KPR Institute of Engineering and Technology

Learn Beyond (Autonomous, NAAC "A")

Avinashi Road, Arasur, Coimbatore.

Great Place To Work. Certified MAR 2022 - MAR 2023 INDIA

B.E. – Mechatronics Engineering

Curriculum and Syllabi

Regulations – 2021 (Revised)

I. Vision & Mission of the Institute

Vision

To become a premier institute of academic excellence by imparting technical, intellectual and professional skills to students for meeting the diverse needs of industry, society, the nation and the world at large

Mission

- Commitment to offer value–based education and enhancement of practical skills
- Continuous assessment of teaching and learning processes through scholarly activities
- Enriching research and innovation activities in collaboration with industry and institutes of repute
- Ensuring the academic processes to uphold culture, ethics and social responsibilities

II. Vision & Mission of the Department

Vision

To be a transdisciplinary department for the development of academic excellence and research in the field of Mechatronics, catering to the needs of the Industry and the Society

Mission

- Preparing graduates to suit the requirements of the Industry by offering quality education
- Providing an education ecosystem to foster R&D, innovation, creativity, and entrepreneurship
- Inculcating professionalism, ethics, human values and lifelong learning practices

III. Program Educational Objectives (PEOs)

PEO 1: The graduates of Mechatronics Engineering will possess adequate knowledge and skills to succeed in their professional career

PEO 2: The graduates of Mechatronics Engineering will Analyze, design, and develop a transdisciplinary engineering–based products and processes for real world applications

PEO 3: The graduates of Mechatronics Engineering will practice their profession with good ethics and human values

IV. Program Outcomes (POs)

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems

PO 2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

PO 3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

PO 4: Conduct investigations of complex problems: Use research–based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitation

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PO 6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice

PO 7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

PO 9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

PO 12: Life–long learning: Recognize the need for, and have the preparation and ability to engage in independent and life–long learning in the broadest context of technological change

V. Program Specific Outcomes (PSOs)

PSO 1: Graduates will be able to apply their gained knowledge and skills to design, develop and implement mechatronics systems in the field of engineering and sciences

PSO 2: Graduates will be able to apply innovative ideas and multidisciplinary approaches to solve real world problems

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Coimbatore

B.E. MECHATRONICS ENGINEERING

REGULATIONS – 2021 (Revised)

(for the students admitted 2022 onwards)

CHOICE BASED CREDIT SYSTEM

CURRICULUM FOR I – VIII SEMESTERS

SEMESTER I

SI. NO.	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
	THEORY COURSES							
1	U21GEG01	Heritage of Tamils	HSMC	1	0	0	0	1
2	U21MA101	Calculus and Differential Equations	BSC	3	1	0	0	4
	THEORY COURSES WITH LABORATORY COMPONENT							
3	U21EN101	English for Technologists	HSMC	1	0	2	0	2
4	U21PH101	Engineering Physics	BSC	2	0	2	0	3
5	U21CY101	Engineering Chemistry	BSC	2	0	2	0	3
6	U21CSG01	Problem Solving and C Programming	ESC	2	0	2	0	3
	LABORATORY COURSES							
7	U21MEG01	Engineering Graphics	ESC	0	0	4	0	2
	MANDATORY NON–CREDIT COURSES							
8	U21MYC01	Induction program	MNC	Three Weeks				
			TOTAL	**11**	**1**	**12**	**0**	**18**

SEMESTER II

SI. NO.	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
	THEORY COURSES							
1	U21GEG02	Tamils and Technology	HSMC	1	0	0	0	1
2	U21MA201	Laplace Transforms and Complex Variables	BSC	3	1	0	0	4
3	U21PH201	Materials Science	ESC	2	0	0	0	2
4	U21ME201	Engineering Mechanics	PCC	3	0	0	0	3
5	U21EC101	Introduction to Electrical and Electronics Engineering	PCC	2	0	0	0	2
	THEORY COURSES WITH LABORATORY COMPONENT							
6	U21EN201	Personality Enhancement	HSMC	1	0	2	0	2
7	U21CSG02	Python Programming	ESC	2	0	2	0	3
	LABORATORY COURSES							
8	U21ECG03	Engineering Studio	ESC	0	0	4	0	2
9	U21MI201	Manufacturing and Automation Practices	ESC	0	0	4	0	2
	MANDATORY NON–CREDIT COURSES							
10	U21MYC02	Environmental Sciences	MNC	1	0	0	0	0
			TOTAL	**15**	**1**	**12**	**0**	**21**

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SEMESTER III

SI. NO.	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
	THEORY COURSES							
1	U21MA303	Fourier Analysis and Boundary Value Problems	BSC	3	1	0	0	4
2	U21MI301	Kinematics of Machinery	ESC	3	1	0	0	4
3	U21MI302	Sensors and Signal Processing	PCC	3	0	0	0	3
4	U21MI303	Manufacturing Processes	PCC	3	0	0	0	3
5	U21MI304	Electrical Drives and Control	PCC	3	0	0	0	3
	THEORY COURSE WITH LABORATORY COMPONENT							
6	U21MI305	Electronic Devices and Digital Circuits	PCC	2	0	2	0	3
	LABORATORY COURSES							
7	U21MI306	Sensors and Signal Processing Laboratory	PCC	0	0	4	0	2
8	U21MI307	Electrical Drives and Control Laboratory	PCC	0	0	4	0	2
9	U21MI308	Design Studio I	EEC	0	0	0	2	1
	MANDATORY NON–CREDIT COURSES							
10	U21MYC03	Essence of Indian Traditional Knowledge	MNC	1	0	0	0	0
			TOTAL	18	2	10	2	25

SEMESTER IV

SI. NO.	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
	THEORY COURSES							
1	U21MA404	Statistics and Numerical Methods	BSC	3	0	0	0	3
2	U21MI401	Dynamics of Machinery	PCC	3	1	0	0	4
3	U21MI402	Control Systems Engineering	PCC	3	0	0	0	3
4	U21MI403	Programmable Automation Controllers	PCC	3	0	0	0	3
5	U21MI404	Microcontroller and Embedded Systems	PCC	3	0	0	0	3
6		Open Elective – I	OEC	3	0	0	0	3
	LABORATORY COURSES							
7	U21SSG01	Soft Skills – I	HSMC	0	0	2	0	1
8	U21MI405	Programmable Automation Controllers Laboratory	PCC	0	0	4	0	2
9	U21MI406	Microcontroller and Embedded Systems Laboratory	PCC	0	0	4	0	2
10	U21MI407	Design Studio II	EEC	0	0	0	2	1
	MANDATORY NON–CREDIT COURSES							
11	U21MYC04	Indian Constitution	MNC	1	0	0	0	0
			TOTAL	19	1	10	2	25

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SEMESTER V

SI. NO.	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
	THEORY COURSES							
1	U21MI501	Robotics and Automation	PCC	3	0	0	0	3
2		Professional Elective – I	PEC	3	0	0	0	3
3		Professional Elective – II	PEC	3	0	0	0	3
4		Open Elective – II	OEC	3	0	0	0	3
	THEORY COURSES WITH LABORATORY COMPONENT							
5	U21MI502	Hydraulics and Pneumatics Systems	PCC	2	0	2	0	3
6	U21MI503	Unmanned Aerial Vehicle Technology	PCC	2	0	2	0	3
	LABORATORY COURSES							
7	U21SSG02	Soft Skills – II	HSMC	0	0	2	0	1
8	U21MI504	Robotics and Automation Laboratory	PCC	0	0	4	0	2
9	U21MI505	CNC and Metrology Laboratory	PCC	0	0	4	0	2
10	U21MI506	Proto Studio I	EEC	0	0	0	2	1
	MANDATORY NON–CREDIT COURSES							
11	U21MYC05	Cyber Security Essentials	MNC	1	0	0	0	0
			TOTAL	17	0	14	2	24

SEMESTER VI

SI. NO.	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
	THEORY COURSES							
1	U21MI601	Mechatronics System Design	PCC	3	1	0	0	4
2		Professional Elective – III	PEC	3	0	0	0	3
3		Professional Elective – IV	PEC	3	0	0	0	3
4		Open Elective – III	OEC	3	0	0	0	3
	THEORY COURSES WITH LABORATORAY COMPONENT							
5	U21MI602	Electric and Hybrid Vehicle Technologies in Automobiles	PCC	2	0	4	0	4
6	U21MI603	Smart Home and Building Automation	PCC	2	0	4	0	4
	LABORATORY COURSES							
7	U21SSG03	Soft Skills – III	HSMC	0	0	2	0	1
8	U21MI604	Modelling and Analysis of Mechatronics System Laboratory	PCC	0	0	4	0	2
9	U21MI605	Proto Studio II	EEC	0	0	0	2	1
	MANDATORY NON–CREDIT COURSES							
10	U21MYC06	Introduction to UNSDGs: An Integrative Approach	MNC	1	0	0	0	0
			TOTAL	17	1	14	2	25

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SEMESTER VII

Sl. NO.	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
	THEORY COURSES							
1	U21MI701	Entrepreneurship Management	PCC	3	0	0	0	3
2	U21MI702	Machine Vision and Image Processing	PCC	3	0	0	0	3
3		Professional Elective – V	PEC	3	0	0	0	3
4		Professional Elective – VI	PEC	3	0	0	0	3
5		Open Elective – IV	OEC	3	0	0	0	3
	LABORATORY COURSES / LABORATORY COURSE WITH PROJECT COMPONENT							
6	U21MI703	Project work Phase – I	EEC	0	0	0	4	2
TOTAL				15	0	0	4	17

SEMESTER VIII

Sl. NO.	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
1	U21MI801	Project work Phase – II	EEC	0	0	0	16	8
			TOTAL	0	0	0	16	8

INDUSTRIAL TRAINING / INTERNSHIP

Sl. NO.	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
1	U21MII01	Industrial Training / Internship *	EEC	0	0	0	0	2
			TOTAL	0	0	0	0	2

***Four Weeks during any semester vacation from III to VI Semester**

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NCC CREDIT COURSES:

SI. NO.	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
1	U21NCC01	National Cadet Corps I	–	1	0	2	0	2
2	U21NCC02	National Cadet Corps II	–	1	0	2	0	2
3	U21NCC03	National Cadet Corps III	–	1	0	2	0	2
4	U21NCC04	National Cadet Corps IV	–	2	0	2	0	3
5	U21NCC05	National Cadet Corps V	–	1	0	2	0	2
6	U21NCC06	National Cadet Corps VI	–	2	0	2	0	3
			TOTAL	8	–	12	–	14

NCC Credit Course (Level 1 – Level 6) are offered for NCC students only. The grades earned by the students will be recorded in the mark sheet, however the same shall not be considered for the computation of CGPA.

TOTAL CREDITS: 165

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PROFESSIONAL ELECTIVES COURSES: VERTICALS

Vertical I ROBOTICS	Vertical II DESIGN AND MANUFACTURING	Vertical III AUTOMOTIVE ENGINEERING AND TECHNOLOGY	Vertical IV INTELLIGENT SYSTEMS	Vertical V INDUSTRIAL AUTOMATION	Vertical VI AVIONICS AND DRONE TECHNOLOGY
Robots and Systems in Smart Manufacturing	Robot and Machine Elements Design	Fundamentals of Automotive Engineering and Technology	Applied Signal Processing	Factory Automation	Avionics
Robot Operating Systems	Design for X	Automotive Electrical, Electronics and Control Systems	Applied Image Processing	Process Control and Automation	Fluid Mechanics and Dynamics
Agricultural Robotics	CNC Machine Tools and Programming	Automotive Thermal Management Systems	Computer Vision and Deep Learning	Virtual Instrumentation	Guidance and Control of Avionics
Micro–Robotics	Computer Integrated Systems	Vehicle Body Dynamics	Immersive Technologies and Haptics	Introduction to Industrial Internet of Things	Computational Fluid Dynamics for Drones
Collaborative Robotics	Advanced Manufacturing Systems	Autonomous Vehicle Systems	System Modelling and Simulation	Motion Control System	Aerodynamics of Drones
Underwater Robotics	Mechatronic Systems in Additive Manufacturing	Design Principles of Hybrid and Electric Vehicles	Machine Learning for Intelligent Systems	Digital Twin and Industry 5.0	Design of UAV
Medical Robotics	Electronics Manufacturing Technology	Energy Storage and Management for Electric Vehicles	Condition Monitoring and Fault Diagnostics	Cyber Physical Systems	Navigation and Communication Systems
Humanoid Robotics	Computer Aided Inspection and Testing	Automotive Fault Diagnostics	Optimization Techniques	Industrial Automation Protocols	Aircraft Mechatronics

Registration of Professional Elective Courses from Verticals:

Professional Elective Courses will be registered in Semesters V to VII. These courses are listed in groups called verticals that represent a particular area of specialization / diversified group. Students are permitted to choose all the Professional Electives from a particular vertical or from different verticals.

The registration of courses for B.E./B.Tech (Honors) or Minor degree shall be done from Semester V to VII.

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PROFESSIONAL ELECTIVE COURSES: VERTICALS

VERTICAL I: ROBOTICS

Sl.No	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
1	U21MIP01	Robots and Systems in Smart Manufacturing	PEC	3	0	0	0	3
2	U21MIP02	Robot Operating Systems	PEC	3	0	0	0	3
3	U21MIP03	Agricultural Robotics	PEC	3	0	0	0	3
4	U21MIP04	Micro–Robotics	PEC	3	0	0	0	3
5	U21MIP05	Collaborative Robotics	PEC	3	0	0	0	3
6	U21MIP06	Underwater Robotics	PEC	3	0	0	0	3
7	U21MIP07	Medical Robotics	PEC	3	0	0	0	3
8	U21MIP08	Humanoid Robotics	PEC	3	0	0	0	3

VERTICAL II: DESIGN AND MANUFACTURING

Sl.No	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
1	U21MIP09	Robot and Machine Elements Design	PEC	3	0	0	0	3
2	U21MIP10	Design for X	PEC	3	0	0	0	3
3	U21MIP11	CNC Machine Tools and Programming	PEC	3	0	0	0	3
4	U21MIP12	Computer Integrated Systems	PEC	3	0	0	0	3
5	U21MIP13	Advanced Manufacturing Systems	PEC	3	0	0	0	3
6	U21MIP14	Mechatronic Systems in Additive Manufacturing	PEC	3	0	0	0	3
7	U21MIP15	Electronics Manufacturing Technology	PEC	3	0	0	0	3
8	U21MIP16	Computer Aided Inspection and Testing	PEC	3	0	0	0	3

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VERTICAL III: AUTOMOTIVE ENGINEERING AND TECHNOLOGY

Sl.No	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
1	U21MIP17	Fundamentals of Automotive Engineering and Technology	PEC	3	0	0	0	3
2	U21MIP18	Automotive Electrical, Electronics and Control Systems	PEC	3	0	0	0	3
3	U21MIP19	Automotive Thermal Management Systems	PEC	3	0	0	0	3
4	U21MIP20	Vehicle Body Dynamics	PEC	3	0	0	0	3
5	U21MIP21	Autonomous Vehicle Systems	PEC	3	0	0	0	3
6	U21MIP22	Design Principles of Hybrid and Electric Vehicles	PEC	3	0	0	0	3
7	U21MIP23	Energy Storage and Management for Electric Vehicles	PEC	3	0	0	0	3
8	U21MIP24	Automotive Fault Diagnostics	PEC	3	0	0	0	3

