	2							3				
3	3			3	3	3			3							
4	3			3		3			3							
5	3		2	3	3				3			3				

LIST OF COURSES FOR MINOR DEGREE IN "AUTOMATION TECHNOLOGY"

RA23043	ROBOTICS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES

1. To introduce Robots history, terminologies, classification and configurations.
2. To get knowledge about basic Geometrical and Algebraic approach to solve forward kinematics of serial manipulator.
3. To get knowledge about advanced forward kinematics of serial manipulator.
4. To get knowledge about inverse kinematics of various serial manipulator.
5. To get knowledge about Jacobian aspects and infinitesimal motion of robot mechanisms.

UNIT – I OVERVIEW OF ROBOTICS 9

Introduction to Robotics - History - Definitions - Law of Robotics – Types of Robots– Terminologies – Classifications Overview – Links & Joints - Degrees of Freedoms - Coordinate Systems - Work Volume - Precision, Repeatability & Accuracy - Position and Orientation of Objects - Roll, Pitch and Yaw Angles - Joint Configuration of Five Types of Serial Manipulators - Wrist Configuration - End Effector - Manipulability of Manipulators -Selection and Application of Serial Manipulators and end effector

UNIT – II FORWARD KINEMATICS - GEOMETRICAL AND ALGEBRAIC APPROACH 9

Need for Forward and Inverse Kinematics Equation – Parameters in Design and Control – Methods of Forward and Inverse Kinematics- Geometrical and Algebraic Approach in Forward Kinematics Solution, 1 DOF - 2 DOF Planar Robot (2P and 2R); 3DOF 2RP Spatial Robot.

UNIT – III FORWARD KINEMATIC MODELING – DENAVIT-HARTEBERG (DH) APPROACH 9

Unit Circle Trigonometry - Translation Matrix - Rotation Matrix, Euler Angles - Quaternion Fundamental –Dot and Cross Products - Frames and Joint Coordinates - Homogeneous Transformation - D-H Convention and Procedures and Solutions: 3 DOF Wrist, RR Planar, 3 DOF RRP, Cartesian, Cylindrical, Spherical, SCARA and Articulated 3 DOF Robots - 3 DOF Robot with Wrist – 6 DOF robots

UNIT – IV INVERSE KINEMATICS 9

Introduction to Inverse Kinematics -Issues in Inverse kinematics - Inverse kinematics of 2 DOF Planar robot - 2 and 3 DOF planar and Spatial robot - Tool Configuration - Inverse Kinematics of 3 Axis Robot and 6 Axis Robot - Inverse kinematics Computation- Closed Loop Solution

UNIT – V JACOBIAN AND DIFFERENTIAL MOTION 9

Forward and Inverse Jacobian- Introduction - Singularity - Linear and Angular Velocity of End Effector using Jacobian - Differential Operator - Finding New Location of End Effector Based on Differential Motion.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course students able to

CO 1: Describe the history, classifications, terminologies and its configuration of robots.

CO 2: Generalize the foundational concepts of robot and its kinematics.

CO 3: Apply the algebraic, geometric and D-H foundations and other concepts for kinematics solution development.

CO 4: Evaluate configuration, forward and inverse kinematic model for planar and spatial multi-DOF manipulators.

CO 5: Choose the appropriate robot configurations, assess kinematic solutions, and analyze differential motion of robots, considering factors such as velocity, acceleration, and singularity avoidance.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	1	-	-	-	-	-	1	-	1	2	2	1
CO2	2	1	1	1	-	-	-	-	-	1	-	1	2	2	1
CO3	2	2	2	1	-	-	-	-	-	1	-	1	2	2	1
CO4	2	2	2	1	-	-	-	-	-	1	-	1	2	2	1
CO5	2	2	1	1	-	-	-	-	-	1	-	1	2	2	1
CO/PO & PSO Average	**2**	**1.7**	**1.5**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS:

1. John J. Craig, “Introduction to Robotics”, 3rdEdition, Addison Wesley, ISE 2020.
2. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2ndedition, 2017.

REFERENCES:

1. S K Saha, Introduction to Robotics, Tata McGraw-Hill, 2nd edition, 2019.
2. Arthor Critchlow, “Introduction to Robotics”, 1stedition, Macmillan, 2009.
3. Mohsen Shahinpoor, “A Robot Engineering Text Book”, 1stedition, Harper and Row, 2004.
4. Deb S.R., “Robotics Technology and Flexible Automation”, 2ndedition, Tata McGraw – Hill Publisher, 2017.
5. J. Srinivas, R. V. Dukkipati, K., “Robotics: Control and Programming”, Narosa Publishing House, 2009.
6. Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd., 2016.
7. King-Sun Fu, C.S.George Lee, Ralph Gonzalez, "Robotics: Control, Sensing, Vision and Intelligence", Tata McGraw Hill, 1986
8. Peter Corke, "Robotics, Vision and Control: Fundamental Algorithms in MATLAB", Springer, 2011

RA23044	INDUSTRIAL AUTOMATION	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

1. To Understand the need of automation in industry
2. To Identify suitable industrial automation hardware for given application
3. To Apply the program logic controller for automation
4. To Understand the operation structure and material handling in total Integrated automation system
5. To Design, model and analyse the plant model suitable for digital manufacturing

UNIT I AUTOMATION OVERVIEW AND PLC 9

Automation Overview, Types of Industrial Automation, Requirement of Automation Systems, Architecture of Industrial Automation System, PLC Architecture, Memory, PLC Programming languages, Input and Output Modules, Timer and Counter, IEC Standards, Ladder programming

UNIT II INPUT DEVICES 9

Input Types and Standards - Analog and Digital Signals - Voltage and Control Inputs - Sensors used for Industrial Automation –Interfacing of Pressure Sensor, Temperature Sensor, Flow Sensor, Level Sensor, Force, Speed and Displacement Sensor –Proximity Sensor- Man-Machine Interfaces.

UNIT III OUTPUT DEVICES AND DATA COMMUNICATION 9

Relays and Transistors – Heaters, Valves - Hydraulic and Pneumatics, Electric Motors - Industrial Data Communications - Fiber Optics – Modbus: RS232, RS485, RS422 – HART – Device Net – Profibus – Fieldbus – Ethernet, Profinet - Ethernet IP/TCP - EtherCAT-CAN- wireless protocols - WiFi

UNIT IV SUPERVISORY CONTROL 9

Introduction to Supervisory Control Systems – SCADA - Distributed Control System (DCS) – Safety Systems – DCS - Network Management - Process Control Systems – Case Studies and Programming,

UNIT V PLANT DESIGN AND SIMULATION 9

Plant Layout - Plant Design - Plant Simulation - Basics and Modelling - Attributes for Plant Control and Statistics - Industry Versions 3.0, 4.0 and 5.0 - Smart Factories - Digital Twin - Programming Case Studies of PLC.

COURSE OUTCOMES:

Upon successful completion of the course, students should be able to:

CO1: State the fundamentals of automation includingPLC, I/Os, communication protocols and simulation.
CO2: Describe the architecture, input/outputs, communication systems and programming languages.
CO3: Interface the input and output devices to PLC.
CO4: Program a PLC for various applications, utilizing appropriate programming languages and techniques.
CO5: Simulate and analyze PLC programming and models for plant design, evaluating their performance and functionality.

Mapping of COs with POs and PSOs

COs/POs & PSOs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	1	1	-	-	-	-	-	1	-	1	2	1	1
CO2	2	1	1	1	-	-	-	-	-	1	-	1	2	2	1
CO3	1	1	1	1	-	-	-	-	-	1	-	1	2	1	1
CO4	1	2	1	2	-	-	-	-	-	1	-	1	2	2	1
CO5	1	2	1	2	-	-	-	-	-	1	-	1	2	1	2
CO/PO & PSO Average	**1.4**	**1.4**	**1**	**1.4**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**1.4**	**1.2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXTBOOKS:

1. Richard L.Shell, Ernest L.Hall., “Handbook of Industrial Automation”, Marcel Dekker Inc, 2000.
2. Frank D, Petruzella, “Programmable Logic Controller” McGraw – Hill Publications, 2016.

REFERENCES:

1. Tan Kok Kiong, Andi Sudjana Putra., “Drives and Control for Industrial Automation”, Advances in Industrial Control, Springer, 2011.
2. Mackay S., Wrijut E., Reynders D. and Park J., “Practical Industrial Data Networks Design,Installation and Troubleshooting”, Newnes Publication - Elsevier, 2004.
3. Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, APress, 2016.
4. Rajput R.K. Robotics and Industrial Automation, S Chand Publishing, revised edition, 2008.

RA23045	MOBILE ROBOTICS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To introduce mobile robotic technology and its types in detail.
2. To learn the kinematics of wheeled and legged robot.
3. To familiarize the intelligence into the mobile robots using various sensors.
4. To acquaint the localization strategies and mapping technique for mobile robot.
5. To aware the collaborative mobile robotics in task planning, navigation and intelligence.

UNIT – I INTRODUCTION TO MOBILE ROBOTICS 9

Introduction – Locomotion of the Robots – Key Issues on Locomotion – Legged Mobile Roots – Configurations and Stability – Wheeled Mobile Robots – Design Space and Mobility Issues – Unmanned Aerial and Underwater Vehicles – Teleportation and Control – Autonomous Mobile Robot-UAV.

UNIT – II KINEMATICS 9

Kinematic Models – Representation of Robot – Forward Kinematics – Wheel and Robot Constraints – Degree of Mobility and Steerability – Manoeuvrability – Workspace – Degrees of Freedom – Path and Trajectory Considerations – Motion Controls – Holonomic -Non Holonomic Robots – Open Loop and Feedback Motion Control – Humanoid Robot - Kinematics Overview.

UNIT – III PERCEPTION 9

Sensor for Mobile Robots – Classification and Performance Characterization – Wheel/Motor Sensors – Heading Sensors – Ground-Based Beacons - Active Ranging - Motion/Speed Sensors – Vision Based Sensors – Uncertainty - Statistical Representation - Error Propagation - Feature Extraction Based on Range Data (Laser, Ultrasonic, Vision-Based Ranging) - Visual Appearance based Feature Extraction.

UNIT – IV LOCALIZATION 9

The Challenge of Localization - Sensor Noise and Aliasing - Effector Noise – Localization Based Navigation Versus Programmed Solutions - Belief Representation – Single - Hypothesis Belief And Multiple-Hypothesis Belief - Map Representation - Continuous Representations - Decomposition Strategies - Current Challenges In Map Representation - Probabilistic Map- Based Localization - Markov Localization - Kalman Filter Localization - Landmark-Based Navigation- Indoor Navigation and Control - Globally Unique Localization - Positioning Beacon Systems - Route-Based Localization - Autonomous Map Building - Stochastic Map Technique - Simultaneous Localization and Mapping (SLAM)- Other Mapping Techniques.

UNIT – V NATURALLY INSPIRED ROBOTICS 9

Introduction - Competences for Navigation: Planning and Reacting - Path Planning - Obstacle Avoidance - Navigation Architectures - Modularity for Code Reuse and Sharing - Control Localization - Techniques for Decomposition - Case Studies – Collaborative Robots – Swarm Robots.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Reproduce the foundations of concepts of mobile robotics construction, localization and navigation

CO2: Express the hardware and software relevant features ofrobotics.

CO3: Deploy the perception, localization and navigation techniques inthe context of mobile robots.

CO4: Demonstrate the architecture, control and algorithms for mobile robotics.

CO5: Evaluate the hardware components, planning and navigation algorithms, and the use of bio-inspired techniques in mobile robotics.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	1	1	1	-	-	-	-	1	-	1	2	1	1
CO2	2	2	1	1	2	-	-	-	-	1	-	1	2	2	1
CO3	2	1	1	1	1	-	-	-	-	1	-	1	2	1	1
CO4	2	1	1	1	1	-	-	-	-	1	-	1	2	1	1
CO5	2	2	1	1	1	-	-	-	-	1	-	1	2	1	1
CO/PO & PSO Average	**2**	**1.4**	**1**	**1**	**1.2**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**1.2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Roland Siegwart and IllahR.Nourbakish, “Introduction to Autonomous Mobile Robots” MIT Press, Cambridge, 2011.
2. Dragomir N. Nenchev, Atsushi Konno, TeppeiTsujita, “Humanoid Robots: Modelling and Control”, Butterworth-Heinemann, 2018

REFERENCES:

1. Mohanta Jagadish Chandra, “Introduction to Mobile Robots Navigation”, LAP Lambert Academic Publishing, 2015.
2. Peter Corke, “Robotics, Vision and Control”, Springer, 2017.
3. Ulrich Nehmzow, “Mobile Robotics: A Practical Introduction”, Springer, 2012.
4. Xiao Qi Chen, Y.Q. Chen and J.G. Chase, “Mobile Robots - State of the Art in Land, Sea, Air, and Collaborative Missions”, Intec Press, 2009.
5. Alonzo Kelly, Mobile Robotics: Mathematics, Models, and Methods, Cambridge University Press, 2013, ISBN: 978-1107031159.

RA23046	ROBOT DYNAMICS AND CONTROL	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To learn and understand generalized co-ordinates, Jacobian matrix Mass Distribution and other fundamental equations.
2. To understand Lagrangean and Hamiltonian mechanics
3. To understand nonlinearities in control system
4. To Understand various force control strategies
5. To understand various concepts in linearizing a no linear signal

UNIT – I ROBOT STATICS 9

Generalized Co-ordinates - Generalized Forces - Equation of Motions – Static Forces in Manipulators - Jacobian Matrix - Jacobians in the Force Domain - Cartesian Transformation of Velocities and Static Forces - Acceleration of a Rigid Body - Mass Distribution –Non-Rigid Body Effects - Newton's Equation - Euler's Equation – Langrage Equation.

UNIT – II ROBOT DYNAMICS 9

General Expressions for Kinetic and Potential Energy - Kinetic Energy for an N-Link Robot - Potential Energy for an N-Link Robot - Equations of Motion - Lagrangean Multiplier - Langrage's Equation - Hamilton Equation - Hamilton Vector Field- Euler - Lagrange Equation – State Vector and Equation Formulation.

UNIT – III ROBOT CONTROL SYSTEM 9

The Manipulator Control Problem, Linear Second-Order Model of Manipulator. Functions of Controller and Power Amplifier. Joint Actuators- Stepper Motor, Servo Motor. Control Schemes: PID Control Scheme – Position and Force Control Schemes. Robotic Sensors and its Classification, Internal Sensors – Position, Velocity, Acceleration and Force Information, External Sensors – Contact Sensors-Limit Switches, Piezoelectric, Pressure Pads, Non-Contact Sensors – Range Sensors, Vision Sensor-Robotic Vision System, Description of Components of Vision System.

UNIT – IV CONTROL OF MANIPULATORS 9

Linear Time Varying and Linearization – Input and Output Stability - Background: The Frobenius Theorem –Single-Input Systems. Introduction to Nonlinear System – Time Varying Systems - Multi-Input, Multi-Output Control Systems - The Control Problem for Manipulators - Practical Considerations - Current Industrial-Robot Control Systems - Lyapunov Stability Analysis – Cartesian - Based Control Systems - Adaptive Control - Limit Cycle - Describing Function.

UNIT – V FORCE CONTROL 9

Constrained Dynamics - Static Force/Torque Relationships - Constraint Surfaces - Natural and Artificial Constraints - Network Models and Impedance - Impedance Operators - Classification of Impedance Operators - Force Control Strategies - Impedance Control - Hybrid Impedance Control – PID controllers

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of this course, the students will be able to;

CO1: State the generalized concepts, methods in dynamics and control of robot.

CO2: Describe the methods in dynamics and control of robot.

CO3: Develop the dynamic and control model of the manipulator.

CO4: Analyse the parameters and linear and nonlinearities in the dynamics of the manipulator.

CO5: Evaluate dynamics and control methods and responses of the manipulator.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	1	1	-	-	-	-	-	-	-	1	2	1	1
CO2	2	1	1	1	-	-	-	-	-	-	-	1	2	1	1
CO3	2	1	1	1	-	-	-	-	-	-	-	1	2	1	1
CO4	2	3	1	1	-	-	-	-	-	-	-	1	2	1	1
CO5	2	3	2	1	-	-	-	-	-	-	-	1	2	1	1
CO/PO & PSO Average	**2**	**1.8**	**1.2**	**1**	-	-	-	-	-	-	-	**1**	**2**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Mark W. Spong, Seth Hutchinson, M. Vidyasagar.," Robot modeling and control" 2nd Edition, 2020
2. John J. Craig, "Introduction to Robotics – Mechanics and control", 3rd Edition, Prentice hall, 2022.
3. Groover. M.P., Weis. M., Nagel. R.N. and Odrey.N.G. "Industrial Robotics Technology, Programming and Applications", 2nd edition McGraw-Hill, Int., 2017.

REFERENCES:

1. K.S.Fu, Gonzalez, R.C. and Lee, C.S.G. "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill, 1987.
2. Saeed B. Niku, "Introduction to Robotics: Analysis, Control, Applications", 2nd edition, John Wiley & sons, Inc., 2020
3. Klafter. R.D., Chmielewski, T.A. and Negin. M. "Robotics Engineering – An Integrated Approach", Prentice-Hall of India Pvt. Ltd., 2006.

RA23047	FLUID POWER SYSTEMS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To understand the basic principles of fluid power.
2. To Know the different properties of hydraulic fluids and their effects
3. To Explain the working principles of various pumps
4. To understand the working principle of hydraulic and pneumatic components and its selection.
5. To design hydraulic and pneumatic circuits for different applications.

UNIT – I BASICS OF FLUID POWER TECHNOLOGY 9

Introduction to Fluid Power Controls – Hydraulics and Pneumatics – Selection Criteria, Application of Fluid Power, Application of Pascal's Law, Transmission and Multiplication of Force – Pressure Losses – Fluids, Selection and Properties – Gas Laws- Properties of Air with Pressure and Temperature - ISO Symbols.

UNIT – II FLUID POWER SOURCES 9

Fluid Power Drives – Pumps – Working Principle and Construction Details of Gear, Vane and Piston Pumps, Hydraulic Motors, Hydrostatic Transmission Drives and Characteristics, Hydraulic Supply Components Pneumatic Power Supply – Compressors, Air Distribution, FRL Unit, Air Motors.

UNIT – III FLUID POWER ACTUATORS AND ELEMENTS 9

Control Valves – Pressure, Flow, and Direction - Working Principle and Construction – Special Type - Valves – Cartridge, Modular, Proportional, and Servo Selection and Actuation Methods. Actuators – Selection and Specification, Cylinders, Mounting, Cushioning, Pipe Fittings – Fluid Conditioning Elements – Accumulators- Intensifier.

UNIT – IV HYDRAULIC AND PNEUMATIC CIRCUITS DESIGN 9

Regenerative, Speed Control, Synchronizing Circuits - Design of Hydraulic and Pneumatic Circuits for Automation, Selection and Specification of Circuit Components, Sequencing Circuits, Cascade, And Karnaugh – Veitch Map Method – Circuits for Industrial Application - Case Studies - Grinding, Milling, Shaping, Press and Material Handling

UNIT – V ELECTRO PNEUMATICS AND PLC CIRCUITS 9

Fluidics -Moving Part Logic Circuits - Use of Electrical Timers, Switches, Solenoid, Relays, Proximity Sensors - Electro and Hydro Pneumatics Sequencing Ladder Diagram – PLC – Elements, Functions and Selection – PLC Programming– Ladder and Different Programming Methods - Sequencing Circuits.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Identify thesymbols, laws and elements of fluid power devices.

CO2: Describe the working of pump, actuators, control elements of fluid power system

CO3: Design the basic and advanced hydraulic and pneumatics circuits.

CO4: Develop the basic, electro pneumatics and hydraulic, PLC integrated circuits for various application including material handling, press, shaping, milling, grinding.

CO5: Appraise the design and working of fluid power circuits.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	1	-	-	-	-	-	1	-	1	2	1	1
CO2	2	-	-	1	-	-	-	-	-	1	-	1	2	1	1
CO3	2	-	2	1	-	-	-	-	-	1	-	1	2	1	1
CO4	2	-	1	1	-	-	-	-	-	1	-	1	2	1	1
CO5	2	-	2	1	-	-	-	-	-	1	-	1	2	1	1
CO/PO & PSO Average	**2**	**-**	**1.6**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**1**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Anthony Esposito, “Fluid power with applications”, Pearson education, 7th edition, 2014.
2. Srinivasan R, “Hydraulic and Pneumatic Controls”, Vijay Nicole Imprints, 3rd edition, 2017.