VERTICAL IV: INTELLIGENT SYSTEMS

Sl.No	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
1	U21MIP25	Applied Signal Processing	PEC	3	0	0	0	3
2	U21MIP26	Applied Image Processing	PEC	3	0	0	0	3
3	U21MIP27	Computer Vision and Deep Learning	PEC	3	0	0	0	3
4	U21MIP28	Immersive Technologies and Haptics	PEC	3	0	0	0	3
5	U21MIP29	System Modelling and Simulation	PEC	3	0	0	0	3
6	U21MIP30	Machine Learning for Intelligent Systems	PEC	3	0	0	0	3
7	U21MIP31	Condition Monitoring and Fault Diagnostics	PEC	3	0	0	0	3
8	U21MIP32	Optimization Techniques	PEC	3	0	0	0	3

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VERTICAL V: INDUSTRIAL AUTOMATION

Sl.No	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
1	U21MIP33	Factory Automation	PEC	3	0	0	0	3
2	U21MIP34	Process Control and Automation	PEC	3	0	0	0	3
3	U21MIP35	Virtual Instrumentation	PEC	3	0	0	0	3
4	U21MIP36	Introduction to Industrial Internet of Things	PEC	3	0	0	0	3
5	U21MIP37	Motion Control System	PEC	3	0	0	0	3
6	U21MIP38	Digital Twin and Industry 5.0	PEC	3	0	0	0	3
7	U21MIP39	Cyber Physical Systems	PEC	3	0	0	0	3
8	U21MIP40	Industrial Automation Protocols	PEC	3	0	0	0	3

VERTICAL VI: AVIONICS AND DRONE TECHNOLOGY

Sl.No	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
1	U21MIP41	Avionics	PEC	3	0	0	0	3
2	U21MIP42	Fluid Mechanics and Dynamics	PEC	3	0	0	0	3
3	U21MIP43	Guidance and Control of Avionics	PEC	3	0	0	0	3
4	U21MIP44	Computational Fluid Dynamics for Drones	PEC	3	0	0	0	3
5	U21MIP45	Aerodynamics of Drones	PEC	3	0	0	0	3
6	U21MIP46	Design of UAV	PEC	3	0	0	0	3
7	U21MIP47	Navigation and Communication Systems	PEC	3	0	0	0	3
8	U21MIP48	Aircraft Mechatronics	PEC	3	0	0	0	3

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OPEN ELECTIVES

(Students shall choose the open elective courses, such that the course contents are notsimilar to any other course contents/title under other course categories).

OPEN ELECTIVES – I (SEMESTER: IV)

Sl.No	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
1	U21MIX01	Design of Mechatronic Systems	OEC	3	0	0	0	3
2	U21MIX02	Modern Robotics	OEC	3	0	0	0	3

OPEN ELECTIVES – II (SEMESTER: V)

Sl.No	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
1	U21MIX03	MEMS & NEMS	OEC	3	0	0	0	3
2	U21MIX04	Robotics Process Automation	OEC	3	0	0	0	3

OPEN ELECTIVES – III (SEMESTER: VI)

Sl.No	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
1	U21MIX05	Product Design and Development	OEC	3	0	0	0	3
2	U21MIX06	Introduction to Industrial Internet of Things	OEC	3	0	0	0	3
3	U21MIX07	Graphical System Design using LabVIEW	OEC	3	0	0	0	3

OPEN ELECTIVES – IV (SEMESTER: VII)

Sl.No	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	J	C
1	U21MIX08	Cyber Physical Systems	OEC	3	0	0	0	3
2	U21MIX09	Introduction to Industry 4.0	OEC	3	0	0	0	3

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Scheme of Credit distribution – Summary

Sl.No.	Stream	Credits/Semester								Credits
		I	II	III	IV	V	VI	VII	VIII	Total
1.	Humanities and Social Sciences including Management (HSMC)	3	3	–	1	1	1	–	–	9
2.	Basic Science Courses (BSC)	10	4	4	3	–	–	–	–	21
3.	Engineering Science Courses (ESC)	5	9	4	–	–	–	–	–	18
4.	Professional Core Courses (PCC)	–	5	16	17	13	14	6	–	71
5.	Professional Elective Courses (PEC)	–	–	–	–	6	6	6	–	18
6.	Open Elective Courses (OEC)	–	–	–	3	3	3	3	–	12
7.	Employability Enhancement Courses (EEC)	–	–	1	1	1	1	2	8	14
8.	Industrial Training/ Internship	–	–	–	–	–	–	–	2	02
9.	Mandatory Non–CreditCourse (MNC)	–	–	–	–	–	–	–	–	–
Total		**18**	**21**	**25**	**25**	**24**	**25**	**17**	**10**	**165**

8.4.2024
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Mapping of Course Outcomes with Program Outcomes

SEM	Subject	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
SEM I	Heritage of Tamils	-	-	-	-	-	-	✓	✓	-	✓	-	✓	-	-
	Calculus and Differential Equations	✓	✓	-	-	-	-	-	-	-	-	-	✓	✓	✓
	English for Technologists	-	-	-	-	-	-	-	✓	✓	✓	-	✓	✓	-
	Engineering Physics	✓	✓	✓	-	-	-	-	-	-	-	-	-	✓	✓
	Engineering Chemistry	✓	✓	-	-	-	-	✓	-	✓	-	-	✓	✓	✓
	Problem Solving and C Programming	✓	✓	✓	✓	-	✓	-	✓	✓	✓	-	✓	✓	✓
	Engineering Graphics	✓	✓	✓	-	✓	-	-	✓	-	✓	-	✓	✓	✓
SEM II	Tamils and Technology	-	-	-	-	-	-	✓	✓	-	✓	-	✓	✓	-
	Laplace Transforms and Complex Variables	✓	✓	-	-	-	-	-	-	-	-	-	✓	✓	✓
	Materials Science	✓	✓	-	-	-	✓	-	-	-	-	-	✓	✓	✓
	Engineering Mechanics	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	✓	✓
	Introduction to Electrical and Electronics Engineering	✓	✓	✓	-	-	-	-	-	-	-	-	-	✓	✓
	Personality Enhancement	-	-	-	-	-	-	-	✓	✓	✓	-	✓	✓	-
	Python Programming	✓	✓	✓	✓	✓	-	-	✓	✓	✓	-	✓	✓	✓
	Engineering Studio	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-	✓	✓	✓
	Manufacturing and Automation Practices	✓	✓	✓	-	✓	-	✓	-	✓	✓	-	✓	✓	✓
SEM III	Fourier Analysis and Boundary Value Problems	✓	✓	-	-	-	-	-	-	-	-	-	✓	✓	✓
	Kinematics of Machinery	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	✓	✓
	Sensors and Signal Processing	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	✓	✓
	Manufacturing Processes	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	Electrical Drives and Control	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	✓	✓

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SEM	Subject	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	Electronic Devices and Digital Circuits	✓	✓	✓	-	✓	-	-	-	✓	-	-	✓	✓	✓
	Sensors and Signal Processing Laboratory	✓	✓	✓	✓	-	-	-	-	✓	-	-	✓	✓	✓
	Electrical Drives and Control Laboratory	✓	✓	✓	✓	✓	-	-	-	✓	-	-	✓	✓	✓
	Design Studio I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SEM IV	Statistics and Numerical Methods	✓	✓	-	-	-	-	-	-	-	-	-	✓	✓	✓
	Dynamics of Machinery	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	✓	✓
	Control Systems Engineering	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	Programmable Automation Controllers	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	Microcontroller and Embedded Systems	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	Soft Skills - I	-	-	-	-	-	-	-	-	✓	✓	-	✓	-	-
	Programmable Automation Controllers Laboratory	✓	✓	✓	✓	✓	-	-	-	✓	✓	-	✓	✓	✓
	Microcontroller and Embedded Systems Laboratory	✓	✓	✓	✓	✓	-	-	-	✓	-	-	✓	✓	✓
	Design Studio II	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-
SEM V	Robotics and Automation	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	Hydraulics and Pneumatics Systems	✓	✓	✓	✓	✓	✓	✓	-	-	-	✓	✓	✓	✓
	Unmanned Aerial Vehicle Technology	✓	✓	✓	-	-	-	-	✓	✓	✓	-	✓	✓	✓
	Soft Skills - II	-	-	-	-	-	-	-	-	✓	✓	-	-	-	-
	Robotics and Automation Laboratory	✓	✓	✓	✓	✓	-	-	-	✓	✓	-	✓	✓	✓
	CNC and Metrology Laboratory	✓	✓	✓	-	✓	-	✓	-	✓	✓	-	✓	✓	✓
	Proto Studio I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SEM VI	Mechatronics System Design	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	Electric and Hybrid Vehicle Technologies in Automobiles	✓	✓	✓	✓	-	✓	✓	-	-	-	-	✓	✓	✓

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SEM	Subject	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	Smart Home and Building Automation	✓	✓	✓	✓	✓	✓	-	-	✓	✓	-	-	✓	-
	Soft Skills - III	-	-	-	-	-	-	-	✓	✓	✓	-	✓	-	-
	Modelling and Analysis of Mechatronic Systems Laboratory	✓	✓	✓	✓	✓	-	-	-	✓	✓	-	✓	✓	✓
	Proto Studio II	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SEM VII	Entrepreneurship Management	-	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	-	✓
	Machine Vision and Image Processing	✓	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	-
	Project work Phase - I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SEM VIII	Project work Phase - II	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Vertical 1: Robotics	Robots and Systems in Smart Manufacturing	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	✓	✓
	Robot Operating Systems	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓	✓
	Agricultural Robotics	✓	✓	✓	-	✓	✓	-	-	-	-	-	✓	-	✓
	Micro-Robotics	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	Collaborative Robotics	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓	✓
	Underwater Robotics	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	✓	✓
	Medical Robotics	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	✓	✓
	Humanoid Robotics	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓	✓
Vertical 2: Desing and Manufacturing	Robot and Machine Elements Design	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	Design for X	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	CNC Machine Tools and Programming	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	Computer Integrated Systems	✓	✓	✓	✓	✓	-	-	-	✓	-	-	✓	✓	✓
	Advanced Manufacturing Systems	✓	✓	✓	✓	✓	-	✓	-	-	-	-	✓	✓	✓
	Mechatronic Systems in Additive Manufacturing	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	Electronics Manufacturing Technology	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓

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KPRIET
Learn Beyond

SEM	Subject	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	Computer Aided Inspection and Testing	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	✓	✓
Vertical 3: Automotive Engineering and Technology	Fundamentals of Automotive Engineering and Technology	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	Automotive Electrical, Electronics and Control Systems	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	✓	✓
	Automotive Thermal Management Systems	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	✓	✓
	Vehicle Body Dynamics	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	✓	✓
	Autonomous Vehicle Systems	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	Design Principles of Hybrid and Electric Vehicles	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	✓	✓
	Energy Storage and Management for Electric Vehicles	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	Automotive Fault Diagnostics	✓	✓	-	✓	✓	-	-	-	-	-	-	✓	✓	✓
Vertical 4: Intelligent Systems	Applied Signal Processing	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	✓	✓
	Applied Image Processing	✓	✓	-	✓	✓	-	-	-	-	-	-	✓	✓	✓
	Computer Vision and Deep Learning	✓	✓	-	✓	✓	-	-	-	-	-	-	✓	✓	-
	Immersive Technologies and Haptics	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	System Modelling and Simulation	✓	✓	-	✓	✓	-	-	-	-	-	-	✓	✓	-
	Machine Learning for Intelligent Systems	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	Condition Monitoring and Fault Diagnostics	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	Optimization Techniques	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
Vertical 5: Industrial Automation	Factory Automation	✓	✓	✓	✓	✓	-	-	-	✓	✓	-	✓	✓	-
	Process Control and Automation	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	Virtual Instrumentation using LabVIEW	✓	✓	✓	✓	-	✓	-	-	-	-	✓	✓	✓	✓
	Introduction to Industrial Internet of Things	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	Motion Control System	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	✓	✓

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SEM	Subject	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	Digital Twin and Industry 5.0	✓	✓	✓	✓	✓	-	✓	✓	✓	-	✓	-	✓	✓
	Cyber Physical Systems	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
	Industrial Automation Protocols	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	✓
Vertical 6: Avionics and Drone Technology	Avionics	✓	✓	✓	✓	-	-	-	-	✓	-	-	✓	✓	✓
	Fluid Mechanics and Dynamics	✓	✓	✓	✓	-	-	-	-	✓	-	-	✓	✓	✓
	Guidance and Control of Avionics	✓	✓	✓	✓	-	-	-	-	✓	-	-	✓	✓	✓
	Computational Fluid Dynamics for Drones	✓	✓	✓	✓	-	✓	-	-	-	-	-	✓	✓	✓
	Aerodynamics of Drones	✓	✓	✓	✓	-	-	-	-	✓	-	-	✓	✓	✓
	Design of UAV	✓	✓	✓	✓	-	-	-	-	✓	-	-	✓	✓	✓
	Navigation and Communication Systems	✓	✓	✓	✓	-	-	-	-	✓	-	-	✓	✓	✓
	Aircraft Mechatronics	✓	✓	✓	✓	-	-	-	-	✓	-	-	✓	✓	✓

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SEMESTER I

U21GEG01	HERITAGE OF TAMILS (Common to all programs)	Category: HSMC				
		L	T	P	J	C
		1	0	0	0	1

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

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

- To learn the extensive literature of classical Tamil
- To review the fine arts heritage of Tamil culture
- To realize the contribution of Tamils in Indian freedom struggle

COURSE OUTCOMES:

CO1: Understand the extensive literature of Tamil and its classical nature (Understand)
CO2: Understand the heritage of sculpture, painting and musical instruments of ancient people (Understand)
CO3: Review on folk and martial arts of Tamil people (Understand)
CO4: Realization of thinai concepts, trade and victory of Chozha dynasty (Understand)
CO5: Understand the contribution of Tamils in Indian freedom struggle, Self–esteem movement and siddha medicine (Understand)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	–	–	–	–	–	–	3	3	–	2	–	3	–	–
CO2	–	–	–	–	–	–	3	3	–	2	–	3	–	–
CO3	–	–	–	–	–	–	3	3	–	2	–	3	–	–
CO4	–	–	–	–	–	–	3	3	–	2	–	3	–	–
CO5	–	–	–	–	–	–	3	3	–	2	–	3	–	–
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I LANGUAGE AND LITERATURE 3

Language Families in India – Dravidian Languages – Tamil as a Classical 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

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UNIT III FOLK AND MARTIAL ARTS 3

Therukoothu, Karagattam, Villu Pattu, Kaniyan Koothu, Oyillattam, Leatherpuppetry, 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

Contact Periods:

Lecture: 15 Periods	Tutorial: – Periods	Practical: – Periods	Project	– Periods
			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 பிரகரம்)
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 Civilization 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 Book and Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book

EVALUATION PATTERN:

Continuous Internal Assessment	Total
	100

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SEMESTER I

		Category: HSMC				
U21GEG01	தமிழர் மரபு (அனைத்து துறைகளுக்கும் பொதுவனது)	L	T	P	J	C
		1	0	0	0	1

முன்கூட்டிய துறைசார் அறிவு:

தேவையில்லை

பாடத்தின் நோக்கங்கள்:

- தமிழ் மொழியின் இலக்கியச் செறிவைக் கற்றுணர்தல்
- தமிழர் பண்பாட்டின் நுண்கலைகள் பற்றிய ஒரு மீள்பார்வை
- இந்திய தேசிய இயக்கத்தில் தமிழர்களின் பங்கினை அறிதல்

பாடம் கற்றதின் விளைவுகள்:

CO1: தமிழ் மொழியின் செந்தன்மை மற்றும் இலக்கியங்கள் குறித்த தெரிதல் (புரிதல்)
CO2: தமிழர்களின் சிற்பக்கலை, ஓவியக்கலை மற்றும் இசைக்கருவிகள் குறித்த தெளிவு (புரிதல்)
CO3: தமிழர்களின் நாட்டுப்புறக் கலைகள் மற்றும் வீரவிளையாட்டுகள் குறித்த அறிமுகம் (புரிதல்)
CO4: தமிழர்களின் திணைக் கோட்பாடுகள், சங்ககால வணிகம் மற்றும் சோழர்களின் வெற்றிகள் குறித்த தகவல்கள் (புரிதல்)
CO5: இந்திய தேசிய இயக்கம், சுயமரியாதை இயக்கம் மற்றும் சித்த மருத்துவம் பற்றிய புரிதல் (புரிதல்)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	–	–	–	–	–	–	3	3	–	2	–	3	–	–
CO2	–	–	–	–	–	–	3	3	–	2	–	3	–	–
CO3	–	–	–	–	–	–	3	3	–	2	–	3	–	–
CO4	–	–	–	–	–	–	3	3	–	2	–	3	–	–
CO5	–	–	–	–	–	–	3	3	–	2	–	3	–	–
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)					

பாடத்திட்டங்கள்:

அலகு I மொழி மற்றும் இலக்கியம் **3**

இந்திய மொழிக்குடும்பங்கள் – 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 - சிற்பக்கலை **3**

நடுகல் முதல் நவீன சிற்பங்கள் வரை – ஐம்பொன் சிலைகள் – பழங்குடியினர் மற்றும் அவர்கள் தயாரிக்கும் கைவினைப்பொருட்கள், பொம்மைகள் – தேர் செய்யும் கலை – கடுமண் சிற்பங்கள் – நாட்டுப்புறத் தெய்வங்கள் – குமரி முனையில் திருவள்ளுவர் சிலை – இசைக்கருவிகள் – மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் – தமிழர்களின் சமூக, பொருளாதார வாழ்வில் கோவில்களின் பங்கு

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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 – சங்க காலத்தில் எழுத்தறிவும், கல்வியும் – சங்ககால நகரங்களும், துறைமுகங்களும் – சங்ககாலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி – கடல்கடந்த நாடுகளில் சோழர்களின் வெற்றி

அலகு V இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்குத் தமிழர்களின் பங்களிப்பு 3

இந்திய விடுதலைப்போரில் தமிழர்களின் பங்கு – இந்தியாவின் பிற பகுதிகளில் தமிழ்ப் பண்பாட்டின் தாக்கம் – சுயமரியாதை இயக்கம் – இந்திய மருந்துவத்தில் சித்த மருத்துவத்தின் பங்கு – கல்வெட்டுகள், கையெழுத்துப்படிகள் – தமிழ்ப் புத்தகங்களின் அச்சு வரலாறு

Contact Periods:

Lecture: 15 Periods Tutorial: – Periods Practical: – Periods Project – Periods

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 Civilization 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 Book and Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book

மதிப்பீட்டு முறை:

தொடர்ச்சியான உள் மதிப்பீடு	மொத்தம்
	100

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SEMESTER I

U21MA101	CALCULUS AND DIFFERENTIAL EQUATIONS (Common to AD, BM, CE, CH, CS, CS(AIML), EC, IT, ME, MI)	Category: BSC				
		L	T	P	J	C
		3	1	0	0	4

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the concepts of matrices and calculus which will enable them to model and analyze physical phenomena involving continuous change
- To understand the methodologies involved in solving problems related to fundamental principles of calculus
- To develop confidence to model mathematical pattern and give appropriate solutions

COURSE OUTCOMES:

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

CO1: Apply the knowledge of matrices with the concepts of eigenvalues to study their problems in core areas (Apply)
CO2: Apply the basic techniques and theorems of functions of several variables in other areas of mathematics (Apply)
CO3: Analyze the triple integrals techniques over a region in two dimensional and three–dimensional geometry (Apply)
CO4: Apply basic concepts of integration to evaluate line, surface and volume integrals (Apply)
CO5: Solve basic application problems described by second and higher order linear differential equations with constant coefficients (Understand)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	–	–	–	–	–	–	–	–	–	1	2	1
CO2	3	2	–	–	–	–	–	–	–	–	–	–	2	1
CO3	2	2	–	–	–	–	–	–	–	–	–	–	1	1
CO4	2	2	–	–	–	–	–	–	–	–	–	–	2	1
CO5	3	2	–	–	–	–	–	–	–	–	–	–	3	1
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I MATRICES **9 + 3**

Eigenvalues and eigenvectors – Properties (without proof) – Cayley Hamilton theorem (without proof) – Diagonalization using orthogonal transformation – Applications

UNIT II FUNCTIONS OF SEVERAL VARIABLES **9 + 3**

Partial derivatives – Total derivative – Jacobians – Taylor's series expansion – Extreme values of functions of two variables – Lagrange multipliers method

UNIT III MULTIPLE INTEGRALS **9 + 3**

Double integrals – Change of order of integration – Triple integrals – Applications in area and volume

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UNIT IV LINE AND SURFACE INTEGRALS **9 + 3**

Line integrals – Surface integrals – Green's theorem in a plane – Gauss divergence theorem – Stokes' theorem (excluding proofs)

UNIT V ORDINARY DIFFERENTIAL EQUATIONS **9 + 3**

Second and higher order linear differential equations with constant coefficients – Variable coefficients – Euler Cauchy equation – Legendre's equation – Method of variation of parameters – Applications

Contact Periods:

Lecture: 45 Periods Tutorial: 15 Periods Practical: – Periods Project – Periods

Total 60 Periods

TEXTBOOKS:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India Pvt Ltd, New Delhi, 2018.
2. Grewal B S, "Higher Engineering Mathematics", 44th Edition, Khanna Publishers, New Delhi, 2017.

REFERENCES:

1. Bali N P and Dr Manish Goyal, "A textbook of Engineering Mathematics", 12th Edition, Laxmi Publications, 2016.
2. Thomas G B and Finney R L, "Calculus and Analytic Geometry", 14th Edition, Pearson Education India, 2018.
3. Maurice D Weir, Joel Hass and Christopher Heil, "Thomas Calculus", 14th Edition, Pearson Education, India, 2018.
4. James Stewart, "Calculus: Early Transcendental", 7th Edition, Cengage Learning, New Delhi, 2015.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	**End Semester Examinations**
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	**60**	**40**	**60**	**200**	**100**
Total				**40**	**60**
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER I

U21EN101	ENGLISH FOR TECHNOLOGISTS (Common to AD, BM, CH, CE, CS, CS(AIML), EE, EC, ME, MI, IT)	Category: HSMC				
		L	T	P	J	C
		1	0	2	0	2

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To infer and interpret the meaning of Technical, Business, Social and Academic contexts
- To enhance the listening skills and facilitate effective pronunciation
- To make effective presentation and conversation in technical and professional environment

COURSE OUTCOMES:

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

CO1: Comprehend language and learn strategies for error–free communication (Understand)
CO2: Improve speaking skills in academic and social contexts (Apply)
CO3: Enhance both reading and writing skills to excel in professional career (Analyze)
CO4: Evaluate different perspectives on a topic (Analyze)
CO5: Develop listening skills to understand complex business communication in a variety of global English accents through Personality Development (Understand)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	–	–	–	–	–	–	–	–	–	3	–	1	1	–
CO2	–	–	–	–	–	–	–	–	2	3	–	–	2	–
CO3	–	–	–	–	–	–	–	–	2	3	–	1	2	–
CO4	–	–	–	–	–	–	–	–	2	3	–	–	1	–
CO5	–	–	–	–	–	–	–	2	–	3	–	1	2	–
Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)														

SYLLABUS:

UNIT I SUBJECTIVE INTROSPECTION 9

Module:1 Vocabulary Building

Activity: Word Puzzles, Snappy words, Word Sleuthing

Module:2 Introducing and Sharing Information

Activity: Get to know oneself, Introducing Peer Members

Module:3 Opinion Paragraph

Activity: Note making, analyzing and writing a review

UNIT II CAREER ENHANCEMENT 9

Module:4 Reading Comprehension

Activity: Reading Newspaper articles/Blogs, Sentence completion

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Module:5E–mail Communication

Activity: Drafting personal and professional emails

Module:6 Career Profiling

Activity: Resume Writing & Digital Profiling

UNIT III LANGUAGE ADEPTNESS 9

Module:7 Rewriting passages

Activity: Conversion of voices & Rephrasing Articles

Module:8 Enhancing Pronunciation skills

Activity: Listening to short technical Reels and reproducing it

Module:9 Making Conversations

Activity: Role play & Narrating Incidents

UNIT IV TECHNICAL WRITING 9

Module:10 Spotting Errors

Activity: Proof reading, Rewriting sentences

Module:11 Data interpretation

Activity: Interpretation of Graphics/Charts/Graphs

Module:12 Expository Writing

Activity: Picture inference, Captions for Posters& Products

UNIT V LANGUAGE UPSKILLING 9

Module:13 Listening for Specific Information

Activity: TED talks/Announcement/Documentaries

Module:14 Presentation

Activity: Extempore & Persuasive Speech

Module:15 Team Communication

Activity: Team building activities, Group Discussion

LIST OF EXERCISES

1. Introducing oneself
2. Role play
3. Listening to short technical Reels
4. Listening to TED Talks/ Announcements/ Documentaries
5. Presentation
6. Group Discussion

Contact Periods:

Lecture:	15 Periods	Tutorial:	– Periods	Practical:	30 Periods	Project:	– Periods
						Total:	45 Periods

TEXTBOOKS:

1. Ashraf Rizvi, "Effective Technical Communication", 2nd Edition, Mc Graw – Hill. India 2017.
2. Rod Ellis, "English for Engineers & Technologists", Vol. II: (English for Engineers and Technologist: A Skills Approach). 2nd Edition, Orient Black Swan, 1990.

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REFERENCES:

1. Raymond Murphy, "Intermediate English Grammar", 2nd Edition, Cambridge University Press, 2009.
2. Thomas L Means, "English and Communication for Colleges", 4th Edition, Cengage 2017.
3. Using English: "A Coursebook for Undergraduate Engineers and Technologists", 1st Edition, Orient Black Swan, 2017.

EVALUATION PATTERN:

<table>
<tr><th colspan="4">Continuous Internal Assessments</th><th>End Semester Examinations</th></tr>
<tr><td colspan="2">Assessment I
(Theory)
(100 Marks)</td><td colspan="2">Assessment II
(Practical)
(100 Marks)</td><td rowspan="2">Practical Examinations

(Examinations will be conducted for 100 Marks)</td></tr>
<tr><td>Individual Assignment / Seminar / MCQ</td><td>Written Test</td><td>Evaluation of Laboratory Observation, Record (Rubrics Based Assessments)</td><td>Test</td></tr>
<tr><td>40</td><td>60</td><td>75</td><td>25</td><td></td></tr>
<tr><td colspan="2">25</td><td colspan="2">25</td><td>50</td></tr>
<tr><td colspan="4">50</td><td>50</td></tr>
<tr><td colspan="5">Total: 100</td></tr>
</table>

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose anyone / two components based on the nature of the course.

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SEMESTER I

U21PH101	ENGINEERING PHYSICS (Common to all branches)	Category: BSC				
		L	T	P	J	C
		2	0	2	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the fundamental principles of laser and fibre optics with their applications
- To acquire the knowledge of ultrasonic waves, thermal conductivity and properties of liquids
- To understand the concepts of crystals

COURSE OUTCOMES:

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

CO1: Demonstrate the types of laser for various industrial and medical applications (Understand)
CO2: Apply the concepts of fibre optics in engineering (Understand)
CO3: Understand the production methods of ultrasonic waves and uses in engineering and medicine (Understand)
CO4: Apply the concepts of thermal conductivity in hybrid vehicles and viscosity of liquids in engineering applications (Understand)
CO5: Explain the basic concepts of crystals and its growth techniques (Understand)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	–	–	–	–	–	–	–	–	–	2	1
CO2	3	2	1	–	–	–	–	–	–	–	–	–	2	1
CO3	3	2	1	–	–	–	–	–	–	–	–	–	2	1
CO4	3	2	1	–	–	–	–	–	–	–	–	–	2	1
CO5	3	2	1	–	–	–	–	–	–	–	–	–	–	–

Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SYLLABUS:

UNIT I LASER **6**

Laser characteristics – Spontaneous and stimulated emission – Pumping methods – CO_2 laser – Semiconductor laser – Material Processing – Selective laser Sintering – Hologram – Medical applications (Opthalmology)

UNIT II FIBER OPTICS **6**

Total internal reflection – Numerical aperture and acceptance angle – Classification of optical fibers (Materials, modes and refractive index profile) – Fiber optical communication system – Displacement and temperature sensor – Medical Endoscopy

UNIT III ULTRASONICS **6**

Properties of ultrasonic waves – Piezoelectric generator – Acoustic grating – Applications of ultrasonics in industry– SONAR – NDT – Ultrasonic scanning methods – Fetal heart movement

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UNIT IV THERMAL PHYSICS AND PROPERTIES OF FLUIDS 6

Modes of heat transfer – Thermal conductivity – Lee's disc method – Solar thermal power generation – Hybrid vehicles – Microwave oven – Surface tension and coefficient of viscosity – Poiseuille's flow experiment

UNIT V CRYSTAL PHYSICS 6

Unit cell – Bravais lattices – SC, BCC, FCC structures – Miller indices – d spacing in cubic lattice – Crystal growth from melt: Bridgeman Technique – Silicon ingots from Czochralski method – Silicon wafers from ingots and its applications.