REFERENCES:

1. Andrew Parr, “Hydraulics and Pneumatics”, Jaico Publishing House, 3rd edition, 2013.
2. Jagadeesha T, "Pneumatics:Concepts, Design and Applications", University Press, 2015.
3. Majumdar, “Oil hydraulics: Principles and Maintenance”, Tata McGraw Hill, 13th edition, 2006.
4. Majumdar, “Pneumatic system: Principles and Maintenance”, Tata McGraw Hill, 7th edition 2008.
5. Peter Rohner, “Fluid Power Logic circuit Design”, Macmillan Press Ltd., 2000.
6. Vickers, “Industrial Hydraulics Manual”, Eaton Hydraulics Training, 5th edition, 2006.

RA23048	VISION TECHNOLOGY	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To understand the basics concepts of optics and vision systems.
2. To learn and understand the fundamentals of image processing
3. To impart knowledge on object recognition and feature extraction.
4. To understand algorithms in image processing.
5. To demonstrate the various applications of machine vision system.

UNIT – I **IMAGE ACQUISITION** **9**

The Nature of Vision- Robotic Vision – Need, Applications - Image Acquisition – Physics of Light – Interactions of Light – Refraction at a Spherical Surface – Thin Lens Equation - Illumination Techniques - Linear Scan Sensor, Planar Sensor, Camera Transfer Characteristic, Raster Scan, Image Capture Time, Volume Sensors, Image Representation, Picture Coding Techniques.

UNIT – II **IMAGE PROCESSING FUNDAMENTALS** **9**

Introduction to Digital Image Processing - Image Sampling and Quantization - Image Enhancement: Image Filtering, Radiometric Calibration, Image Smoothing– Geometric Transformation– Image Segmentation – Hough transforms - Edge Linking - Boundary Detection - Region Growing - Region Splitting and Merging-Stereo Vision – Epipolar Geometry

UNIT – III **FEATURE EXTRACTION AND OBJECT RECOGNITION** **9**

Feature Extraction: Region Features, Gray Value Features, Contour Features- Hough Circle Transformation – SIFT and SURF –Freeman Chain Code-Boundary Descriptors-Regional Descriptors – Recognition- Structural Methods- Recognition Procedure, Mahalanobis Procedure

UNIT – IV **COLLISION FRONTS ALGORITHM** **9**

Introduction, Skeleton of Objects. Gradients, Propagation, Definitions, Propagation Algorithm, Thinning Algorithm, Skeleton Lengths of Top Most Objects.

UNIT – V **ROBOT VISION APPLICATION** **9**

Case Study-Automated Navigation Guidance by Vision System – Vision Based Depalletizing- Line Tracking- Automatic Part Recognition. Image Processing Techniques -Implementation through Image Processing Software. (PYTHON, Open CV)

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon Completion of the course, the students will be able to

CO 1: Know the various types of sensors, lightings, hardware and concept for robot vision.

CO 2: Acquire the image by the appropriate use of sensors, lightings and hardware.

CO 3: Apply the various techniques of acquisition and image processing in real time applications.

CO 4: Suggest the suitable sensors, lightings, hardware and algorithm.

CO 5: Create, analyse and implement the hardware and image processing methodology for robotic vision.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	1	1	-	-	-	-	1	-	1	2	2	1
CO2	2	1	-	1	1	-	-	-	-	1	-	1	2	2	1
CO3	2	1	-	1	1	-	-	-	-	1	-	1	2	2	1
CO4	2	1	-	1	1	-	-	-	-	1	-	1	2	2	1
CO5	2	2	-	1	1	-	-	-	-	1	-	1	2	2	1
CO/PO & PSO Average	**2**	**1.2**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Rafael C. Gonzales, Richard. E. Woods, “Digital Image Processing Publishers”, Fourth Edition, Pearson, 2018
2. Emanuele Trucco, Alessandro Verri, “Introductory Techniques for 3D Computer Vision”, First Edition, Pearson, 1998.

REFERENCES:

1. Yi Ma, Jana Kosecka, Stefano Soatto, Shankar Sastry, “An Invitation to 3-D Vision From Images to Models”, First Edition, 2004
2. Fu .K.S, Gonzalez .R.S, Lee .C.S.G, “Robotics – Control Sensing, Vision and Intelligence”, Tata McGraw-Hill Education, 2008.
3. RafelC.Gonzalez, Richard E.Woods,Steven L. Eddins, “Digital Image Processing using MATLAB”, 2nd edition, Tata McGraw Hill, 2010.
4. Peter Corke, "Robotics, Vision and Control: Fundamental Algorithms in MATLAB", Springer, 2011

LIST OF EMERGING TECHNOLOGY COURSES

RA23E01	ROBOT OPERATING SYSTEMS	L	T	P	TCP
		1	0	4	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1. Apply the principles and concepts of ROS in robotic systems.
2. Select and create robot environments using CAD tools and ROS packages.
3. Relate robots using Gazebo and integrate ROS controllers for joint movement.
4. Use V-REP as a multi-platform simulator for robotic arm and wheeled robot simulation.
5. Implement mapping, navigation, and motion planning using ROS MoveIt.

UNIT – I ROS ESSENTIALS 3

Introduction to ROS- Advantages and Disadvantages of ROS - ROS Framework- ROS package C++, Python – ROS computation Graph – nodes, Messages, topics, services, bags, ROS Master- ROS Community- Basic programming and Syntax overview in C++ and Python – start with ROS programming - Creating Environment - Services-Actions and Nodes- Simple Interaction with the Simulation environment.

UNIT – II BUILD YOUR OWN ROBOT ENVIRONMENT 3

CAD Tools for Robot Modelling – ROS Packages for robot modelling – Unified Robot Description Format and Tags- Kinematics and Dynamics Library – Create URDF Model - Robot Modelling using Unified Robot Description Format (URDF) –

ROS parameter server and adding real-world object representations to the simulation environment _ Create Robot description using 7 DOF: joint number, name, type and angle limits – Xacro – Rviz – viewing of 7 DOF arm – creation of wheeled robot.

UNIT – III SIMULATION ROBOTS IN ROS WITH GAZEBO 3

Robot simulation - Gazebo –create simulation model at Gazebo- Adding colors, textures, transmission tags, 3D vision sensor to Gazebo- Moving robot joints using ROS controllers- ROS controller interacts with Gazebo, interfacing state controller, simulation of moving the robot joints simulation of differential wheeled robot in Gazebo.

UNIT – IV ROS WITH VREP 3

REP is a multi-platform robotic simulator - Simulating the robotic arm using V-REP - Adding the ROS interface to V-REP joint - Simulating a differential wheeled robot, Adding a laser sensor , 3D vision sensor.

UNIT – V MAPPING, NAVIGATION AND MOTION PLANNINGROS WITH MOVEIT 3

Move it Instattion - Generating the Self-Collision matrix .virtual joints, planning groups, robot poses, robot end effector - MoveIt Architecture Diagram - Trajectory from RViz GUI executing in Gazebo- Planning scene overview diagram- Collision Checking **-** Motion Planning, Pick and Place Behaviors using Industrial Robots with ROS Moveit – ROS with MATLAB - ROS with Industrial.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO.1: Demonstrate the ability to apply ROS principles and concepts in practical robotic systems.

CO.2: Design and develop robot environments using CAD tools and ROS packages.

CO.3: Simulate robot models using Gazebo and incorporate ROS controllers for joint manipulation.

CO.4: Utilize V-REP as a multi-platform simulator for realistic robot simulation scenarios.

CO.5: Compute mapping, navigation, and motion planning using ROS MoveIt for efficient robot motion.

Mapping of COs with POs and PSOs

COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	1	1	1	-	1	-	-	-	-	1	-	1	2	2	1
CO2	1	1	2	-	1	-	-	-	-	1	-	1	2	2	1
CO3	1	1	2	-	1	-	-	-	-	1	-	1	2	2	1
CO4	1	1	1	-	1	-	-	-	-	1	-	1	2	2	1
CO5	1	1	1	-	1	-	-	-	-	1	-	1	2	2	1
CO/PO & PSO Average	**1**	**1**	**1.4**	**-**	**1**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Lentin Joseph, Jonathan Cacace, “Mastering ROS for Robotics Programming”, Second Edition, Packt Publishing, 2015.

REFERENCES:

1. Lentin Joseph, Aleena Johny, “Robot Operating System (ROS) for Absolute Beginners Robotics Programming Made Easy”, Second Edition, Apress, 2022.
2. Lentin Joseph, “ROS Robotics Projects”, Packet publishing, 2017

PROJECTS

Team Size : 3 Members

Mobile robot simulation in ROS

Manipulator simulation in ROS

Legged robot simulation in ROS and etc.,

RA23E02	ROBOTIC PROCESS AUTOMATION	L	T	P	TCP
		1	0	4	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To understand the basic concepts of Robotic Process Automation.
2. To expose to the key RPA design and development strategies and methodologies.
3. To learn the fundamental RPA logic and structure.
4. To explore the Exception Handling, Debugging and Logging operations in RPA.
5. To learn to deploy and Maintain the software bot.
6. To explore Employability and enterprise applications in RPA.

UNIT – I ROBOTIC PROCESS AUTOMATION (RPA) FUNDAMENTALS 9

Introduction of Robotic Process Automation (RPA), Evolution of RPA, Compare and contrast RPA from Automation - Benefits of RPA - Application of RPA, Components of RPA, UiPath Studio Overview. Robotic Process Automation Tools - Templates, User Interface, Domains in Activities, Workflow Files.

UNIT – II UiPATH STUDIO ACTIVITIES AND WORKFLOW COMPONENTS 9

Sequence, Flowchart & Control Flow: Sequencing the Workflow, Activities, Flowchart, Control Flow for Decision making. Data Manipulation: Variables, Collection, Arguments, Data Table, Clipboard management, File operations Controls: Finding the control, waiting for a control, Act on a control, UiExplorer, Handling Events

UNIT – III UiPATH AUTOMATION CONCEPTS AND TECHNIQUES 9

Exception handling, Common exceptions, Logging- Debugging techniques, Collecting crash dumps, Error reporting. Code management and maintenance: Project organization, Nesting workflows, Reusability, Templates, Commenting techniques, State Machine.

UNIT – IV RPA DEPLOYMENT AND MANAGEMENT 9

Publishing using publish utility, Orchestration Server, Control bots, Orchestration Server to deploy bots, License management, Publishing and managing updates. RPA Vendors – Open Source RPA

UNIT – V EMPLOYABILITY AND ENTERPRISE APPLICATIONS IN RPA 9

Introduction to RPA and Its Role in Enterprises,Essential Technical Skills for RPA Professionals,Advanced RPA Development, Introduction to Orchestrator - Collaboration and Communication Skills, Employability Skills, Business Process Understanding, Open Source RPA and Future Trends, Capstone Project - Real-world Enterprise Automation

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Understand the basic concepts of Robotic Process Automation.

CO2: Enunciate the key distinctions between RPA and existing automation techniques and platforms.

CO3: Use UiPath to design control flows and work flows for the target process

CO4: Implement recording, web scraping and process mining by automation
CO5: Use UIPath Studio to detect, and handle exceptions in automation processes

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	1	1	1	-	1	-	-	-	-	1	-	1	2	2	1
CO2	1	1	2	-	1	-	-	-	-	1	-	1	2	2	1
CO3	1	1	2	-	1	-	-	-	-	1	-	1	2	2	1
CO4	1	1	1	-	1	-	-	-	-	1	-	1	2	2	1
CO5	1	1	1	-	1	-	-	-	-	1	-	1	2	2	1
CO/PO & PSO Average	**1**	**1**	**1.4**	**-**	**1**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**2**	**1**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Learning Robotic Process Automation: Create Software robots and automate business processes with the leading RPA tool - UiPath by Alok Mani Tripathi, Packt Publishing, 2018.
2. Tom Taulli , “The Robotic Process Automation Handbook: A Guide to Implementing RPA Systems”, Apress publications, 2020.

REFERENCES:

1. Frank Casale, Rebecca Dilla, Heidi Jaynes, Lauren Livingston, Introduction to Robotic Process Automation: a Primer, Institute of Robotic Process Automation, Amazon Asia-Pacific Holdings Private Limited, 2018
2. Richard Murdoch, Robotic Process Automation: Guide To Building Software Robots, Automate Repetitive Tasks & Become An RPA Consultant, Amazon Asia-Pacific Holdings Private Limited, 2018
3. A Gerardus Blokdyk, “Robotic Process Automation RpaA Complete Guide “, 2020.

PROJECTS

Team Size : 3 Members

Web Scraping
CRM Upgrading
Support Sales and Marketing Process
Data Migration
Call Center Operations
Onboarding Employees
Payroll Processing
Legal Process
Data Wiring for Healthcare
10. Claims Processing

RA23E03	DIGITAL TWIN AND INDUSTRY 5.0	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1. Understand the key principles and concepts of Digital Twin technology.
2. Introduce the applications and benefits of Digital Twin in various industries.
3. Evaluate the role of Digital Twin in industry innovation and improvement.
4. Analise data collection and analysis techniques for product and process enhancements.
5. Know the advancements and challenges of Industry 5.0 and Smart Manufacturing.

UNIT – I INTRODUCTION 9

Digital twin – Definition, types of Industry and its key requirements, Importance, Application of Digital Twin in process, product, service industries, History of Digital Twin, DTT role in industry innovation, Technologies/tools enabling Digital Twin – Virtual CAD Models – control Parameters- Real time systems – control Parameters – Handshaking Through Internet – cyber physical systems.

UNIT – II DIGITAL TWIN IN A DISCRETE INDUSTRY 9

Basics of Discrete Industry, Trends in the discrete industry, control system requirements in a discrete industry, Digital Twin of a Product, Digital Thread in Discrete Industry, Data collection & analysis for product & production improvements, Automation simulation, Digital Enterprise.

UNIT – III DIGITAL TWIN IN A PROCESS INDUSTRY 9

Basics of Process Industry, Trends in the process industry, control system requirements in a process industry, Digital Twin of a plant, Digital Thread in process Industry, Data collection and analysis for process improvements, process safety, Automation simulation, Digital Enterprise.

UNIT – IV INDUSTRY 5.0 9

Industrial Revolutions, Industry 5.0 – Definition, principles, Application of Industry 5.0 in process & discrete industries, Benefits of Industry 5.0, challenges in Industry 5.0, Smart manufacturing, Internet of Things 5.0, Industrial Gateways, Basics of Communication requirements – cognitive systems 5.0.

UNIT – V ADVANTAGES OF DIGITAL TWIN 9

Improvement in product quality, production process, process Safety, identify bottlenecks and improve efficiency, achieve flexibility in production, continuous prediction and tuning of production process through Simulation, reducing the time to market.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO 1: Demonstrate a thorough understanding of Digital Twin technology and its applications.
CO 2: Recognize the significance and impact of Digital Twin in industry innovation.
CO 3: Apply data collection and analysis methods to improve product and process performance.
CO 4: Obtain the role of Digital Twin in enhancing product quality and process efficiency.
CO 5: Evaluate the advantages and challenges of Industry 5.0 and Smart Manufacturing.

Mapping of COs with POs and PSOs															
COs/Ps & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	-	1	-	-	-	-	1	-	1	2	2	2
CO2	2	2	-	-	1	-	-	-	-	1	-	1	2	2	2
CO3	2	2	-	1	1	-	-	-	-	1	-	1	2	2	2
CO4	2	2	1	1	1	-	-	-	-	1	-	1	2	2	2
CO5	2	2	1	1	1	-	-	-	-	1	-	1	2	2	2
CO/PO & PSO Average	**2**	**1.8**	**1**	**1**	**1**	-	-	-	-	**1**	**-**	**1**	**2**	**2**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Alp Ustundag and Emre Cevikcan, “Industry 4.0: Managing The Digital Transformation”, Springer Series in Advanced Manufacturing., Switzerland, 2018
2. Andrew Yeh Chris Nee, Fei Tao, and Meng Zhang, “Digital Twin Driven Smart Manufacturing”, Elsevier Science., United States, 2019

REFERENCES:

1. UthayanElangovan, Industry 5.0: The Future of the Industrial Economy, CRC Press, 2022.
2. Namit Gupta, Roopa Shinde, Rakesh Kumar Malviya and Anjali Gupta, Industry 5.0 and Paradigm Shift—Emerging Challenges, Allied Publishers Private Limited, 2023.
3. Anirban Bhattacharyya and Cristina Dolan, Industry 5.0 and Data Economy: Precursor to Embracing ESG and AI Led Transformation, Vitasta Publishing Private Limited; First Edition, 2023
4. Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, Apress., United States 2015.
5. Christoph Jan Bartodziej, “The Concept Industry 4.0 an Empirical Analysis of Technologies and Applications in Production Logistics”, Springer Gambler., Germany, 2017.
6. Ibrahim Garbie, “Sustainability in Manufacturing Enterprises, Concepts, analyses and assessments for Industry 4.0”, Springer., Switzerland, 2016.
7. Ronald R. Yager and Jordan Pascual Espada, “New Advances in the Internet of Things”, Springer., Switzerland, 2018
8. Ulrich Sendler, “The Internet of Things, Industries 4.0 Unleashed”, Springer., Germany, 2018

RA23E04	SMART MOBILITY AND INTELLIGENT VEHICLES	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

1. Understand the fundamental concepts and principles of automated, connected, and intelligent vehicles.
2. Analyze the role and impact of sensor technology in smart mobility systems.
3. Apply control system theory and cyber-physical system principles to connected autonomous vehicles.
4. Examine the wireless technology and networking aspects of vehicle autonomy.
5. Evaluate the challenges and considerations related to connected car and autonomous vehicle technology.

UNIT – I INTRODUCTION TO AUTOMATED, CONNECTED, AND INTELLIGENT VEHICLES **9**

Concept of Automotive Electronics, Electronics Overview, History & Evolution, Infotainment, Body, Chassis, and Powertrain Electronics, Introduction to Automated, Connected, and Intelligent Vehicles. Case studies: Automated, Connected, and Intelligent Vehicles.

UNIT – II SENSOR TECHNOLOGY FOR SMART MOBILITY **9**

Basics of Radar Technology and Systems, Ultrasonic Sonar Systems, Lidar Sensor Technology and Systems, Camera Technology, Night Vision Technology, Other Sensors, Use of Sensor Data Fusion, Integration of Sensor Data to On-Board Control Systems.

UNIT – III CONNECTED AUTONOMOUS VEHICLE **9**

Basic Control System Theory applied to Automobiles, Overview of the Operation of ECUs, Basic Cyber-Physical System Theory and Autonomous Vehicles, Role of Surroundings Sensing Systems and Autonomy, Role of Wireless Data Networks and Autonomy.

UNIT – IV VEHICLE WIRELESS TECHNOLOGY & NETWORKING **9**

Wireless System Block Diagram and Overview of Components, Transmission Systems – Modulation/Encoding, Receiver System Concepts– Demodulation/Decoding, Wireless Networking and Applications to Vehicle Autonomy, Basics of Computer Networking – the Internet of Things, Wireless Networking Fundamentals, Integration of Wireless Networking and On-Board Vehicle Networks.

UNIT – V CONNECTED CAR & AUTONOMOUS VEHICLE TECHNOLOGY **9**

Connectivity Fundamentals, Navigation and Other Applications, Vehicle-to-Vehicle Technology and Applications, Vehicle-to-Roadside and Vehicle-to-Infrastructure Applications, Autonomous Vehicles- Driverless Car Technology, Moral, Legal, Roadblock Issues, Technical Issues, Security Issues

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Demonstrate a comprehensive understanding of the concepts and components of automated, connected, and intelligent vehicles.

CO2: Apply sensor technology knowledge to analyze and integrate data for on-board control systems.

CO3: Evaluate the role of wireless data networks in enabling vehicle autonomy.

CO4: Design and analyze wireless networking solutions for on-board vehicle systems.