LIST OF EXPERIMENTS

1. Determination of the wavelength of a given laser source
2. Determination of acceptance angle and numerical aperture of an optical fibre
3. Determination of velocity of sound and compressibility of a liquid using Ultrasonic interferometer
4. Determination of thermal conductivity of a bad conductor using Lee's disc method
5. Determination of viscosity of the given liquid using Poiseuille's flow method

Contact Periods:

Lecture: 30 Periods Tutorial: – Periods Practical: 30 Periods Project: – Periods

Total: 60 Periods

TEXTBOOKS:

1. Bhattacharya D K and Poonam Tandon, "Engineering Physics", 2nd Edition, Oxford University Press, Chennai, 2017
2. Marikani A, "Engineering Physics", 3rd Edition, PHI publishers, Chennai, 2021
3. Lab Manual

REFERENCES:

1. Shatendra Sharma and Jyotsna Sharma, "Engineering Physics", 2nd Edition, Pearson India Education Services Private Limited, Chennai, 2018
2. Avadhanulu M N, Kshirsagar P G and Arun Murthy TVS, "A Text book of Engineering Physics", 2nd Edition, S Chand Publishing, New Delhi, 2018
3. Thyagaran K, Ajoy Ghatak, "Lasers – Fundamentals and Applications", 2nd Edition, Laxmi Publications Pvt Limited, New Delhi, 2019
4. https://nptel.ac.in/downloads/104104085/
5. https://nptel.ac.in/courses/122107035/8/

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EVALUATION PATTERN:

Continuous Internal Assessments				End Semester Examinations	
Assessment I (Theory) (100 Marks)		**Assessment II (Practical) (100 Marks)**		**Theory Examinations (Examinations will be conducted for 100 Marks)**	**Practical Examinations (Examinations will be conducted for 100 Marks)**
*Individual Assignment / Case Study / Seminar / Mini Project / MCQ	Written Test	Evaluation of Laboratory Observation, Record **(Rubrics Based Assessments)**	Test		
40	**60**	**75**	**25**		
25		**25**		**25**	**25**
50				**50**	
Total: 100					

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER I

U21CY101	ENGINEERING CHEMISTRY (Common to all BE./B.Tech. courses)	Category: BSC				
		L	T	P	J	C
		2	0	2	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To inculcate the fundamentals of water technology and electrochemistry
- To gain basic knowledge of corrosion of metals and alloys
- To acquire knowledge about the properties of fuels and applications of polymers

COURSE OUTCOMES:

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

CO1: Apply the principles of water technology in treatment of industrial and domestic water and estimate the various constituents of industrial water (Apply)
CO2: Describe the principles and applications of electrochemical cells, fuel cells and solar cells (Understand)
CO3: Outline the different types of corrosion processes and preventive methods adopted in industries (Understand)
CO4: Explain the analysis and calorific value of different types of fuels (Understand)
CO5: Classify the polymers and their engineering applications (Understand)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	–	–	–	–	2	–	1	–	–	1	1	2
CO2	3	1	–	–	–	–	2	–	1	–	–	1	2	2
CO3	3	1	–	–	–	–	2	–	1	–	–	1	–	–
CO4	3	1	–	–	–	–	2	–	1	–	–	1	1	1
CO5	3	1	–	–	–	–	2	–	1	–	–	1	1	1
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)				3: Substantial (High)							

SYLLABUS:

UNIT I CHARACTERISTICS OF WATER AND ITS TREATMENT 6

Characteristics of water – Hardness – Types, Dissolved oxygen, Total dissolved solids, Disadvantages due to hard water in industries – (Scale, Slu1dge, Priming, Foaming and Caustic embrittlement), Water softening methods – Lime–soda, Zeolite, Ion exchange processes and reverse Osmosis and their applications. Specifications of domestic water (ICMR and WHO). Water treatment for municipal supply –Sedimentation with coagulant – Sand Filtration – Chlorination, Disinfection methods– UV treatment, Ozonolysis, Electro dialysis

UNIT II ELECTROCHEMISTRY AND ENERGY STORAGE SYSTEMS 6

Introduction, Electrodes – (Calomel electrode), Electrochemical series and its applications, Brief introduction to conventional primary and secondary batteries – (Pb acid, Lithium)

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Fuel cells – Polymer membrane fuel cells, Solid–oxide fuel cells – Working principles, advantages, applications. Solar cells – Dye sensitized solar cells –Working principles, characteristics and applications

UNIT II CORROSION AND ITS CONTROL **6**

Types – Dry – Chemical corrosion and Wet – Galvanic and differential aeration (Pitting, Crevice, pipeline) – Factors influencing rate of corrosion – Corrosion control methods – Sacrificial anode and impressed current method – Protective coating – Electroplating – Ni plating.

Alloys – Ferrous (stainless steel), Heat treatment – Non–ferrous alloys (Brass –Dutch metal, German Silver) – Composition, properties and uses

UNIT IV FUELS AND COMBUSTION **6**

Fuels– Solid fuel: Coal – Analysis of coal (Proximate analysis only) – Liquid fuel – Manufacture of synthetic petrol (Bergius process) – Octane number, cetane number, Knocking in engines– Anti–knocking agents, Gasoline additives, Gaseous fuel: Compressed natural gas (CNG) – Liquefied petroleum gases (LPG) – Composition only.

Calorific value – Higher and lower calorific values – Flue gas analysis (ORSAT method). Measurement of calorific value using bomb calorimeter, Three–way catalytic converter – Selective catalytic reduction of NO_x

UNIT V POLYMERS **6**

Introduction – Monomer, dimers, functionality, degree of polymerisation, transition glass temperature Classification of polymers, Difference between thermoplastics and thermosetting plastics, Engineering application of plastics – ABS, PVC, PTFE and Bakelite.

Types of compounding of plastics – Moulding, Injection moulding, Extrusion moulding, Compression moulding

Conducting polymers – Polypyrrole, Polyacetylene, Polyaniline – Structure and applications, Composites – FRP – Properties and applications

LIST OF EXPERIMENTS

1. Determination of total, permanent and temporary hardness of a given sample water by EDTA method
2. Estimation of ferrous ion by potentiometric titration
3. Estimation of Copper in Brass by EDTA method
4. Determination of percentage of moisture, volatile, ash and carbon content in a given sample of coal.
5. Determination of molecular weight and degree of polymerization of an oil sample by viscosity measurement (Ostwald's viscometer).
6. Determination of chloride content in the water sample
7. Determination of strength of HCl by pH metric method

Contact periods:

Lecture:	30 Periods	Tutorial:	– Periods	Practical:	30 Periods	Project	– Periods
						Total	60 Periods

TEXTBOOKS:

1. Jain P C and Monika Jain, "Engineering Chemistry", 16th Edition, Dhanpat Rai Publishing Company, Pvt. Ltd., New Delhi, 2015
2. Vairam S, Kalyani P and Suba Ramesh, "Engineering Chemistry", 2nd Edition, Wiley India Pvt. Ltd, New Delhi, 2014
3. Lab Manual

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REFERENCES:

1. Friedrich Emich, "Engineering Chemistry", 2nd Edition, Scientific International Pvt. Ltd, New Delhi, 2014
2. Prasanta Rath, "Engineering Chemistry", 1st Edition, Cengage Learning India, Pvt. Ltd, Delhi, 2015
3. Shikha Agarwal, "Engineering Chemistry, Fundamentals and Applications", 1st Edition, Cambridge University Press, 2015
4. https://nptel.ac.in/courses/113/104/113104008/

EVALUATION PATTERN:

<table>
<tr><th colspan="4">Continuous Internal Assessments</th><th colspan="2" rowspan="2">End Semester Examinations</th></tr>
<tr><th colspan="2">Assessment I
(Theory)
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<tr><td>*Individual Assignment / Case Study / Seminar / Mini Project / MCQ</td><td>Written Test</td><td>Evaluation of Laboratory Observation, Record
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<tr><td>40</td><td>60</td><td>75</td><td>25</td></tr>
<tr><td colspan="2">25</td><td colspan="2">25</td><td>25</td><td>25</td></tr>
<tr><td colspan="4">50</td><td colspan="2">50</td></tr>
<tr><td colspan="6">Total: 100</td></tr>
</table>

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Designer can choose any one / two components based on the nature of the course.

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SEMESTER I

U21CSG01	PROBLEM SOLVING AND C PROGRAMMING Common to All Branches	Category: ESC				
		L	T	P	J	C
		2	0	2	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To provide exposure to problem–solving through programming
- To develop computational thinking perspective of one's own discipline
- To write, compile and debug programs using C language

COURSE OUTCOMES:

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

CO1: Formulate the algorithmic solutions for a given computational problem (Understand)
CO2: Describe modularization, structures and pointers in C language (Understand)
CO3: Design and implement algorithms for a given problem using C control structures (Apply)
CO4: Apply the C programming constructs for searching and sorting techniques (Apply)
CO5: Solve real time problems using suitable non–primitive data structures in C (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	2	–	–	–	1	2	2	–	3	3	1
CO2	2	1	1	2	–	–	–	1	2	2	–	2	3	1
CO3	3	2	2	2	–	2	–	1	2	2	–	2	3	1
CO4	3	2	2	2	–	–	–	1	2	2	–	2	3	1
CO5	3	2	2	2	–	–	–	1	2	2	–	2	3	1
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)				3: Substantial (High)							

SYLLABUS:

UNIT I COMPUTATIONAL THINKING 6

Computational Thinking – Modern Computer – Information based Problem solving – Real world information and Computable Data – Data types and data encoding – Number Systems – Introduction to programming languages – Basics of C programming – variables– Data types – keywords – C program structure – Simple programs in C

UNIT II ALGORITHMIC APPROACH 6

Logic – Boolean Logic – Applications of Propositional logic – Problem Definition – Logical Reasoning and Algorithmic thinking – Pseudo code and Flow chart – Constituents of algorithms – Sequence, Selection and Repetition – Problem understanding and analysis – Control structures in C – Algorithm design and implementation using control structures

UNIT III SEARCHING, SORTING, AND MODULARIZATION 6

Data Organization – Arrays – Introduction to Searching and Sorting – Linear Search, Binary Search – Basic sorting techniques – Two–dimensional arrays – Matrix manipulation – Modularization – Functions

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– Function prototype – Function definition – Function call – Built–in functions (string functions and math functions) – Recursion

UNIT IV STRUCTURES AND POINTERS 6

Pointers – Pointer operators – Pointer arithmetic – Arrays and pointers – Array of pointers – Example Program – Sorting of names – Parameter passing – Pass by value – Pass by reference – Structure – Nested structures – Pointer and Structures – Array of structures – Example Program using structures and pointers – Unions

UNIT V FILES 6

Files – Types of file processing – Sequential access – Random access – Sequential access file – Example Program – Finding average of numbers stored in sequential access file – Random access file – Example Program – Transaction processing using random access files – Command line arguments

LIST OF EXPERIMENTS

A. Lab Programs

1. Using IO Statements, get higher secondary marks of a student. Calculate and display the medical and engineering cut–off marks. [Assume the calculation formula]
2. Develop a C program to emulate the operations of an ATM using control structures. Authentication, Deposit, Withdrawal, and Balance check and pin change operations are to be supported.
3. Develop a calculator to perform the operations including addition, subtraction, multiplication, division and square of a number.
4. Given different prices of a vegetable which is varying through the day (from morning to evening), find out the best buy price and sell price for the maximum profit. Eg. For the prices [33, 35, 28, 36, 39, 25, 22, 31], best buy is at 28 and best sell is at 39.
5. Collect height and weight of 4 of your friends and calculate their body mass index. Use 2–dimensional array to store the values.
6. Weights of 10 students of your class who are standing in a line is given in a random order. Find out if there is a heavy person whose weight is the sum of previous two persons.
7. Convert the given decimal number into binary, octal and hexadecimal numbers using user defined functions.
8. From a given paragraph perform the following using built–in functions:
   a) Find the total number of words.
   b) Capitalize the first word of each sentence.
9. Solve Towers of Hanoi using recursion.
10. Develop an expense manager which reads date, product, price and product category. The program should display the total expense amount based on product category or date as per user's selection. Use structures.
11. Develop a banking application to store details of accounts in a file. Count the number of account holders based on a search condition such as – whose balance is less than the minimum balance.

B. Mini Project (SAMPLE)

Create a Railway Reservation system with the following modules of Booking,

- Availability checking
- Cancellation
- Prepare chart

Contact Periods:

Lecture:	30 Periods	Tutorial:	– Periods	Practical:	30 Periods	Project:	– Periods
						Total	60 Periods

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TEXTBOOKS:

1. David D. Railey and Kenny A.Hunt , "Computational Thinking for Modern problem Solver", 1st Edition, CRC Press, 2014
2. Brian W. Kernighan and Dennis Ritchie, "The C Programming Language", 2nd Edition, Pearson, 2015
3. Lab Manual

REFERENCES:

1. Paolo Ferragina and Fabrizio Luccio, "Computational Thinking First Algorithms", Then Code" ,1st Edition, Springer International Publishing, 2018
2. Reema Thareja, "Programming in C", 2nd Edition, Oxford University Press, 2016
3. Paul Deitel and Harvey Deitel, "C How to Program", 7th Edition, Pearson Publication
4. Juneja, B. L and Anita Seth, "Programming in C",1st Edition, Cengage Learning India Pvt. Ltd., 2011
5. Pradip Dey, Manas Ghosh, "Fundamentals of Computing and Programming in C", 1st Edition, Oxford University Press, 2009

EVALUATION PATTERN:

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SEMESTER I

U21MEG01	ENGINEERING GRAPHICS	Category: ESC				
		L	T	P	J	C
		0	0	4	0	2

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To expose the standards and conventions followed in preparation of engineering drawings
- To develop graphic skills for communication of concepts, ideas and engineering drawings
- To expose on 2D & 3D drawings and its projections

COURSE OUTCOME:

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

CO1: Sketch the curves and orthographic projections of points as per BIS conventions (Apply)
CO2: Illustrate the orthographic projections of straight lines and plane surfaces (Apply)
CO3: Sketch the orthographic projections of solids, lateral surfaces of frustums, truncated solids and its development (Apply)
CO4: Develop the lateral surfaces of simple solids (Apply)
CO5: Interpret the orthographic and isometric views of simple components (Apply)

CO PO Mapping:

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	–	3	–	–	1	–	2	–	1	3	2
CO2	3	2	2	–	3	–	–	–	–	2	–	1	2	1
CO3	3	2	2	–	3	–	–	–	–	3	–	1	3	2
CO4	3	2	2	–	3	–	–	–	–	3	–	1	2	1
CO5	3	2	2	–	3	–	–	–	–	3	–	1	3	2
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)				3: Substantial (High)							

SYLLABUS:

BASICS OF ENGINEERING DRAWING AND CAD (Not for examination) 12

Introduction – drawing instruments and its uses – sheet layout – BIS conventions – lines – lettering and dimensioning practices – lines – Co–ordinate points – axes – poly lines – square – rectangle – polygons – splines – circles – ellipse – text – move – copy – off–set – mirror – rotate – trim – extend – break – chamfer – fillet – curves – constraints viz. agency – parallelism – inclination and perpendicular

UNIT I CONICS, SPECIAL CURVES AND PROJECTION OF POINTS 12

Construction of parabola – ellipse and hyperbola using eccentricity method – construction of involutes for squares and circles – Construction of Tangent and normal to the above curves – Introduction – method of projection – planes of projection – reference line and notations – Orthographic Projection of points – Points in all four quadrants

UNIT II PROJECTION OF STRAIGHT LINES AND SURFACES 12

Projection of straight lines – Lines inclined to HP / VP plane – inclined to both HP and VP planes (straight lines are assumed to be in first quadrant only) – Projection of planes – Projection of square –

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rectangle – pentagon – hexagon and circular plane – inclined to both the plane by change of position method

UNIT III PROJECTION OF SOLIDS 12

Introduction – projection of solids – prisms – pyramids – cylinders and cones with axis inclined to both the planes (Solids resting on HP only)

UNIT IV DEVELOPMENT OF LATERAL SURFACES OF SOLIDS 12

Introduction – Cutting plane – sectional views of right regular solids resting with base on HP – prisms – pyramids – cylinder and cone – True shapes of the sections – Development of lateral surfaces of right regular prisms – pyramids – cylinders – cones resting with base on HP only – Development of the frustums and truncations

UNIT V ORTHOGRAPHIC AND ISOMETRIC PROJECTIONS 12

Orthographic projection – Simple machine components using free hand sketching – Isometric projection – Simple Solid exercises and combination of solids

Contact Periods:

Lecture: – Periods Tutorial: – Periods Practical: 60 Periods Project: – Periods

Total 60 Periods

TEXTBOOKS:

1. ND Bhat & VM Panchal, "Engineering Drawing", Charotar Publishing House, Gujarat, 51st Edition, 2013.
2. Venugopal K. and Prabhu Raja V, "Engineering Graphics", New Age International (P) Limited, 6th Edition 2019.
3. Lab Manual

REFERENCE BOOKS:

1. Natrajan K.V., A textbook of Engineering Graphics, Dhanalakshmi Publishers, Chennai, 21st Edition 2017.
2. Sam Tickoo, AutoCAD 2013 for Engineers and Designers, Dream tech Press, 1st Edition 2013.
3. M.H.Annaiah & Rajashekar Patil, Computer Aided Engineering Drawing, New Age International Publishers,4th Edition,2012.
4. Basant Aggarwal, Engineering Drawing, Tata Mc Graw Hill Education Private Limited, 1st Edition, 2010.
5. D.M.Kulkarni, A.P.Rastogi, A.K.Sarkar, Engineering Graphics with AutoCAD, PHI Learning Private Limited, New Delhi, Revised Edition,2010.