CO5: Assess the ethical, legal, technical, and security issues associated with connected and autonomous vehicles.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	-	-	-	-	-	-	-	-	1	-	1	1	2	2
CO2	2	2	-	-	-	-	-	-	-	1	-	1	1	2	2
CO3	2	1	-	-	-	-	-	-	-	1	-	1	1	2	2
CO4	2	1	2	-	-	-	-	-	-	1	-	1	1	2	2
CO5	2	1	-	-	-	2	-	1	-	1	-	1	1	2	2
CO/PO & PSO Average	**2**	**1.2**	**2**	**-**	**-**	**2**	**-**	**1**	**-**	**1**	**-**	**1**	**1**	**2**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. “Intelligent Transportation Systems and Connected and Automated Vehicles”, 2016,Transportation Research Board
2. Radovan Miucic, “Connected Vehicles: Intelligent Transportation Systems”, 2019, Springer

REFERENCES:

1. Tom Denton, “Automobile Electrical and Electronic systems, Roult edge”, Taylor & Francis Grup, 5th Edition, 2018.

LIST OF INDUSTRY ORIENTED COURSES

INVERSE KINEMATIC SOLVERS FOR SERIAL ROBOTS IN PYTHON	L	T	P	TCP
	1	0	0	1

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

1. Understand the basics of Python programming\
2. Explain the planar robot kinematics
3. Illustrate the spatial robot kinematics
4. Demonstrate the concept of closed loop iterative solvers for inverse kinematics
5. Understand the various case studies using python

UNIT-I BASICS **3**

DOF, Transformation matrices for translation and rotation. DH parameter- Python basics- Programme and library installations (numpy, scipy, matplotlib etc.). understandingscalar, list, array, and matrices data objects.

UNIT-II PLANAR ROBOT KINEMATICS **3**

Forward and inverse kinematics, Jacobian matrices, and inverse techniques

UNIT-III SPATIAL ROBOT KINEMATICS **3**

Jacobian generating vectors and Jacobian matrices, constructing Jacobian matrix directly fromDH table. Kinematic decoupling techniques.

UNIT-IV CLOSED LOOP ITERATIVE SOLVERS FOR INVERSE KINEMATICS **3**

Code development- writing FK code, error estimation, Matrix transformation functions,computing projection vectors, IK codes-Jacobina inverse, Pseudo inverse, and Damped leastsquares inverse functions. Path travel minimization and solving an IK code to compute path andposition reach. Position and velocity IK closed-loop solutions.

UNIT-V CASE STUDIES **3**

Writing IK code for Planar serial robotic system through python with graphics- Writing IK code for spatial serial robotic system through python with graphics

TOTAL: 15 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Identify the basic terminologies related to inverse kinematics and python
CO2: Develop a basic code in python
CO3: Develop codes in python for planar and spatial robot kinematics
CO4: Evaluate the closed loop iterative solvers for inverse kinematics
CO5: Analyse the given application and develop suitable program using Python

REFERENCE BOOKS:

1.Theory of Applied Robotics - Kinematics, Dynamics & control(2nd Edition.), Reza N. Jazar,Springer Science & Business Media, 5 Nov 2010 - Technology & Engineering - 883 pages
2. Fundamentals of Robotics: Analysis and Control, Schilling Robert J. PHI Publications.
3. Introduction to Robotics, S. K. Saha, McGraw Hill publications

INDUSTRIAL INTERNET OF THINGS	L	T	P	TCP
	1	0	0	1

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1. Understand the fundamental concepts and architecture of IoT systems.
2. Evaluate the challenges and considerations associated with implementing IoT.
3. Apply machine learning and data science techniques in IIoT analytics
4. Assess the security measures and best practices for securing IoT systems.
5. Examine real-world case studies to understand practical applications of IIoT.

UNIT-I INTRODUCTION AND ARCHITECTURE OF IoT 3

Introduction – Definition and characteristics of IoT – Physical and Logical Design of IoT - Communication models and APIs – Challenges in IoT - Evolution of IoT- Components of IoT - A Simplified IoT Architecture – Core IoT Functional Stack.

UNIT-II INDUSTRIAL IoT 3

IIoT-Introduction, Industrial IoT: Business Model and Reference Architecture: IIoT-Business Models, Industrial IoT- Layers: IIoT Sensing, IIoT Processing, IIoT Communication, IIoT Networking.

UNIT-III IIOT ANALYTICS 3

Big Data Analytics and Software Defined Networks, Machine Learning and Data Science, Julia Programming, Data Management with Hadoop.

UNIT-IV IOT SECURITY 3

Industrial IoT: Security and Fog Computing - Cloud Computing in IIoT, Fog Computing in IIoT, Security in IIoT.

UNIT-V CASE STUDY 3

Industrial IOT- Application Domains: Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries, Real case studies: Milk Processing and Packaging Industries, Manufacturing Industries.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Enumerate a comprehensive understanding of the concepts and architecture of IoT.
CO2: Critically analyze the challenges and considerations in implementing IoT systems.
CO3: Apply machine learning and data science techniques to analyzeIIoT data.
CO4: Develop strategies to enhance the security of IoT systems.
CO5: Evaluate and interpret real-world case studies to identify IIoT applications.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	-	-	1	-	-	-	-	1	-	1	2	2	2
CO2	2	2	-	-	1	-	-	-	-	1	-	1	2	2	2
CO3	2	2	-	1	1	-	-	-	-	1	-	1	2	2	2
CO4	2	2	1	1	1	-	-	-	-	1	-	1	2	2	2
CO5	2	2	1	1	1	-	-	-	-	1	-	1	2	2	2
CO/PO & PSO Average	**2**	**1.8**	**1**	**1**	**1**	-	-	-	-	**1**	**-**	**1**	**2**	**2**	**2**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXTBOOKS:

1. Industry 4.0: The Industrial Internet of Things", by Alasdair Gilchrist (Apress), 2017

REFERENCE BOOKS:

1. "Industrial Internet of Things: CybermanufacturingSystems"by Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat (Springer), 2017
2. Hands-On Industrial Internet of Things: Create a powerful Industrial IoT by Giacomo Veneri, Antonio Capasso, Packt, 2018.

MARINE ROBOTICS

L	T	P	TCP
1	0	0	1

COURSE OBJECTIVES:

- To provide the students an advanced knowledge in various types of marine robots and its applications a relatively nascent field
- To impart knowledge in students in the areas of marine robotics design, development and deployment in the real world applications

UNIT I MARINE ROBOTS 3

Types and classification of marine robots – robotic sailing – submersibles, applications of sailing robots and submersibles, Limitations in marine autonomy

UNIT II ROBOTIC SAILING 3

History and recent developments in robotic sailing – miniature sailing robot platform (MOOP) – autonomous sailing vessel – design, development and deployment

UNIT III SUBMERSIBLES 3

Unmanned submersibles- towed vehicles – Remotely Operable Vehicles (ROV) – The ROV business – Design theory and standards – control and simulation – design and stability – components of ROV - applications

UNIT IV AUTONOMOUS UNDERWATER VEHICLE (AUV) 3

Gliders – construction – buoyancy driven – Control strategies, AUV – construction – components – control strategies

UNIT V UNDERWATER VEHICLE GUIDANCE AND CONTROL 3

Modelling of marine vehicles – kinematics – rigid body dynamics – hydrodynamic forces and moments – equation of motion – stability and control of underwater vehicles

TOTAL :45 PERIODS

COURSE OUTCOMES:

- Students will have knowledge in various types of marine robots.
- Students should get an introduction about designing, developing and deploying marine robots in the field

TEXT BOOKS:

1. Alexander schlaelfer and ole blaurock, Robotic sailing, Proceedings of the 4th International sailing conference, Springer, 2011
2. Sabiha A. wadoo,pushkinkachroo, Autonomous underwater vehicles, modelling, control design and Simulation, CRC press, 2011
3. Robert D. Christ,Robert L. Wernli, Sr. “The ROV Manual A User Guide for Remotely Operated Vehicles”, Elsevier, second edition, 2014
4. Thor I Fossen, Guidance and control of ocean vehicles, John wiley and Sons, 1999

REFERENCES

1. Mae L. Seto, Marine Robot Autonomy, Springer, 2013
2. Richard A Geyer, “Submersibles and their use in oceanography and ocean engineering”, Elsevier, 1997
3. Gianluca Antonelli, Underwater robotics, Springer, 2014

ELECTRO MECHANICAL AUTOMATION	L	T	P	TCP
	0	0	1	1

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students:

1. To provide a foundational understanding of the diverse applications of Electromechanical Automation products and solutions
2. To introduce the principles and practices of designing EM Automation functionality and addressing applications
3. To explore various motion controllers / Servo drives / VFDs, Electric Linear actuators and related applications assemblies to plastic parts.
4. To Sizing and selection of Motion controllers / Linear actuators for different applications
5. To Work on direct applications demo with the Motion controller and linear actuators

UNIT-I INTRODUCTION & ARCHITECTURE 6

Introduction to Motion and Control system & architecture- Applications - Gantry study

UNIT-II PROGRAMMING 6

Various motion controllers / PAC / PLC / Servo drives /Codesys programming – 1- Codesys Programming/ Ladder

UNIT-III LINEAR ACTUATOR 6

Introduction to Linear actuators (Belt / ball screw and Linear Motors) - Linear actuator programming lab

UNIT-IV 6

Motion sizing software / selection, Intro to Gear Heads, DD Motors and HMI - Various applications - Work shop

UNIT-V APPLICATIONS 6

Applications - Servo press and Gantry / Handling applications - Lab

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Use Motion controller & its application.
CO2: Use Servo drive functions and it applications.
CO3: Write codesys programming.
CO4: Develop applications.
CO5: Acquire working knowledge on practical applications.

FUNCTIONAL DESIGN OF ROBOT CELL AND END OF ARM TOOL	L	T	P	TCP
	0	0	1	1

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students:

1. To provide an overview of various applications of Robots, Types of End Effectors and Selection Criteria of Tools.
2. To explore the advanced techniques used in Design of End of Arm Tool.
3. To explain the principles and configurations of Multi – Tool EF, Vision and Part Feeding Systems.
4. To examine the methods of safety, Robot Routing Management and Collision.
5. To provide an overview of Robot Cell Design with Path optimization, 7th& 8th Axis Synchronization.