EVALUATION PATTERN:

Continuous Internal Assessments		End Semester Examinations
Evaluation of Laboratory Observation, Record (Rubrics Based Assessments)	Test	
75	25	
100		100
60		40
100		

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER II

U21GEG02	TAMILS AND TECHNOLOGY (Common to all programs)	Category: HSMC				
		L	T	P	J	C
		1	0	0	0	1

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

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

- To learn weaving, ceramic and construction technology of Tamils
- To understand the agriculture, irrigation and manufacturing technology of Tamils
- To realize the development of scientific Tamil and Tamil computing

COURSE OUTCOMES:

CO1: Understand the weaving and ceramic technology of ancient Tamil people nature (Understand)
CO2: Understand the construction technology, building materials in Sangam period and case studies (Understand)
CO3: Infer the metal process, coin and beads manufacturing with relevant archaeological evidence (Understand)
CO4: Realize the agriculture methods, irrigation technology and pearl diving (Understand)
CO5: Apply the knowledge of scientific Tamil and Tamil computing (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	–	–	–	–	–	–	3	3	–	2	–	3	1	–
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CO4	–	–	–	–	–	–	3	3	–	2	–	3	1	–
CO5	–	–	–	–	–	–	3	3	–	2	–	3	1	–
Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)														

SYLLABUS:

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 Nayakar Mahal – Chetti Nadu 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 Stone beads – Glass beads

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– Terracotta beads – Shell beads/ bone beats – Archaeological evidences – Gem stone types described in Silappathikaram

UNIT IV AGRICULTURE AND IRRIGATION TECHNOLOGY 3

Dam, Tank, ponds, Sluice, Significance of Kumizhi Thoompu of Chola Period, Animal Husbandry – Wells designed for cattle use – Agriculture and Agro Processing – Knowledge of Sea – Fisheries – Pearl – Conche diving – Ancient Knowledge of Ocean – Knowledge Specific Society

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

Contact Periods:

Lecture: 15 Periods Tutorial: – Periods Practical: – Periods Project – Periods

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 Civilization 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 Book and Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book

EVALUATION PATTERN:

Continuous Internal Assessment	**Total**
	100

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SEMESTER II

U21GEG02	தமிழரும் தொழில்நுட்பமும் (அனைத்து துறைகளுக்கும் பொதுவனது)	Category: HSMC				
		L	T	P	J	C
		1	0	0	0	1

முன்கூட்டிய துறைசார் அறிவு:
தேவையில்லை

பாடத்தின் நோக்கங்கள்:

- தமிழர்களின் சங்ககால நெசவு, பானை வனைதல் மற்றும் கட்டட தொழில்நுட்பம் குறித்து அறிதல்
- தமிழர்களின் சங்ககால வேளாண்மை, நீர்ப்பாசனம் மற்றும் உற்பத்தி முறைகள் குறித்த கற்றல்
- நவீன அறிவியல் தமிழ் மற்றும் கணித்தமிழ் குறித்த புரிதல்

பாடம் கற்றதின் விளைவுகள்:

CO1: சங்ககாலத் தமிழர்களின் நெசவு மற்றும் பானை வனைதல் தொழில்நுட்பம் குறித்த கற்றுணர்தல் (புரிதல்)
CO2: சங்ககாலத் தமிழர்களின் கட்டட தொழில்நுட்பம், கட்டுமானப் பொருட்கள் மற்றும் அவற்றை விளக்கும் தளங்கள் குறித்த அறிவு (புரிதல்)
CO3: சங்ககாலத் தமிழர்களின் உலோகத்தொழில், நாணயங்கள் மற்றும் மணிகள் சார்ந்த தொல்லியல் சான்றுகள் பற்றிய அறிவு (புரிதல்)
CO4: சங்ககாலத் தமிழர்களின் வேளாண்மை, நீர்ப்பாசன முறைகள் மற்றும் முத்து குளித்தல் குறித்த தெளிவு (புரிதல்)
CO5: நவீன அறிவியல் தமிழ் மற்றும் கணித்தமிழ் குறித்த புரிந்துகொள்ளலும் மற்றும் பயன்படுத்துதலும் (கற்றலை பயன்படுத்துதல்)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	–	–	–	–	–	–	3	3	–	2	–	3	1	–
CO2	–	–	–	–	–	–	3	3	–	2	–	3	1	–
CO3	–	–	–	–	–	–	3	3	–	2	–	3	1	–
CO4	–	–	–	–	–	–	3	3	–	2	–	3	1	–
CO5	–	–	–	–	–	–	3	3	–	2	–	3	1	–
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

பாடத்திட்டங்கள்:

அலகு I நெசவு மற்றும் பானைத் தொழில்நுட்பம் **3**

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

அலகு II வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம் **3**

சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் மற்றும் சங்க காலத்தில் வீட்டுப் பொருட்களின் வடிவமைப்பு – சங்க காலத்தில் கட்டுமானப் 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 – செட்டிநாடு வீடுகள் – பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோ-சாரோசெனிக் கட்டிடக்கலை

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அலகு III உற்பத்தித் தொழில்நுட்பம் 3

கப்பல் கட்டும் கலை – உலோகவியல் – இரும்புத் தொழிற்சாலை – இரும்பை உருகுதல், எக்கு – வரலாற்றுச் சான்றுகளாக செம்பு மற்றும் தங்க நாணயங்கள் – நாணயங்கள் அச்சடித்தல் – மணி உருவாக்கும் தொழிற்சாலைகள் – கல்மணிகள் – கண்ணாடி மணிகள் – சுடுமண் மணிகள் – சங்கு மணிகள் – எலும்புத் துண்டுகள் – தொல்லியல் சான்றுகள் – சிலப்பதிகாரத்தில் மணிகளின் வகைகள்

அலகு IV வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில்நுட்பம் 3

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

அலகு V அறிவியல் தமிழ் மற்றும் கணினித்தமிழ் 3

அறிவியல் தமிழின் வளர்ச்சி – கணினித்தமிழ் வளர்ச்சி – தமிழ் நூல்களை மின்பதிப்பு செய்தல் – தமிழ் மென்பொருட்கள் உருவாக்கம் – தமிழ் இணையக் கல்விக் கழகம் – தமிழ் மின்நூலகம் – இணையத்தில் தமிழ் அகராதிகள் – சொற்குவைத் திட்டம்

Contact Periods:

Lecture: 15 Periods Tutorial: – Periods Practical: – Periods Project – Periods

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 Civilization 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 Book and Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book

மதிப்பீட்டு முறை:

தொடர்ச்சியான உள் மதிப்பீடு	மொத்தம்
	100

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SEMESTER II

U21MA201	LAPLACE TRANSFORMS AND COMPLEX VARIABLES (Common to CE, EE, CH, ME, MI)	Category: BSC				
		L	T	P	J	C
		3	1	0	0	4

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the mathematical aspects of conversion time domain to frequency domain using Laplace transform and Inverse Laplace transform vice versa
- To use the concepts of complex analysis, in the study of heat flow, fluid dynamics and electrostatics
- To understand the concepts of singularities in the various domains of engineering fields

COURSE OUTCOMES:

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

CO1: Apply the concepts of Laplace transform in core engineering applications (Apply)
CO2: Apply the concepts of Inverse Laplace transform with their properties in engineering field (Apply)
CO3: Analyze the complex functions and their mapping in certain complex planes (Understand)
CO4: Evaluate complex contour integrals directly and use the Cauchy integral theorem in its various versions (Understand)
CO5: Compute the residues of a function at given points or singularities and use the residue theorem to evaluate a contour integral (Understand)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	–	–	–	–	–	–	–	–	–	1	2	2
CO2	3	2	–	–	–	–	–	–	–	–	–	–	2	2
CO3	2	2	–	–	–	–	–	–	–	–	–	–	2	1
CO4	2	2	–	–	–	–	–	–	–	–	–	–	2	1
CO5	3	3	–	–	–	–	–	–	–	–	–	–	1	1

Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SYLLABUS:

UNIT I LAPLACE TRANSFORM **9 + 3**

Laplace transform – Conditions for existence – Transform of elementary functions – Standard properties (statement only) – Transforms of unit step function – Impulse function – Periodic function – Initial and final value theorems – Convolution theorem(without proof)

UNIT II INVERSE LAPLACE TRANSFORM **9 + 3**

Inverse Laplace transform – Standard properties (statement only) – Second order linear differential equations with constant coefficients

UNIT III COMPLEX DIFFERENTIATION **9 + 3**

Analytic functions: Cauchy–Riemann equations (Cartesian form) and sufficient conditions (excluding proofs) – Harmonic and orthogonal properties of analytic function – Construction of analytic functions – Bilinear transformations

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UNIT IV COMPLEX INTEGRATION **9 + 3**

Complex integration – Statement and applications of Cauchy's integral theorem and Cauchy's integral formula

UNIT V SINGULARITIES AND RESIDUES **9 + 3**

Taylor's and Laurent's series expansions – Singular points – Classification of singularities – Residues – Cauchy's residue theorem

Contact Periods:

Lecture: 45 Periods Tutorial: 15 Periods Practical: – Periods Project – Periods

Total 60 Periods

TEXTBOOKS:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India Pvt Ltd, New Delhi, 2018.
2. Grewal B S, "Higher Engineering Mathematics", 44th Edition, Khanna Publishers, New Delhi, 2017.

REFERENCES:

1. Bali N P and Dr Manish Goyal, "A text book of Engineering Mathematics", 12th Edition, Laxmi Publications, 2016.
2. Thomas G B and Finney R L, "Calculus and Analytic Geometry", 14th Edition, Pearson Education India, 2018.
3. James Stewart, "Calculus: Early Transcendental", 7th Edition, Cengage Learning, New Delhi, 2015.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	**End Semester Examinations**
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	**60**	**40**	**60**	**200**	**100**
Total				**40**	**60**
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER II

U21PH201	MATERIALS SCIENCE (Common to all branches except BME)	Category: BSC				
		L	T	P	J	C
		2	0	0	0	2

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To gain the knowledge of conducting and semiconducting materials
- To understand the concepts of magnetic, dielectric and optical properties of materials
- To enhance the knowledge of new engineering materials

COURSE OUTCOMES:

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

CO1: Demonstrate the electrical characteristics of conducting materials (Understand)
CO2: Interpret the properties and types of semiconducting materials (Understand)
CO3: Compare various types of magnetic materials for engineering applications (Understand)
CO4: Explain the fundamental concepts of dielectric and optical materials (Understand)
CO5: Examine new engineering materials for industrial applications (Understand)

CO–PO MAPPING:

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	–	–	–	1	–	–	–	–	–	1	2	1
CO2	3	2	–	–	–	1	–	–	–	–	–	1	2	1
CO3	3	2	–	–	–	1	–	–	–	–	–	1	2	1
CO4	3	2	–	–	–	1	–	–	–	–	–	1	1	1
CO5	3	2	–	–	–	1	–	–	–	–	–	1	2	1
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)				3: Substantial (High)							

SYLLABUS:

UNIT I CONDUCTING MATERIALS **6**

Classical free electron theory – Expression for electrical conductivity and thermal conductivity – Wiedemann – Franz law – Drawbacks – Fermi distribution function – Density of energy states in metals

UNIT II SEMICONDUCTING MATERIALS **6**

Intrinsic and Extrinsic semiconductor – Carrier concentration in n–type semiconductor – P–type semiconductor(qualitative) – Applications of semiconductors – Solar cell – LED – Hall effect and its experimental determination

UNIT III MAGNETIC MATERIALS **6**

Origin of magnetism – Dia, para and ferro magnetic materials – Domain theory – Soft and hard magnetic materials – Magnetic bubble memories – GMR sensor

UNIT IV DIELECTRIC AND OPTICAL MATERIALS **6**

Dielectrics – Types of polarisation – Electronic polarisation – Dielectric breakdown – Ferroelectrics – Applications of dielectrics – Classification of optical materials – Nonlinear optics – Applications

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UNIT V NEW ENGINEERNG MATERIALS AND CHARACTERIZATION TECHNIQUES 6

SMA – SiC – GaN – Rheological materials – Nanomaterials – Synthesis (Ball milling and CVD) – Quantum dot, quantum wire and quantum well(qualitative) – Characterisation techniques – Powder XRD(qualitative) – SEM

Contact Periods:

Lecture: 30 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 30 Periods

TEXTBOOKS:

1. Wahab M A, "Solid State Physics: Structure and Properties of Materials", 3rd Edition, Narosa Publishing House, Chennai, 2018
2. Marikani A, "Materials Science", 1st Edition, PHI publishers, Chennai, 2017

REFERENCES:

1. Pillai S O "Solid State Physics", 9th Edition, New Age International Publishers, New Delhi, 2020
2. Bangwei Zhang, "Physical Fundamentals of Nanomaterials", Chemical Industry Press, China, 2018
3. Joginder Singh Galsin, "Solid State Physics – An Introduction to Theory", Academic Press, India, 2019
4. https://nptel.ac.in/courses/108/108/108108122/
5. https://nptel.ac.in/courses/113/105/113105081/

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	**End Semester Examinations**
Individual Assignment / Seminar / Mini Project / MCQ	Written Test	Individual Assignment / Seminar / Mini Project / MCQ	Written Test		
40	**60**	**40**	**60**	**200**	**100**
Total				**40**	**60**
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER II

U21ME201	ENGINEERING MECHANICS	Category: PCC					
		L	T	P	J	C	
		3	0	0	0	3	

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To expose various laws of force for equilibrium of rigid bodies
- To introduce the concepts of properties of surfaces and solids
- To impart knowledge on the fundamentals of dynamics of particles and rigid bodies

COURSE OUTCOMES (CO)

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

CO1: Identify various force systems in a plane (Apply)
CO2: Solve equilibrium of rigid bodies in two dimensions (Apply)
CO3: Calculate the centroid, area and mass moment of inertia for surfaces and solids (Apply)
CO4: Apply the concept of dynamics for particle motions (Apply)
CO5: Determine the friction of elements and dynamics of rigid bodies (Apply)

COURSE ARTICULATION MATRIX:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	–	–	–	–	–	–	–	2	2	2
CO2	3	3	2	1	–	–	–	–	–	–	–	2	2	2
CO3	3	3	2	1	–	–	–	–	–	–	–	2	2	1
CO4	3	3	2	1	–	–	–	–	–	–	–	2	2	2
CO5	3	3	2	1	–	–	–	–	–	–	–	2	2	1
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)								3: Substantial (High)			

SYLLABUS:

UNIT I EQUILIBRIUM OF FORCES 9

Types of force systems – coplanar concurrent forces – Resultant – Moment of a force and its application – Couples and resultant of a force system, equations of equilibrium of coplanar concurrent and non – concurrent force systems, Lami's theorem, resolution of a force into a force and a couple, polygon law of forces for resultant

UNIT II EQUILIBRIUM OF RIGID BODIES 9

Free body diagram – Types of supports – Support reactions – Moment of a force about a point and about an axis – Moments and couples – Scalar components of a moment – Varignon's theorem – Single equivalent force – Equilibrium of rigid bodies in two dimensions

UNIT III PROPERTIES OF SURFACES AND SOLIDS 9

Centroids and centre of mass – Centroids of lines and areas – Rectangular, circular, triangular areas by integration – T section, I section and Hollow section by using standard formula. Theorems of Pappus – Area moments of inertia of plane areas – Rectangular, circular, triangular areas by integration. T section, I section, Hollow section by using standard formula – Parallel axis theorem and perpendicular

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axis theorem. Principal moments of inertia of plane areas – Principal axes of inertia–Mass moment of inertia – Mass moment of inertia for prismatic and cylindrical solids

UNIT IV DYNAMICS OF PARTICLES 9

Displacements, velocity and acceleration – relationship – Relative motion – Curvilinear motion. Newton's laws of motion – Work energy equation – Impulse and momentum – Impact of elastic bodies

UNIT V FRICTION AND ELEMENTS OF RIGID BODY DYNAMICS 9

Friction force – Laws of sliding friction – Equilibrium analysis of simple systems with sliding friction – Wedge friction. Rolling resistance – Translation and Rotation of Rigid Bodies – Velocity and acceleration – General Plane motion of simple rigid bodies such as cylinder, disc/wheel and sphere

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total 45 Periods

TEXTBOOKS

1. Vela Murali, "Engineering Mechanics", Oxford University Press, 1st Edition 2010
2. S. S. Bhavikatti, Engineering Mechanics, New Age International Publishers, 3rd Edition 2016.