UNIT - I INTRODUCTION 6

Robots - Types of End Effectors – Parts of End Effectors - Selection Criteria of Tools - Application Study

UNIT - II DESIGN OF END OF ARM TOOL 6

TCP – Weight, Inertia – Force, Moments - Reaction Forces - Industrial Communication Protocols

UNIT - III END EFFECTOR CONFIGURATIONS AND APPLICATIONS 6

Multi-Tool EF – Vision – Force Torque Feedback – Automatic Tool Changer – Part Feeding Systems – Special Applications

UNIT - IV SAFETY, COLLISION, AND PRACTICAL CHALLENGES 6

Safety – Collision – Re-calibration – Compensation Techniques – Emergency – Robot Routing Management – Robot Jackets – Noise and Vibration Mitigation Techniques

UNIT - V DESIGN OF ROBOT WORK CELL AND SIMULATION 6

Process Cycle Time Chart – Simulation – Path Optimization – Cell Layout Design – 7 th& 8th Axis Synchronization

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Overview of Robots, Types of End Effectors and Selection Criteria of Tools.
CO2: Advanced techniques in Design of End of Arm Tool.
CO3: Implementation of Multi – Tool EF, Vision and Part Feeding Systems.
CO4: Enhance the Safety, Collision and Robot Routing Management.
CO5: Design, Execute and Path Optimization Methods.

LIST OF SKILL DEVELOPMENT COURSES

RA23S01	BASIC DESIGN	L	T	P	TCP
		0	0	2	1

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1.Understand the basics of CAD and NX
2. Perform sketching operation
3. Edit the sketches created
4. Load and work with the assemblies
5. Create simple drawings

UNIT - I INTRODUCTION **6**

Introduction to cad - Introduction NX - Opening and closing parts and activity - User interface and working with interface and activity

UNIT - II SKETCHING **6**

Sketching methods - Sketching constraints and activity –Sweeping geometry and activity - Creating datum geometry (planes) and activity

UNIT - III EDITING **6**

Creating and editing holes and activity - Blending and chamfering

UNIT - IV ASSEMBLIES **6**

Loading assemblies - Working with assembly’s

UNIT - V PROJECT **6**

Simple drawings –Project

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Understand the basics of cad.
CO2: Apply the concepts of constraints.
CO3: Recognize the concept of editing.
CO4: Expose to various assembling tools.
CO5: Design a component.

RA23S02	MOTION SIMULATION	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1. Understand the basics of motion simulation
2. Learn about constraints
3. Master various components of simulation
4. Explore contacts, bushings and load transfer
5. Analyse various components

UNIT-I INTRODUCTION **6**

Introduction to Motion Simulation – Workflow – Links – Joints

UNIT-II CONSTRAINTS **6**

Specialized constraints and couplers - Motion drivers - Working with results - Working with assemblies

UNIT-III COMPONENTS FOR SIMULATIONS **6**

Springs and dampers - Forces and torques - Markers, Smart Points, and sensors

UNIT-IV CONTACTS **6**

2D contact - 3D contact – Bushings - Load Transfer

UNIT-V ANALYSIS **6**

Flexible body analysis - PMDC electric motors

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Understand kinematics
CO2: Know motion drivers.
CO3: Expose to various components.
CO4: Appraise contacts
CO5: Design electric motors.

RA23S03	BASICS OF SOFTWARE	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1.Understand the basics of Robcad
2. Design work cell layout
3. Perform modelling and kinematics
4. Master basic simulation techniques
5. Learn CAD integration and translation

UNIT-I ROBCAD **6**

Introduction to Robcad - Activity& Practice

UNIT-II WORKCELL LAYOUR **6**

Work cell Layout - Activity & Practice

UNIT-III KINEMATICS **6**

Modeling and Kinematics - Processing - Activity & Practice

UNIT-IV SIMUATION **6**

Basic Simulation Techniques - Activity & Practice

UNIT-V CAD **6**

Data Menu CAD Translating, More on Robot Motion - Activity & Practice

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Understand the Software environment
CO2: Draw work cell layout
CO3: Do modeling and kinematics of robot
CO4: Understand the Process design and simulation
CO5: Know CAD integration and translation

RA23S04	BASICS OF PLC	L	T	P	TCP
		0	0	2	1

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1. Understand the Fundamentals of Automation
2. Learn Digital Fundamentals Using TIA Portal
3. Explore PLC Devices and Networks
4. Master Advanced PLC Programming Techniques
5. Understand Blocks and Integration in Automation

UNIT-I INTRODUCTION TO AUTOMATION SYSTEMS 6

Automation Overview, system over view

UNIT-II DIGITAL FUNDAMENTALS AND TIA PORTAL SOFTWARE 6

Digital Fundamentals - Engineering Software TIA Portal

UNIT-III PLC DEVICES AND NETWORKS 6

Devices & Networks - PLC Tags - Program Blocks and Program Editor

UNIT-IV ADVANCED PLC PROGRAMMING 6

Binary Operations – Digital Operations - Data Blocks - Functions and Function Blocks

UNIT-V BLOCKS AND INTEGRATION 6

Organization Blocks - Connecting an HMI Device - Troubleshooting

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Understand the fundamental concepts of automation
CO2: Design and analyze the digital fundamentals using TIA portal
CO3: Explore the devices and networks in real time applications
CO4: Analyze the arithmetic operations and functional blocks
CO5: Perform block organization and troubleshooting

RA23S05	BASICS OF LOW VOLTAGE SWITCH GEAR	L	T	P	TCP
		0	0	2	1

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1. Learn the basics of motors
2. Understand MCBs
3. Illustrate DOL and RDOL
4. Explain power delta starter
5. Apply soft starter for various applications

UNIT-I INTRODUCTION 6

Introduction to switch gear and Fuse, General purpose relay - Overload relay - Contactor, Types of contactor, maintenance

UNIT-II MCB 6

MCB Construction, Protection in MCB - RCCB and ELCB, Advantage of RCBO, Limitations of RCCB - MPCB, Super switch - MCCB, 3VL MCCB

UNIT-III DOL AND RDOL 6

Power and control wiring of DOL starter, DOL starter practice session - Power and control wiring RDOL starter, RDOL starter practice session

UNIT-IV DELTA STARTER 6

Power and control wiring of star delta starter - Practice session on Star delta starter

UNIT-V SOFT STARTERS 6

Soft starter basics, Sirius soft starter - Soft Starter Starting method of IM using 3RW44 - Parameterization of soft starter

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Understand the basics of low voltage switch gear
CO2: Analyze the advantages and disadvantages of different circuit breakers
CO3: Explore the power and control wiring concepts of DOL and RDOL starter
CO4: Carry out the power and control wiring of star delta starter
CO5: Apply the concepts of soft starter in real time applications

RA23S06	BASICS OF INDUCTION MOTORS	L	T	P	TCP
		0	0	2	1

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1. Learn the concepts related to motors
2. Understand the working of motors
3. Explain 3-phase squirrel cage induction motor
4. Characterize and maintain motors
5. Master Simocode

UNIT-I INTRODUCTION 6

Basic of Electrical Quantity - Basic of Induction Motor - What Is Motor? Different Types of Motor Parts of Induction Motor

UNIT-II WORKING OF MOTOR 6

Basic of Induction Motor: The Concept of Rotating Magnetic Field - The Effect of RMF On Closed Conductor

UNIT-III 3-PHASE SQUIRREL CAGE INDUCTION MOTOR 6

3-Phase Squirrel Cage Induction Motor - Energy Efficient Motor - Motor Control Starter - Product Spectrum

UNIT-IV CHARACTERIZATION, MAINTENANCE AND STANDARDS 6

Characteristics and Malfunction - Motor Maintenance - Standards and Name Plate

UNIT-V SIMOCODE 6

Simocode: Introduction System Components Functions - Simocode Hands On Practices On Different Applications

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Understand the fundamental concepts of induction motor
CO2: Analyze the effect of rotating magnetic field in a closed conductor
CO3: Determine the principle of operation of motor and starter
CO4: Examine the characteristics and malfunctioning effects of induction motor
CO5: Explore and carry out different applications with suitable simocode

RA23S07	BASIC COURSE ON AC - DC DRIVE	L	T	P	TCP
		0	0	2	1

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1. Learn the concepts of power electronics
2. Introduce siemens products
3. Explain types, construction and working of AC motors
4. Master SINAMIC G
5. Understand shutdown functions and energy saving concepts

UNIT-I CONCEPTS OF POWER ELECTRONICS 6

Power Electronic concepts (Diodes, Thyristors, IGBT, BJT) - Concept of Drive & Expectation from Drive Basic fundamentals of Drives

UNIT-II SIEMENS PRODUCTS PORTFOLIO 6

Siemens Product Portfolio, Starters Basic concept - Starters Wiring, Hands on practices - DC motors & Concept of DC Drive in details- Features of SINAMIC DCM DC Drive & Parameterization

UNIT-III AC MOTORS 6

Types of AC motors and construction & working principle - Concept of AC Drive in details - Selection of AC Drive and its applications

UNIT-IV SINAMIC G 6

Features of SINAMIC G-120 AC Drive & Parameterization - Working with STARTER Software- Inputs / Outputs, Motor potentiometer - Fixed speed set point, Speed lock Application, Skip Band Application

UNIT-V SHUTDOWN FUNCTIONS AND ENERGY SAVING 6

Basic Ramp Function generator, Shutdown functions - Energy Saving Concept in Motors

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Understand the basic concepts of power electronics
CO2: Analyze the concepts of starters, DC motors and DC drives
CO3: Apply the concepts of AC motors and AC drives in suitable application
CO4: Perform the desired application using starter software and motor potentiometer
CO5: Explore the concepts of shut down functions and energy saving in motors

RA23S08	BASIC OF PROCESS INSTRUMENTATION	L	T	P	TCP
		0	0	2	1

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1. Identify the terminologies related to process instrumentation
2. Perform temperature measurements
3. Explore level measurements
4. Master flow measurements
5. Understand control elements and protocols

UNIT-I INTRODUCTION 6

Introduction and Fundamentals of Instrumentation using Process Control - Pressure Measurement Transducers – Transducers – Techniques

UNIT-II TEMPERATURE MEASUREMENTS 6

DS III and SITRANS P300 – Parameterization – Temperature Measurement Transducers – Compensation - Product Portfolio – Applications

UNIT-III LEVEL MEASUREMENT 6

SITRANS TH300 with RTD – Parameterization - Level Measurement – Techniques – Product Portfolio – Applications

UNIT-IV FLOW MEASUREMENT 6

obe LU, LR 250, CLS 200 – Parameterization – Flow Measurement Techniques - Product portfolio - Applications

UNIT-V CONTROL ELEMENTS AND PROTOCOLS 6

Final control element - linear and rotary valves - Product portfolio and applications - sipart PS 2 – parameterization - communication protocols – parameterization

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Understand the basics of process instrumentation
CO2: Analyze and select the instruments for suitable application
CO3: Learn and calibrate measuring instruments
CO4: Apply measurement techniques in real time applications
CO5: Know the concepts of control element, valves and protocols