REFERENCES

1. Beer, F.P and Johnston Jr. E.R., "Vector Mechanics for Engineers: Statics and Dynamics", 8th Edition, Tata McGraw–Hill Publishing company, New Delhi 2014.
2. S. Timoshenko, D.H. Young, J.V. Rao, Sukumar Pati, Engineering Mechanics, 4th Edition, TMH Education, 2016.
3. Sanjay Bansal, R.K. Bansal, A Textbook of Engineering Mechanics, Laxmi Publications Pvt Ltd, 8th Edition,2011

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	Final Continuous Assessment
Individual Assignment / Seminar / Mini Project / MCQ	Written Test	Individual Assignment / Seminar / Mini Project / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose anyone / two components based on the nature of the course.

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SEMESTER II

U21EC101	INTRODUCTION TO ELECTRICAL AND ELECTRONICS ENGINEERING (Common to EC and MI : For EC, It is offered during I Semester and For MI, It is offered during II Semester)	Category: PCC				
		L	T	P	J	C
		2	0	0	0	2

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To learn the basic concepts of electric circuits
- To acquire the knowledge on constructional details of DC and AC machines
- To understand the working of measuring instruments and consumer electronic gadgets

COURSE OUTCOMES:

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

CO1: Outline the fundamental concepts of electric circuits (Understand)
CO2: Utilize DC machines for real time applications (Apply)
CO3: Explain the construction and operation of AC machines (Understand)
CO4: Compare the principles of various measuring instruments (Apply)
CO5: Summarize the consumer electronic gadgets (Understand)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	–	–	–	–	–	–	–	–	–	–	–	2	2
CO2	3	2	–	–	–	–	–	–	–	–	–	–	2	2
CO3	2	–	–	–	–	–	–	–	–	–	–	–	2	2
CO4	3	2	2	–	–	–	–	–	–	–	–	–	2	2
CO5	2	–	–	–	–	–	–	–	–	–	–	–	2	2
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)				3: Substantial (High)							

SYLLABUS:

UNIT I FUNDAMENTALS OF ELECTRIC CIRCUITS **6**

Basic terminology – Voltage, current, power, electromotive force, resistor and its types, capacitors and inductors – Types, V–I relations and energy stored – AC fundamentals – Three phase power supply – Line and phase voltages – Star connection – Delta connection

UNIT II DC MACHINES **6**

Construction – Operating principle – Types – Applications of DC generator and motor

UNIT III AC MACHINES **6**

Construction – Principle of operation – Types – Applications of transformers – Single and three phase induction motor – Stepper motor – Servo motor

UNIT IV MEASURING INSTRUMENTS **6**

Voltmeter – Ammeter – Digital multimeter – Megger – CRO – Storage oscilloscope – Energy meter – Spectrum Analyzer

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UNIT V CONSUMER ELECTRONICS 6

Microphone – Loudspeaker – Display devices – Digital cameras – Smart TV – Washing machine – Microwave oven – Mobile phones

Contact Periods:

Lecture: 30 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 30 Periods

TEXTBOOKS:

1. S. Salivahnan, R. Rengaraj, G R Venkatakrishnan., "Basic Electrical, Electronics and Measurement Engineering", 1st Edition, Tata McGraw Hill Publishing Company Ltd, 2018
2. A.K.Sawhney, "A course in Electrical and Electronic Measurements and Instrumentation"' 2nd Edition, Dhanpat Rai & Sons, 2005

REFERENCES:

1. Bhattacharya S.K., "Electrical Machines", 4th Edition, McGraw–Hill Education, New Delhi, 2017
2. Mitchel E Schultz, "Basic Electronics", 10th Edition, McGraw Hill Publishers, 2017
3. Bali S P, "Consumer Electronics", 1st Edition, Pearson Education Asia Pvt. Ltd., 2008

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	**End Semester Examinations**
*Individual Assignment / Case Study / Seminar / Mini Project / MCQ	Written Test	*Individual Assignment / Case Study / Seminar / Mini Project / MCQ	Written Test		
40	**60**	**40**	**60**	**200**	**100**
Total				**40**	**60**
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER II

U21EN201	PERSONALITY ENHANCEMENT Common to AD, BM, CH, CE, CS, CS(AIML),EE,EC,ME,MI,IT)	Category: HSMC				
		L	T	P	J	C
		1	0	2	0	2

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To develop of personality traits that contributes in the professional environment
- To create a basic awareness about the significance of soft skills in professional and interpersonal communications
- To enhance the level of self–confidence that helps to excel in the leadership skills

COURSE OUTCOMES:

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

CO1: Nurture a deep understanding of personality development and interpersonal relationship for overall self–development (Understand)
CO2: Communicate proficiently in high–end interviews and in all social situations (Understand)
CO3: Synthesize complex concepts and present them in speech and writing (Analyze)
CO4: Negotiate lead teams towards success (Understand)
CO5: Present ideas in an effective manner using web tools (Apply)

CO–PO MAPPING:

POs / Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	–	–	–	–	–	–	–	–	2	3	–	1	1	–
CO2	–	–	–	–	–	–	–	1	2	3	–	1	1	–
CO3	–	–	–	–	–	–	–	–	2	3	–	–	1	–
CO4	–	–	–	–	–	–	–	–	2	3	–	–	1	–
CO5	–	–	–	–	–	–	–	1	–	3	–	–	1	–

Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SYLLABUS:

UNIT I LEXICAL REASONING 9

Module:1 Establishing Associations

Activity: Verbal Analogy, Logical Reasoning

Module:2 Lateral Thinking

Activity: Reasoning and Assertions

Module:3 Sentence Completion

Activity: Cloze Test, Single Word Substitutes

UNIT II SOCIAL CORRESPONDENCE 9

Module:4 Etiquettes

Activity: Brain storming & performing in actions

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Module:5 Introspection

Activity: SWOT Analysis, Goal Setting

Module:6 Co–verbal Gesture

Activity: Body Language, Nonverbal cues

UNIT III ART OF NETWORKING 9

Module:7 Addressing a Multitude

Activity: Welcome address, Vote of Thanks, Public Speaking

Module:8 Persuasive Communication

Activity: Making Technical Presentation

Module:9 Career Oriented Communication

Activity: Face to face Conversation, Mock Interview

UNIT IV CRITICAL THINKING 9

Module:10 Organizing ideas

Activity: Mind Mapping

Module:11 Problem Solving Skills

Activity: Conflict management, Case Study

Module:12 Critical Review

Activity: Book/ Movie Review, Comparative Analysis

UNIT V CONTENT WRITING 9

Module:13 Reports

Activity: Writing Event Report, Project Report

Module:14 Writing for Digital platform

Activity: Writing Posts, Blogs

Module:15 Developing Content

Activity: Product Description, Writing Proposals

LIST OF EXERCISES

1. Listening to Inspirational Speech
2. Listening to Product Description
3. Book/Movie Review
4. Presentation
5. Mock Interview
6. Public Speaking

Contact Periods:

Lecture: 15 Periods Tutorial: – Periods Practical: 30 Periods Project: – Periods

Total: 45 Periods

TEXTBOOKS:

1. Meenakshi Raman & Sangeetha Sharma. "Professional English: for AKTU", 1st Edition, Oxford University Press. 2018.
3. Barun. K.Mitra. "Personality Development and Soft Skills", OUP India. 2nd Edition, 2016.

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4. Lab Manual

REFERENCES:

1. Mathew Allen. "Smart Thinking: Skills for Critical Understanding and Writing", 2nd Edition, OUP India, 2016.
2. Means, Thomas L, "English and Communication for Colleges", 4th Edition, Cengage 2017
3. Using English: "A Coursebook for Undergraduate Engineers and Technologists", 1st Edition, Orient Black Swan, 2017

EVALUATION PATTERN:

<table>
<tr><th colspan="4">Continuous Internal Assessments</th><th>End Semester Examinations</th></tr>
<tr><td colspan="2">Assessment I
(Theory)
(100 Marks)</td><td colspan="2">Assessment II
(Practical)
(100 Marks)</td><td rowspan="2">Practical Examinations
(Examinations will be conducted for 100 Marks)</td></tr>
<tr><td>Individual Assignment / Seminar / MCQ</td><td>Written Test</td><td>Evaluation of Laboratory Observation, Record
(Rubrics Based Assessments)</td><td>Test</td></tr>
<tr><td>40</td><td>60</td><td>75</td><td>25</td><td></td></tr>
<tr><td colspan="2">25</td><td colspan="2">25</td><td>50</td></tr>
<tr><td colspan="4">50</td><td>50</td></tr>
<tr><td colspan="5">Total: 100</td></tr>
</table>

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SEMESTER II

		Category: ESC				
		L	T	P	J	C
U21CSG02	PYTHON PROGRAMMING Common to All Branches	2	0	2	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand syntax and semantics of python programming
- To implement programs using python data structures
- To gain expertise in using python libraries for solving real time problems

COURSE OUTCOMES:

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

CO1: Describe the basic operations of tokens in python (Understand)
CO2: Demonstrate the programs using control statements (Apply)
CO3: Develop programs using python data structures (Apply)
CO4: Implement the exceptions in file–handling concepts (Apply)
CO5: Apply the python libraries in real–world problems (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	2	–	–	–	1	2	2	–	2	2	2
CO2	2	1	1	2	–	–	–	1	2	2	–	2	2	2
CO3	3	2	2	2	–	–	–	1	2	2	–	2	2	2
CO4	3	2	2	2	–	–	–	1	2	2	–	2	2	2
CO5	3	2	2	2	1	–	–	1	2	2	–	2	2	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I LANGUAGE BASICS **6**

Python interpreter and interactive mode – Tokens – Data types – Numbers and math functions – Input and Output operations – Comments – Reserved words – Indentation – Operators and expressions – Precedence and associativity – Type conversion – Debugging – Common errors in Python

UNIT II CONTROL STATEMENTS, FUNCTIONS, AND MODULES **6**

Selection – Conditional branching statements – if – if–else – Nested–if – if–elif–else statements – Iterative statements – while – for loop – break – continue and pass statements – Functions – Function Definition and Function call – Variable scope and Lifetime – Return statement – Lambda functions or Anonymous functions – Recursion – Modules and Packages

UNIT III PYTHON DATA STRUCTURES **6**

Strings – Slicing – Immutability – Built–in string methods and functions – Concatenating – Appending and Multiplying strings – String modules – List – Creation – Accessing values – Slicing – List methods – In–built functions for Lists – Tuples – Creation – Operations on tuples – Traversing – Indexing and Slicing – Tuple assignment – In–built functions for tuples – Sets – Creation – Operations – Dictionaries – operations and methods

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UNIT IV EXCEPTION AND FILE HANDLING 6

Exceptions – Errors and Exceptions – Handling exception – Built–in and User–defined exceptions – Files – Types – Operations – Open – Read – Write – Close

UNIT V NUMPY and PANDAS 6

Numpy – Introduction – Computations using NumPy functions – Computation on Arrays – Aggregation – Indexing and Sorting – Pandas – Introduction and Basic Pandas Concepts – Data frames – Data Handling

LIST OF EXPERIMENTS

1. Programs on selection and Iteration operations.
2. Get an integer input from a user. If the number is odd, then find the factorial of a number and find the number of digits in the factorial of the number. If the number is even, then check the given number is palindrome or not.
3. Strings and its operations.
4. Given two strings, PRINT (YES or NO) whether the second string can be obtained from the first by deletion of none, one or more characters.
5. List and its operations.
6. Programs for positive and negative indexing.
7. Program to check if the given list is in Ascending order or Not.
8. Tuples and its operations.
9. Python program to convert a tuple to a string.
10. Python program to reverse a tuple.
11. Sets and its operations.
12. Python program to check if a set is a subset of another set.
13. Dictionaries and its operations.
14. Python program to iterate over dictionaries using for loops.
15. Computations using NumPy functions.
16. NumPy program to convert a list of numeric value into a one–dimensional NumPy array.
17. NumPy program to convert a list and tuple into arrays.
18. Data manipulations using Pandas.
19. Program to convert a NumPy array and series to data frames.
20. Program to add, subtract, multiple and divide two Pandas Series.
21. Program to retrieve and manipulate data using dataframes.