RA23S09	BASIC MECHATRONICS	L	T	P	TCP
		0	0	2	1

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1. Learn the basics of mechatronics
2. Explore mechatronics components
3. Understand various mechanical components
4. Understand service units
5. Illustrate testing and processing

UNIT-I INTRODUCTION 6

Mechatronics Introduction

UNIT-II MECHATRONICS COMPONENTS 6

Electrical Components - Switches, Solenoids, Potentiometer, Indicators, Reed Contacts, Photoelectric Sensors, Ultrasonic - Proximity Sensors, Capacitive Sensors

UNIT-III MECHANICAL COMPONENTS 6

Mechanical Components: - Principles, Application - Electro Pneumatic Components - Signal Processing via Relays and PLC - Electrically Actuated Directional Control Valves(DCVs) - Digital Fundamentals - Programmable Logic Controller

UNIT-IV SERVICE UNITS 6

Service Unit: - Introduction and technical Specifications - Operator Panel - Distribution station unit: - Introduction and technical Specifications

UNIT-V TESTING AND PROCESSING 6

Testing station unit: - Introduction and technical Specifications – Processing station unit: Introduction and technical Specifications – Buffer station: - Introduction and technical Specifications

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Understand the basics of Mechatronics
CO2: Know the fundamental concepts of Electrical components
CO3: Analyze the principle of operation of Mechanical components
CO4: Interpret the different units and its specification in real time application
CO5: Determine the operations of testing station, processing station and buffer station

RA23S10	TURNING -NUMERICAL CONTROL PROGRAMMING	L	T	P	TCP
		0	0	2	1

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1. Understand CNC Technology Fundamentals
2. Learn CNC Controller Basics
3. Develop CNC Part Programming Skills
4. Master Turning Cycles and Milling Integration
5. Perform and Optimize Milling Program Simulations

UNIT-I INTRODUCTION TO CNC **6**

Introduction to CNC

UNIT-II INTRODUCTION TO CNC CONTROLLER (808D) **6**

Introduction to CNC controller (808D)

UNIT-III INTRODUCTION TO CNC PART PROGRAMMING **6**

Introduction to CNC Part Programming

UNIT-IV STANDARD TURNING CYCLES FOR TURNING FUNCTIONS **6**

Standard Turning cycles for Turning functions

UNIT-V TURNING PROGRAM SIMULATION **6**

Turning Program Simulation

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Explain applications and advantages of CNC machines and technology.

CO2: Demonstrate and explain various CNC control Calculate technological data for CNC machining and part programming.

CO3: Understand the importance and use of PPE's.

CO4: Expose with CNC turning operation

CO5: Simulate the turning machine with program

RA23S11	INTRODUCTION TO PLM	L	T	P	TCP
		0	0	2	1

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1.Learn the basics of teamcentre
2. Create and manage datasets
3. Work with products and projects
4. Configure the products
5. Understand the workflow

UNIT - I INTRODUCTION TO TEAMCENTRE 6

Introduction to Teamcenter - Working in My Teamcenter - Working with items in Teamcenter

UNIT - II CREATION AND EDITING 6

Viewing and modifying object properties - Creating and managing datasets - Applying data security practices - Performing and managing searches

UNIT - III WORKING WITH PRODUCTS 6

Working in projects - Opening and viewing product structures - Controlling assembly configuration views - Creating and managing product structures - Working with product structures

UNIT - IV CONFIGURING PRODUCTS 6

Configuring a product structure with variants - Navigating the relation hierarchy of an object - Classifying and using standard data - Viewing and working with visualization files

UNIT - V WORKFLOW 6

Initiating a workflow - Managing workflow task assignments – Managing Teamcenter data through the Microsoft Office - Using Change Manager - Creating and managing change objects - Elaborating and executing the change - Working in the Teamcenter thin client - Course summary

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Get exposure with the concept of product lifecycle management
CO2: Create and manage product structures
CO3: Become familiar with rich client user interface
CO4: Initiate workflow model using team center
CO5: Navigate the relation hierarchy

RA23S12	ADVANCED MODELLING & KINEMATICS	L	T	P	TCP
		0	0	2	1

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1. Learn basics of modelling and kinematics
2. Perform advanced modelling
3. Master automatic kinematic creation
4. Explore kinematic functions
5. Illustrate attribute based component searching

UNIT-I OVERVIEW OF ADVANCED MODELING AND KINEMATICS 6

Advanced Modeling and Kinematics Overview - Activity & Practice

UNIT-II ADVANCED MODELING 6

Advanced Modeling – Activity & Practice

UNIT-III AUTOMATIC KINEMATIC CREATION 6

Automatic Kinematic Creation - Activity & Practice

UNIT-IV KINEMATIC FUNCTIONS 6

Kinematic Functions and More - Activity & Practice

UNIT-V ATTRIBUTE BASED COMPONENT SEARCHING 6

Attribute Based Component Searching - Activity & Practice

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Understand the principles of modelling and simulation
CO2: Know the advantages of advanced modelling
CO3: Expose Automatic Kinematic creation
CO4: Explain the kinematic functions of robot
CO5: Analyse the attribute based components in advanced modelling

RA23S13	CNC TURNING- OPERATION AND MACHINING	L	T	P	TCP
		0	0	2	1

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1. Understand turning centre
2. Illustrate different operating modes of CNC
3. Program CNC
4. Explain different types of CNC operation
5. Perform machining

UNIT-I INTRODUCTION TO TURNING CENTRE 6

Introduction to Turning Centre

UNIT-II INTRODUCTION TO CNC 6

Introduction to CNC Machine Controller (828D) - Introduction to Different Operating Modes

UNIT-III PROGRAMMING 6

Introduction to Tools and Inserts- Introduction to Basic Programming

UNIT-IV CNC OPERATIONS 6

Introduction to Different Types of Operation - Work Offset & Tool Offset

UNIT-V SAFETY AND MAINTENANCE 6

Hands on Practice (Machining) - Introduction to Safety & Maintenance

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Understand the basic procedures and concepts of programming, set up and operation of a CNC Machining Center.

CO2: Identify and understand the basic programming codes.

CO3: Create geometry and toolpaths from the specifications on a blueprint for simple parts using Mastercam programming software.

CO4: Identify and define the functions of the CNC machine control.

CO5: Set up the CNC machining centre for manufacturing simple parts

RA23S14	ADVANCED SIMULATION PROCESS	L	T	P	TCP
		0	0	2	1

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1. Understand advanced simulation process
2. Learn boundary conditions
3. Master various geometry operations
4. Create meshes
5. Analyse meshes

UNIT-I INTRODUCTION **6**

Introduction to Advanced Simulation - Working with Advanced Simulation - Selecting entities - Basic meshing techniques

UNIT-II BOUNDARY CONDITIONS **6**

Boundary conditions - Boundary condition techniques - Using fields in boundary Condition – Solving - Post-processing – Reports

UNIT-III GEOMETRY **6**

ealization - Geometry abstraction – Synchronous modelling - Geometry repair - Mesh collectors

UNIT-IV PROPERTIES **6**

Material and physical properties - Element size and mesh density - Beam modelling - Connecting meshes

UNIT-V MESHING **6**

3D swept meshing - Bolt modelling and pre-loads - Manual meshing - Mesh quality

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Understand concepts of simulation
CO2: Identify boundary conditions
CO3: Expose to geometry repair
CO4: Appraise upon connecting meshes
CO5: Interpret mesh quality

RA23S15	BASIC OF INDUSTRIAL ROBOTICS – KUKA ROBOTS	L	T	P	TCP
		0	0	2	1

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to:

1. Understand the Basics of Robotics and KUKA Robots
2. Learn the Basic Components of Robots
3. Master the Operation and Safety of Robots
4. Explore Robot Motion and Coordinate Systems
5. Develop Skills in Robot Jogging and Tool Management

UNIT-I INTRODUCTION TO ROBOTICS **6**

Introduction of Robots - Introduction of KUKA Robots

UNIT-II BASIC COMPONENTS OF ROBOT **6**

KUKA Robot Components -1 - KUKA Robot Components -2

UNIT-III OPERATION OF ROBOTS **6**

Robot Safety - Robot Cell Demo - Robot Installation Phases

UNIT-IV ROBOT MOTION - I **6**

Robot Coordinate Systems - KUKA Smart PAD - Robot Mastering - Robot Load

UNIT-V ROBOT MOTION - II **6**

Robot Jogging - Robot Tool & Base Calibration - KukaSimpro - KRL Programming

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of this course the students are expected to:

CO1: Understand about the concepts of machine learning
CO2: Understand the types of trees and bias
CO3: Apply the supervised learning methods with various case studies
CO4: Compare the learning methodologies and dimensionality concepts
CO5: Summarize the programming part of KUKA Robot

OPEN ELECTIVE COURSES

RA23901	BASICS OF FLUID POWER AUTOMATION	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To understand the basic principles of fluid power.
2. To Know the different properties of hydraulic fluids and their effects
3. To Explain the working principles of various pumps
4. To understand the working principle of hydraulic and pneumatic components and its selection.
5. To design hydraulic and pneumatic circuits for different applications.

UNIT – I BASICS OF FLUID POWER TECHNOLOGY 9

Introduction to Fluid Power Controls – Hydraulics and Pneumatics – Selection Criteria, Application of Fluid Power, Application of Pascal's Law, Transmission and Multiplication of Force – Pressure Losses – Fluids, Selection and Properties – Gas Laws- Properties of Air With Pressure and Temperature - ISO Symbols.

UNIT – II FLUID POWER SOURCES 9

Fluid Power Drives – Pumps – Working Principle and Construction Details of Gear, Vane and Piston Pumps, Hydraulic Motors, Hydrostatic Transmission Drives and Characteristics, Hydraulic Supply Components Pneumatic Power Supply – Compressors, Air Distribution, Air Motors.

UNIT – III FLUID POWER ACTUATORS AND ELEMENTS 9

Control Valves – Pressure, Flow, and Direction - Working Principle and Construction – Special Type - Valves – Cartridge, Modular, Proportional, and Servo Selection And Actuation Methods. Actuators – Selection and Specification, Cylinders, Mounting, Cushioning, Pipe Fittings – Fluid Conditioning Elements – Accumulators- Intensifier.