Contact Periods:

Lecture: 30 Periods Tutorial: – Periods Practical: 30 Periods Project – Periods

Total 60 Periods

TEXTBOOKS:

1. Reema Thareja, "Python programming: Using problem solving approach", 1st Edition, Oxford Press, 2017
2. William McKinney, Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython, 2nd Edition, Shroff/O'Reilly Publication, 2017
3. Lab Manual

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REFERENCES:

1. Allen B. Downey, "Think Python: How to Think Like a Computer Scientist", 2nd Edition, Updated for Python 3, Shroff/O'Reilly Publishers, 2016
2. Ashok Namdev Kamthane and Amit Ashok Kamthane, "Programming and Problem Solving with Python", 2nd Edition, McGrawHill Education, 2018
3. Robert Sedgewick, Kevin Wayne, Robert Dondero, "Introduction to Programming in Python: An Inter–disciplinary Approach",1st Edition, Pearson India Education Services Pvt. Ltd., 2016
4. https://python–iitk.vlabs.ac.in/List%20of%20experiments.html
5. http://greenteapress.com/wp/think–python/

EVALUATION PATTERN:

<table>
<tr><th colspan="4">Continuous Internal Assessments</th><th colspan="2" rowspan="2">End Semester Examinations</th></tr>
<tr><th colspan="2">Assessment I
(Theory)
(100 Marks)</th><th colspan="2">Assessment II
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(100 Marks)</th></tr>
<tr><td>*Individual Assignment / Case Study / Seminar / Mini Project / MCQ</td><td>Written Test</td><td>Evaluation of Laboratory Observation, Record
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(Examinations will be conducted for 100 Marks)</td><td rowspan="2">Practical Examinations
(Examinations will be conducted for 100 Marks)</td></tr>
<tr><td>40</td><td>60</td><td>75</td><td>25</td></tr>
<tr><td colspan="2">25</td><td colspan="2">25</td><td>25</td><td>25</td></tr>
<tr><td colspan="4">50</td><td colspan="2">50</td></tr>
<tr><td colspan="6">Total: 100</td></tr>
</table>

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER II

U21ECG03	ENGINEERING STUDIO (Common to all Programmes)	Category: ESC				
		L	T	P	J	C
		0	0	4	0	2

PRE–REQUISITES:

- NIL

COURSE OBJECTIVES:

- To enable the students understand the functioning of simple to complex devices and systems
- To help the students design and build simple applications on their own
- To create an immersive environment in the engineering lab

COURSE OUTCOMES:

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

CO1: Understand basics of electronics (Understand)
CO2: Use basic electronic components and Arduino for prototyping (Apply)
CO3: Create simple real time use cases (Create)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	1	2	–	–	–	1	–	–	1	2	2
CO2	3	3	3	3	2	2	1	1	2	–	–	1	2	2
CO3	3	3	3	3	3	2	3	3	3	–	–	3	2	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)					

LIST OF EXPERIMENTS

Basics of Electronics

1. Breadboard Basics – LED glowing, Ohm's Law
   Series and Parallel Circuits
2. Controlling the circuit response using Potentiometer
   Capacitor Charging and Discharging
3. Water level Indicator using transistor
   Touch sensor using transistor
4. Automatic night light– (LDR –transistor) circuit
   Fire alarm Circuit
5. IR Sensor–Obstacle detecting circuit
   Doorbell using 555 Timer circuit
6. LED Chaser circuit using Counter IC
   Shadow detector using IC741
7. Regulated output using Regulator IC
   Logic gate Realization

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Basics of IoT (With Arduino)

1. Basics of ARDUINO and IoT
   Working with LEDs
2. Working with digital switch
   Adjusting voltage using potentiometer
3. Measuring the presence / absence of light using LDR
   Finding the distance of an object using ultrasonic sensor
4. Finding the Temperature and Humidity in the surroundings
   Detecting the motion of human using PIR
5. Working with Servo motor
   Establish communication using Bluetooth

Contact Periods:

Lecture: – Periods Tutorial: – Periods Practical: 60 Periods Project – Periods

Total 60 Periods

EVALUATION PATTERN:

Continuous Internal Assessments
Evaluation of course workbook, Tasks **(Rubrics based)**
100

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SEMESTER II

		Category: ESC				
U21MI201	MANUFACTURING AND AUTOMATION PRACTICES	L	T	P	J	C
		0	0	4	0	2

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To provide exposure in manufacturing and automation processes related to mechatronics.
- To provide hands on training experiences in woodwork, sheet metal, welding, soldering, sensors and actuators.
- To provides hands–on experience in additive manufacturing process (FDM and SLA)

COURSE OUTCOMES:

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

CO1: Identify the various tools and measuring equipment used in manufacturing and automation process related to mechatronics (Understand)
CO2: Fabricate products using carpentry and sheet metal (Apply)
CO3: Perform operations such as welding and soldering (Apply)
CO4: Connect and run the sensors and actuators (Apply)
CO5: Develop simple components using 3D printer (Apply)

CO PO Mapping:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	–	1	–	1	–	1	1	–	1	2	1
CO2	3	1	1	–	3	–	1	–	2	1	–	2	2	2
CO3	3	1	1	–	1	–	1	–	3	2	–	1	2	2
CO4	3	1	1	–	1	–	1	–	3	2	–	1	2	2
CO5	3	1	1	–	1	–	1	–	3	2	–	1	2	2

Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

LIST OF EXPERIMENTS

Introduction to Fabrication

1. Fabrication of wooden box/tray/any innovative model using T–joint, Dovetail joint, Mortise and Tenon joint.
2. Fabrication of sheet metal tray/funnel/any innovative model using cutting, drilling, taping, polishing and assembly operation.
3. Preparation of MS plate for Lap, Butt and Tee joints using arc welding
4. Soldering of a simple circuit consists of THC and SMD components.

Introduction to Sensors and Actuators

5. Test the response and range of the inductive proximity sensor to various materials.
6. Test the response and range of the capacitive sensor to various materials.

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7. Perform direct control of single–acting cylinder for both extension and retraction.
8. Perform direct and indirect control of double–acting cylinder.

Introduction to Additive Manufacturing Process

9. 3D prototyping of simple components using FDM method.
10. 3D Printing of simple geometric shapes using SLA printer.

Contact Periods:

Lecture: – Periods Tutorial: – Periods Practical: 60 Periods Project: – Periods

Total: 60 Periods

REFERENCES:

1. Workshop Manual

EVALUATION PATTERN:

Continuous Internal Assessments		End Semester Examinations
Evaluation of Laboratory Observation, Record **(Rubrics Based Assessments)**	Test	
75	25	
100		100
60		40
100		

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER III

U21MA303	FOURIER ANALYSIS AND BOUNDARY VALUE PROBLEMS (Common to CE, EE, ME, MI)	Category: BSC				
		L	T	P	J	C
		3	1	0	0	4

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the concepts of partial differential equations and its solutions
- To understand the concept of Fourier series and Fourier transform techniques in the field of engineering
- To understand the mathematical aspects that contribute to the solution of one– and two–dimensional partial differential equations

COURSE OUTCOMES:

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

CO1: Apply the fundamental concepts of partial differential equations to solve real life practical applications (Apply)
CO2: Demonstrate Fourier series to study the behavior of periodic functions and their applications in system communications and digital signal processing (Apply)
CO3: Analyze the spectral characteristics of signals using Fourier transforms to find the discrete/continuous function arising in signals (Apply)
CO4: Apply Fourier series to solve an initial–boundary value problem for one dimensional wave and heat equation (Apply)
CO5: Apply Fourier series to solve an initial–boundary value for two–dimensional heat equations (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	–	–	–	–	–	–	–	–	–	–	3	2
CO2	3	2	–	–	–	–	–	–	–	–	–	1	3	2
CO3	3	2	–	–	–	–	–	–	–	–	–	–	3	2
CO4	3	2	–	–	–	–	–	–	–	–	–	–	3	2
CO5	2	2	–	–	–	–	–	–	–	–	–	–	3	2
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)				3: Substantial (High)							

SYLLABUS:

UNIT I PARTIAL DIFFERENTIAL EQUATIONS **9 + 3**

Formation of partial differential equations – Singular integrals – Solutions of standard types of first order partial differential equations – Lagrange's linear equation – Solution methods for second order homogeneous equations with constant coefficients

UNIT II FOURIER SERIES **9 + 3**

Dirichlet's conditions – General Fourier series – Odd and even functions – Half range series – Parseval's identity – Harmonic analysis

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UNIT III FOURIER TRANSFORM 9 + 3

Fourier transform pair – Fourier sine and cosine transforms – Properties (without proof) – Transforms of simple functions – Convolution theorem – Parseval's identity

UNIT IV ONE DIMENSIONAL BOUNDARY VALUE PROBLEMS 9 + 3

Fourier series solution – Vibration of strings – One dimensional wave equation – One dimensional heat flow equation (unsteady state)

UNIT V TWO–DIMENSIONAL BOUNDARY VALUE PROBLEMS 9 + 3

Fourier series solution – Two–dimensional (steady state) heat flow equations (Cartesian form only) separation of variables

Contact Periods:

Lecture: 45 Periods Tutorial: 15 Periods Practical: – Periods Project – Periods

Total 60 Periods

TEXTBOOKS:

1. Erwin Kreyszig, "Advanced Engineering Mathematics",10th Edition Wiley India Pvt Ltd, New Delhi, 2018.
2. Grewal B. S, "Higher Engineering Mathematics", 44th Edition, Khanna Publishers, 2021.

REFERENCES:

1. Bali N.P and Manish Goyal, "A text book of Engineering Mathematics", Laxmi Publications; 12th Edition, 2016.
2. Wylie C. R. and Barrett L. C, "Advanced Engineering Mathematics", 6th Edition, Tata McGraw–Hill, New Delhi, 2016.
3. Narayanan S, Manicavachagom Pillay T. K. and Ramanaiah G, "Advanced Mathematics for Engineering Students", Vol. II & III, 2nd Edition, S. Viswanathan Publishers Pvt. Ltd, Chennai, 1998.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER III

U21MI301	KINEMATICS OF MACHINERY	Category: ESC				
		L	T	P	J	C
		3	1	0	0	4

PRE–REQUISITES:

- U21ME201: Engineering Mechanics
- U21MEG01: Engineering Graphics

COURSE OBJECTIVES:

- To introduce the basics of mechanisms
- To train the students to construct velocity diagram, acceleration diagram and cam profiles
- To provide in–depth understanding of kinematic principles of gears, gear trains and friction in various machine elements

COURSE OUTCOMES:

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

CO1: To create simple mechanisms based on the degrees of freedom (Apply)
CO2: To apply the concepts of kinematics to compute the velocity and acceleration of planar mechanisms by using graphical method (Apply)
CO3: To design and analyze the profile of various cam mechanisms for different applications (Apply)
CO4: To demonstrate the kinematic aspects of gears and gear trains (Apply)
CO5: To demonstrate the understanding of friction principles in clutches, brakes and bearings (Apply)

CO–PO MAPPING:

POs / Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	–	–	–	–	–	–	–	2	2	1
CO2	3	3	2	2	–	–	–	–	–	–	–	2	3	1
CO3	3	3	2	2	–	–	–	–	–	–	–	2	3	2
CO4	3	3	2	2	–	–	–	–	–	–	–	2	3	2
CO5	3	3	2	2	–	–	–	–	–	–	–	2	3	2
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)				3: Substantial (High)							

SYLLABUS:

UNIT I BASICS OF MECHANISMS **9 + 3**

Classification of mechanisms – Basic kinematic concepts and definitions – Degree of freedom, Mobility – Kutzbach criterion, Gruebler"s criterion – Grashof's Law – Kinematic inversions of four bar chain and slider crank chains – Limit positions – Mechanical advantage – Transmission Angle – Description of some common mechanisms – Quick return mechanisms, Straight line generators, Universal Joint – Rocker mechanisms

UNIT II KINEMATICS OF LINKAGE MECHANISMS **9 + 3**

Displacement, velocity and acceleration analysis of simple mechanisms – Graphical method– Velocity and acceleration polygons – Velocity analysis using instantaneous centre – Kinematic analysis of simple mechanisms – Coincident points – Coriolis component of Acceleration – Introduction to linkage synthesis problem

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UNIT III KINEMATICS OF CAM AND FOLLOWER 9 + 3

Classification of cams and followers – Terminology and definitions – Displacement diagrams – Uniform velocity, parabolic, simple harmonic and cycloidal motions – Derivatives of follower motions – Layout of plate cam profiles – Specified contour cams – Circular arc and tangent cams – Pressure angle and undercutting – Sizing of cams

UNIT IV GEARS AND GEAR TRAINS 9 + 3

Types of gears – Spur gear – Law of toothed gearing – Involute gearing – Interchangeable gears – Gear tooth action interference and undercutting – Nonstandard teeth – Gear trains – Parallel axis gears trains – Epicyclic gear trains – Automotive transmission gear trains

UNIT V FRICTION DEVICES 9 + 3

Clutches, Brakes and Bearings – Classification of clutches – Torque transmission capacity – Considerations for uniform wear and uniform pressure theory – Single plate and multi–plate clutch, centrifugal clutch. Classification of brakes – Braking effect – Classification of Brake – Analysis of Brakes – Classification of bearing – Friction in journal bearings

Contact Periods:

Lecture: 45 Periods Tutorial: 15 Periods Practical: – Periods Project: – Periods

Total: 60 Periods

TEXTBOOKS:

1. Rattan, S.S, "Theory of Machines", 4th Edition, Tata McGraw–Hill, New Delhi, 2017.
2. Singh, V.P., "Theory of Machines", 6th Edition, Dhanpat Raj & Co., New Delhi, 2017.

REFERENCES:

1. Uicker, J.J., Pennock G.R and Shigley, J.E., "Theory of Machines and Mechanisms", 4th Edition, Oxford University Press, England, 2014.
2. Khurmi, R.S and Gupta, K, "Theory of Machines", 14th revised Edition, S. Chand & Co. Ltd, New Delhi, 2020.
3. https://nptel.ac.in/courses/112105268

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose anyone / two components based on the nature of the course.

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SEMESTER III

U21MI302	SENSORS AND SIGNAL PROCESSING	Category: PCC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- U21PH101: Engineering Physics
- U21EC101: Introduction to Electrical and Electronics Engineering

COURSE OBJECTIVES:

- To understand the concepts of measurement and sensors
- To learn the different sensors used to measure various physical parameters
- To learn the fundamentals of signal processing circuits used in mechatronics system development

COURSE OUTCOMES:

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

CO1: Infer the basic concepts of measurement systems and sensors (Understand)
CO2: Demonstrates the sensor's basic working principles based on the change in R, L, and C, and smart sensors (Understand)
CO3: Explain the working principle and applications of proximity, ranging, magnetic and heading sensors (Understand)
CO4: Infer the basic concepts of the signals and operational amplifier (Understand)
CO5: Select a suitable signal conditioning system to enhance the quality of the signal (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	–	–	–	–	–	–	–	1	2	1
CO2	3	1	2	2	–	–	–	–	–	–	–	1	2	2
CO3	3	1	2	2	–	–	–	–	–	–	–	1	2	2
CO4	3	1	2	2	–	–	–	–	–	–	–	1	2	2
CO5	3	1	2	2	–	–	–	–	–	–	–	1	3	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I INTRODUCTION TO MEASUREMENT AND SENSORS 9

Basics of Measurement – Classification of errors – Error analysis – Static and dynamic characteristics of transducers – Performance measures of sensors – Classification of sensors – Sensor Output Signal Types – Sensor calibration techniques

UNIT II RESISTIVE, INDUCTIVE, CAPACITIVE, AND SMART SENSORS 9

Resistive transducers: Potentiometer, RTD, Thermistor – Thermocouple – Strain gauge – Torque measurement – Force measurement – Radiation sensor– Inductive transducer: LVDT, RVDT – Capacitive transducers – Introduction to Smart Sensors – Film sensor, MEMS & Nano Sensors

UNIT III PROXIMITY, RANGING, MAGNETIC AND HEADING SENSORS 9

Accelerometer – GPS, Bluetooth, Range Sensors – RF beacons, Ultrasonic Ranging, Reflective beacons, Laser Range Sensor (LIDAR) – Magnetic Sensors –types, principle, requirement and

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advantages: Magneto resistive – Hall Effect – Current sensor Heading Sensors – Compass, gyroscope, inclinometers