UNIT – IV HYDRAULIC AND PNEUMATIC CIRCUITS DESIGN 9

Regenerative, Speed Control, Synchronizing Circuits - Design of Hydraulic and Pneumatic Circuits for Automation, Selection and Specification of Circuit Components, Sequencing Circuits, Cascade, And Karnaugh – Veitch Map Method – Circuits for Industrial Application - Case Studies - Grinding, Milling, Shaping, Press and Material Handling

UNIT – V ELECTRO PNEUMATICS AND PLC CIRCUITS 9

Fluidics - Moving Part Logic Circuits - Use of Electrical Timers, Switches, Solenoid, Relays, Proximity Sensors - Electro Pneumatics Sequencing Ladder Diagram – PLC – Elements, Functions and Selection – PLC Programming– Ladder and Different Programming Methods - Sequencing Circuits.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1: Identify the symbols, laws and elements of fluid power devices.
CO2: Describe the working of pump, actuators, control elements of fluid power system
CO3: Design the basic and advaced hydraulic and pneumatics circuits.

CO4: Develop the basic, electro pneumatics and hydraulic, PLC integrated circuits for various application including material handling, press, shaping, milling, grinding.
CO5: Appraise the design and working of fluid power circuits.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	2	2	2	-	-	-	-	-	-	-	2	1	1
CO2	2	1	3	1	3	-	-	-	-	-	-	-	2	2	1
CO3	3	3	3	3	2	-	-	-	-	-	-	-	1	2	1
CO4	3	1	3	1	3	-	-	-	-	-	-	-	2	2	2
CO5	2	2	2	3	2	-	-	-	-	-	-	-	1	1	3
CO/PO & PSO Average	**2.6**	**1.8**	**2.6**	**2**	**2.4**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1.6**	**1.6**	**1.6**
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS

1. Anthony Esposito, “Fluid power with applications”, Pearson education, 7th edition, 2014.
2. Srinivasan R, “Hydraulics and Pneumatic Controls”, Vijay Nicole Imprints, 2nd edition, 2008.

REFERENCES:

1. Andrew Parr, “Hydraulics and Pneumatics”, Jaico Publishing House, 3rd edition, 2013.
2. Jagadeesha T, "Pneumatics: Concepts, Design and Applications", University Press, 2015.
3. Majumdar, “Oil hydraulics: Principles and Maintenance”, Tata McGraw Hill, 13th edition, 2006.
4. Majumdar, “Pneumatic system: Principles and Maintenance”, Tata McGraw Hill, 7th edition 2008.
5. Peter Rohner, “Fluid Power Logic circuit Design”, Macmillan Press Ltd., 2000.

RA23902	ROBOTICS	L	T	P	TCP
		3	0	0	3

COURSE OBJECTIVES:

1. To study the kinematics, drive systems and programming of robots.
2. To study the basics of robot laws and transmission systems.
3. To familiarize students with the concepts and techniques of robot manipulator, its kinematics.
4. To familiarize students with the various Programming and Machine Vison application in robots.
5. To build confidence among students to evaluate, choose and incorporate robots in engineering systems.

UNIT – I FUNDAMENTALS OF ROBOT 9

Robot – Definition – Robot Anatomy – Co-ordinate systems, Work Envelope, types and classification – specifications – Pitch, yaw, Roll, Joint Notations, Speed of Motion, Pay Load – Robot Parts and their functions – Need for Robots – Different Applications.

UNIT – II ROBOT KINEMATICS 9

Forward kinematics, inverse kinematics and the difference: forward kinematics and inverse Kinematics of Manipulators with two, three degrees of freedom (in 2 dimensional), four degrees of freedom (in 3 dimensional) – derivations and problems. Homogeneous transformation matrices, translation and rotation matrices Dennavit and Hartenberg transformation.

UNIT – III ROBOT DRIVE SYSTEMS AND END EFFECTORS 9

Pneumatic Drives – Hydraulic Drives – Mechanical Drives – Electrical Drives – D.C. Servo Motors, Stepper Motor, A.C. Servo Motors – Salient Features, Applications and Comparison of All These Drives. End Effectors – Grippers – Mechanical Grippers, Pneumatic and Hydraulic Grippers, Magnetic grippers, vacuum grippers, two fingered and three fingered grippers, internal grippers and external grippers, selection and design considerations of a gripper - gripper force calculation and analysis.

UNIT – IV SENSORS IN ROBOTICS 9

Force sensors, touch and tactile sensors, proximity sensors, non-contact sensors, safety considerations in robotic cell, proximity sensors, fail safe hazard sensor systems, and compliance mechanism. Machine vision system - camera, frame grabber, sensing and digitizing image data – signal conversion, image storage, lighting techniques, image processing and analysis – data reduction, segmentation, feature extraction, object recognition, other algorithms, applications – Inspection, identification, visual serving and navigation.

UNIT – V PROGRAMMING AND APPLICATIONS OF ROBOT 9

Teach pendant programming, lead through programming, robot programming languages -Role of robots in inspection, assembly, material handling, underwater, space and medical fields.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Interpret the features of robots and technology involved in the control.

CO2: Apply the basic engineering knowledge and laws for the design of robotics.

CO3: Explain the basic concepts like various configurations, classification and parts of end effectors compare various end effectors and grippers and tools and sensors used in robots.
CO4: Explain the concept of kinematics, degeneracy, dexterity and trajectory planning.
CO5: Demonstrate the image processing and image analysis techniques by machine vision system.

Mapping of COs with POs and PSOs															
COs/POs & PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															
CO/PO & PSO Average															
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOKS:

1. Ganesh.S.Hedge,"A textbook of Industrial Robotics", Lakshmi Publications, 2006. McGraw Hill 2th edition 2012.
2. Mikell.P.Groover , "Industrial Robotics – Technology, Programming and applications"

REFERENCES:

1. Fu K.S. Gonalz R.C. and ice C.S.G."Robotics Control, Sensing, Vision andIntelligence", McGraw Hill book co. 2007.
2. YoramKoren, "Robotics for Engineers", McGraw Hill Book, Co., 2002.
3. Janakiraman P.A., "Robotics and Image Processing", Tata McGraw Hill 2005.
4. John. J.Craig, "Introduction to Robotics: Mechanics and Control" 2nd Edition, 2002.
5. Jazar, "Theory of Applied Robotics: Kinematics, Dynamics and Control", Springer India reprint, 2010.

UC23E01 ENGINEERING ENTREPRENEURSHIP DEVELOPMENT L T P C

2 0 2 3

COURSE OBJECTIVES:

1. Learn basic concepts in entrepreneurship, develop mind-set and skills necessary to explore entrepreneurship
2. Apply process of problem - opportunity identification and validation through human centred approach to design thinking in building solutions as part of engineering projects
3. Analyse market types, conduct market estimation, identify customers, create customer persona, develop the skills to create a compelling value proposition and build a Minimum Viable Product
4. Explore business models, create business plan, conduct financial analysis and feasibility analysis to assess the financial viability of a venture ideas & solutions built with domain expertise
5. Prepare and present an investible pitch deck of their practice venture to attract stakeholders

MODULE – I: ENTREPRENEURIAL MINDSET **4L,8P**

Introduction to Entrepreneurship: Definition – Types of Entrepreneurs – Emerging Economies – Developing and Understanding an Entrepreneurial Mindset – Importance of Technology Entrepreneurship – Benefits to the Society.

Case Analysis: Study cases of successful & failed engineering entrepreneurs - Foster Creative Thinking: Engage in a series of Problem-Identification and Problem-Solving tasks

MODULE – II: OPPORTUNITIES **4L,8P**

Problems and Opportunities – Ideas and Opportunities – Identifying problems in society – Creation of opportunities – Exploring Market Types – Estimating the Market Size, - Knowing the Customer and Consumer - Customer Segmentation - Identifying niche markets – Customer discovery and validation; Market research techniques, tools for validation of ideas and opportunities

Activity Session: Identify emerging sectors / potential opportunities in existing markets - Customer Interviews: Conduct preliminary interviews with potential customers for Opportunity Validation - Analyse feedback to refine the opportunity.

MODULE – III: PROTOTYPING & ITERATION **4L,8P**

Prototyping – Importance in entrepreneurial process – Types of Prototypes - Different methods – Tools & Techniques.

Hands-on sessions on prototyping tools (3D printing, electronics, software), Develop a prototype based on identified opportunities; Receive feedback and iterate on the prototypes.

MODULE – IV: BUSINESS MODELS & PITCHING **4L,8P**

Business Model and Types - Lean Approach - 9 block Lean Canvas Model - Riskiest Assumptions in Business Model Design – Using Business Model Canvas as a Tool – Pitching Techniques:

Importance of pitching - Types of pitches - crafting a compelling pitch – pitch presentation skills - using storytelling to gain investor/customer attention.

Activity Session: Develop a business model canvas for the prototype; present and receive feedback from peers and mentors - Prepare and practice pitching the business ideas- Participate in a Pitching Competition and present to a panel of judges - receive & reflect feedback

MODULE – V: ENTREPRENEURIAL ECOSYSTEM **4L,8P**

Understanding the Entrepreneurial Ecosystem – Components: Angels, Venture Capitalists, Maker Spaces, Incubators, Accelerators, Investors. Financing models – equity, debt, crowdfunding, etc, Support from the government and corporates. Navigating Ecosystem Support: Searching & Identifying the Right Ecosystem Partner – Leveraging the Ecosystem - Building the right stakeholder network

Activity Session: Arrangement of Guest Speaker Sessions by successful entrepreneurs and entrepreneurial ecosystem leaders (incubation managers; angels; etc), Visit one or two entrepreneurial ecosystem players (Travel and visit a research park or incubator or makerspace or interact with startup founders).

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:

CO1: Develop an Entrepreneurial Mind-set and Understand the Entrepreneurial Ecosystem Components and Funding types

CO2: Comprehend the process of opportunity identification through design thinking, identify market potential and customers

CO3: Generate and develop creative ideas through ideation techniques

CO4: Create prototypes to materialize design concepts and conduct testing to gather feedback and refine prototypes to build a validated MVP

CO5: Analyse and refine business models to ensure sustainability and profitability Prepare and deliver an investible pitch deck of their practice venture to attract stakeholders

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4. Ries, E. (2011). The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Crown Business
5. Blank, S. G., & Dorf, B. (2012). The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company. K&S Ranch

6. Osterwalder, A., & Pigneur, Y. (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. John Wiley & Sons

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