UNIT IV FUNDAMENTALS OF SIGNALS AND OPERATIONAL AMPLIFIERS 9

Standard signals – Operations on signal – Classification of Continuous Time (CT) and Discrete Time (DT) signals – Periodic and aperiodic signal, odd and even signal, energy and power signal, deterministic and random signal, causal and non–casual signal – Ideal op–amp– DC characteristics – Bias, offset, thermal drift – AC characteristics – Frequency response, slew rate

UNIT V SIGNAL CONVERTERS AND PROCESSING 9

Signal Converters: Design of S/H circuit, D/A converter (weighted resistor and R– 2R ladder types), A/D converters (Flash type, Successive approximation types) using op–amps. **Signal Processing:** DC bridges: Classification of resistances – Wheatstone bridge. AC bridges: Introduction –Sources and Detectors – Maxwell's inductance bridge – Wien's bridge

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Sawhney. A.K, "A Course in Electrical and Electronics Measurements and Instrumentation", 18th Edition, Dhanpat Rai & Company Private Limited, New Delhi, 2015.
2. Patranabis D, "Sensors and Transducers", 2nd Edition, PHI, New Delhi, 2011

REFERENCES:

1. John G. Webster, "Measurement, Instrumentation, and Sensors Handbook", 2nd Edition, CRC Press, United States, 2018
2. D Choudhury Roy., "Linear Integrated Circuits ", 5th Edition, New Academic Science, New Delhi, 2018.
3. Ramon Pallas.Amey and John G.Webster, "Sensors and Signal Conditioning", 2nd Edition, John Wiley & Sons, 2012.
4. Simon Haykin and Barry Van Veen, "Signals and Systems", 2nd Edition, Wiley, 2021.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER III

		Category: PCC				
U21MI303	MANUFACTURING PROCESSES	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To impart fundamentals knowledge on traditional and non–traditional manufacturing processes
- To equip the students with practical knowledge of the manufacturing processes
- To demonstrate the application of manufacturing processes in different components

COURSE OUTCOMES:

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

CO1: To study the concepts and basic mechanics of material removal processes and the significance of advanced CNC machining. (Understand)
CO2: To learn the basics, application, and limitation of various welding process. (Understand)
CO3: To impart the knowledge on various casting process. (Understand)
CO4: To familiarize with the advanced manufacturing process. (Understand)
CO5: To teach the basics of machine tools with reciprocating and rotating motions and abrasive finishing processes (Understand)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	2	2	3	–	–	–	–	–	–	1	2	2
CO2	3	1	2	2	3	–	–	–	–	–	–	1	2	2
CO3	3	1	2	2	3	–	–	–	–	–	–	1	2	2
CO4	3	1	2	2	3	–	–	–	–	–	–	1	2	2
CO5	3	1	2	2	3	–	–	–	–	–	–	1	2	2
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)					3: Substantial (High)						

SYLLABUS:

UNIT I MATERIAL REMOVAL PROCESSES **9**

Classification of machining processes and machine tools, different types of cutting tools, Nomenclature of single point and multi point cutting tool, Concept of cutting speed, feed and depth of cut. Coolants. Drilling, Boring and broaching machines. Indexing head, milling operations using simple, differential, and compound indexing. Introduction to CNC Machines and laser cutting machines

UNIT II SHEET METAL AND WELDING PROCESSES **9**

Introduction to sheet metal forming operations, Types of presses, drives, Operations: shearing bending, spinning, embossing, blanking, coining and deep drawing. Die materials, compound and progressive dies and punches. Classification of welding processes, electric arc, special welding methods: MMAW, GTAW, GMAW, GMAW–CO2 12 welding, submerged arc welding, electro–slag welding, electron beam welding, laser beam welding, ultrasonic welding, resistance welding, welding defects, and arc blow

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UNIT III CASTING AND FORMING PROCESSES 9

Types of Casting, Gating system, Special casting methods: Centrifugal casting, Permanent mold casting, Investment casting, Shell mold casting, Plaster mold casting, CO_2 mold casting, Casting defects and remedies. Forging, Rolling, Extrusion, Wire Drawing and Tube drawing, Forging Defects and Remedies

UNIT IV ADVANCED MANUFACTURING PROCESSES 9

Types of advanced manufacturing processes, Process principle, application, and limitations of: Ultra Sonic Machining, Abrasive Water Jet Machining, Chemical, Photo–Chemical, Bio–chemical and Electro–Chemical Machining and Electro Discharge Machining

UNIT V FINISHING PROCESSES 9

Operations and applications of surface, cylindrical and centreless grinding processes; dressing, truing and balancing of grinding wheels; grading and selection of grinding wheels. Magnetic Abrasive Finishing

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Groover, M. P., "Fundamentals of Modern Manufacturing", John Wiley and Sons Inc., 6th Edition, 2015
2. Kalpakjian. S, "Manufacturing Engineering and Technology", Pearson Education India Edition, 6th Edition, 2018.

REFERENCES:

1. Rao, P. N., "Manufacturing Technology (Vol. 1&2)", Tata McGraw Hill, 2013
2. Michael Fitzpatrick, Machining and CNC Technology, McGraw–Hill Education; 4th Edition, 2013.
3. Mishra P. K., "Nonconventional Machining", Narosa Publishing House, New Delhi, 2018
4. Jain V. K.,"Advanced Machining Processes", Allied Publishers, New Delhi, 12th Edition, 2010

EVALUATION PATTERN:

Continuous Internal Assessments				Total Internal Assessments	End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)			
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER III

U21MI304	ELECTRICAL DRIVES AND CONTROL	Category: PCC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- U21EC101: Introduction to Electrical and Electronics Engineering

COURSE OBJECTIVES:

- To learn the basic concepts of power semiconductor devices and electric drives
- To acquire the knowledge in the characteristics and operation of DC, AC drives and servo motor
- To understand the control techniques of DC, AC drives and servo motor

COURSE OUTCOMES:

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

CO1: Explain the construction and operation of power semiconductor devices (Understand)
CO2: Illustrate the characteristics of various electric drives (Understand)
CO3: Infer the operation and control techniques of DC motor drives (Understand)
CO4: Explicit the operation and control strategies of AC motor drives and servo motor (Understand)
CO5: Select the motor drives for industrial applications (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	–	–	–	–	–	–	–	–	1	2	1
CO2	3	2	2	–	–	–	–	–	–	–	–	1	2	1
CO3	3	2	2	–	–	–	–	–	–	–	–	1	2	1
CO4	3	2	2	–	–	–	–	–	–	–	–	1	2	1
CO5	3	2	2	1	–	–	–	–	–	–	–	1	2	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I POWER SEMICONDUCTOR DEVICES **9**

VI and Switching Characteristics: SCR, TRIAC, BJT, MOSFET and IGBT – Triggering and commutation circuit – Snubber circuit

UNIT II CHARACTERISTICS OF DRIVES **9**

Electric drive – Equations governing motor load dynamics –Steady state stability – Multi quadrant Dynamics: acceleration, deceleration, starting & stopping – Selection of power rating – Speed torque characteristics: Various types of load and drive motors

UNIT III DC DRIVES **9**

Speed control of DC motors using controlled rectifiers – DC choppers: Four quadrant operation – BLDC motors – Principle of operation – Drive schemes – Characteristics and control

UNIT IV AC DRIVES **9**

Induction motor drives – Torque equation – Speed control of 3–phase induction motor – Stator voltage control – Stator voltage and frequency control – Stator current control – Static rotor resistance control – Slip power recovery scheme – Servo Mechanism

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UNIT V DRIVE APPLICATIONS 9

Selection of motor – Digital techniques in speed control – Microcontroller based control of electric drives – Drive applications in robotic process automation – Case Studies

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Bimbhra B.S., "Power Electronics", 5th Edition, Khanna Publishers, New Delhi, 2018
2. Vedam Subrahmanyam," Electric Drives: Concepts and Applications", 2nd Edition, McGraw Hill, New Delhi, 2017

REFERENCES:

1. Singh M.D. & Kanchandhani K.B., "Power Electronics", 2nd Edition, McGraw Hill, New Delhi, 2017
2. Theraja B.L. & Theraja A.K., "A Textbook of Electrical Technology", Revised Edition, S. Chand& Co. Ltd., New Delhi, 2015
3. Gobal K. Dubey, "Fundamentals of Electrical Drives", 2nd Edition, Narosa Publishing House, New Delhi, 2022

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER III

		Category: PCC				
U21MI305	ELECTRONIC DEVICES AND DIGITAL CIRCUITS	L	T	P	J	C
		2	0	2	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To learn the fundamentals of semiconductor devices
- To understand the basics of digital logic circuits
- To design the combinational logic circuits and sequential circuits

COURSE OUTCOMES:

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

CO1: Illustrate the fundamentals of semiconductor materials and junction diodes (Understand)
CO2: Experiment with BJT and JFET characteristics (Understand)
CO3: Verify the Boolean functions using logic gates (Understand)
CO4: Design the combinational circuits (Apply)
CO5: Construct the sequential circuits (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	–	–	2	–	–	–	–	–	–	1	2	2
CO2	3	2	1	–	–	–	–	–	2	–	–	1	2	2
CO3	3	2	1	–	–	–	–	–	2	–	–	1	2	2
CO4	3	3	2	–	–	–	–	–	2	–	–	1	2	2
CO5	3	2	1	–	–	–	–	–	2	–	–	1	2	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)					

SYLLABUS:

UNIT I SEMICONDUCTOR DEVICES 6

Classification of semiconductors – Conductivity of semiconductors – PN junction diodes, Zener diode – I–V Characteristics – Applications, rectifiers and Zener voltage regulators

UNIT II TRANSISTOR THEORY 6

NPN and PNP Transistors – Early effect – Input and output characteristics of CE configuration – Construction and operation of JFET and MOSFET

UNIT III DIGITAL ELECTRONICS FUNDAMENTALS 6

Number systems–Boolean Algebra – Boolean postulates and laws – De–Morgan's Theorem – Minimization of Boolean expressions – Canonical forms – Gate level minimization– Karnaugh map, Tabulation Method – Don't care conditions

UNIT IV COMBINATIONAL LOGIC CIRCUITS 6

Half Adder – Full Adder – Half Subtractor – Full Subtractor – Multiplexer – Demultiplexer – Encoder / Decoder.

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UNIT V SEQUENTIAL LOGIC CIRCUITS 6

Latches: SR and D – SR, JK, D and T Flip flops – Excitation tables –Realization of one flip flop using other flip flops – Analysis and design of clocked sequential circuits with state diagram and State table – Design of synchronous and asynchronous counters

LIST OF EXPERIMENTS

1. Study the volt–ampere characteristics of PN diode and Zener diode
2. Application of Zener diode as voltage regulator
3. Characteristics of digital logic IC's
4. Implementation of combinational logic design using MUX IC's
5. Characteristics of SR and JK flip–flops
6. Simulation of full wave rectifier using multisim software

Contact Periods:

Lecture: 30 Periods Tutorial: – Periods Practical: 30 Periods Project: – Periods

Total: 60 Periods

TEXTBOOKS:

1. S. Salivahanan, N.Sureshkumar, A. Vallavaraj, Electronic Devices and Circuits, 3rd Edition, Tata McGraw–Hill Inc., 2010.
2. M.Morris Mano, Michael D Ciletti, "Digital Design", 6th Edition, Pearson, 2018
3. Lab Manual

REFERENCES:

1. Jacob Millman, Christos C Halkias, Satyabrata Jit, Electronic Devices and Circuits, 4th Edition, McGraw Hill India, 2015
2. Yang, Fundamentals of Semiconductor devices, 1st Edition, McGraw Hill International, 2017
3. Thomas L.Floyd, "Digital Fundamentals", 11th Edition, Prentice Hall, 2015
4. A.Anand Kumar, "Fundamentals of Digital Circuits", 2nd Edition, PHI Learning, 2013

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EVALUATION PATTERN:

<table>
<tr><td colspan="4">Continuous Internal Assessments</td><td colspan="2" rowspan="2">End Semester Examinations</td></tr>
<tr><td colspan="2">Assessment I
(Theory)
(100 Marks)</td><td colspan="2">Assessment II
(Practical)
(100 Marks)</td></tr>
<tr><td>*Individual Assignment / Case Study / Seminar / Mini Project / MCQ</td><td>Written Test</td><td>Evaluation of Laboratory Observation, Record
(Rubrics Based Assessments)</td><td>Test</td><td rowspan="2">Theory Examinations
(Examinations will be conducted for 100 Marks)</td><td rowspan="2">Practical Examinations
(Examinations will be conducted for 100 Marks)</td></tr>
<tr><td>40</td><td>60</td><td>75</td><td>25</td></tr>
<tr><td colspan="2">25</td><td colspan="2">25</td><td>25</td><td>25</td></tr>
<tr><td colspan="4">50</td><td colspan="2">50</td></tr>
<tr><td colspan="6">Total: 100</td></tr>
</table>

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER III

		Category: PCC				
U21MI306	SENSORS AND SIGNAL PROCESSING LABORATORY	L	T	P	J	C
		0	0	4	0	2

PRE–REQUISITES:

- U21ECG03: Engineering Studio
- U21MI201: Manufacturing and Automation Practices

COURSE OBJECTIVES:

- To learn about various force, pressure and vibration measuring sensors.
- To learn about various Temperature, optical and magnetic field–measuring sensors
- To learn about various displacement and speed–measuring sensors.

COURSE OUTCOMES:

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

CO1: Identify and measure the physical parameters using sensors and signal conditioning units. (Apply)
CO2: Analyze and measure the physical parameters using sensors (Apply)
CO3: Utilize the measurement systems to characterize the given physical quantity (Apply)
CO4: Interface the operational amplifier with sensors (Apply)
CO5: Measure the physical quantities using bridge circuits (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	–	–	–	–	2	–	–	1	2	1
CO2	3	2	1	2	–	–	–	–	2	–	–	1	2	1
CO3	3	2	1	2	–	–	–	–	2	–	–	1	2	1
CO4	3	2	1	2	–	–	–	–	2	–	–	1	2	2
CO5	3	2	1	2	–	–	–	–	2	–	–	1	2	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

LIST OF EXPERIMENTS

1. Determination of load, torque, and force using strain gauge
2. Study the characteristics of pressure sensor and piezoelectric accelerometer sensor
3. Determination of displacement using LVDT & RVDT
4. Determination of the characteristics of various temperature sensors (Thermocouple, RTD & Thermistors).
5. Determination of the Characteristics of light detectors (Optical Sensors).
6. Study the characteristics of Hall Effect sensor and its applications
7. Measurement of water level using capacitive level sensor
8. Measurement of speed, position, and direction using encoders
9. Measurement of linear and angular displacement using potentiometer
10. Measurement of torque using torque sensor

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11. Study the characteristics of three stage instrumentation amplifier with its applications
12. Measurement of the unknown resistance, inductance and capacitance using bridge circuits

Contact Periods:

Lecture: – Periods Tutorial: – Periods Practical: 60 Periods Project – Periods

Total 60 Periods

TEXTBOOKS:

1. Lab Manual

EVALUATION PATTERN:

Continuous Internal Assessments		**End Semester Examinations**
Evaluation of Laboratory Observation, Record **(Rubrics Based Assessments)**	Test	
75	25	
100		100
60		40
100		

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER III

		Category: PCC				
U21MI307	ELECTRICAL DRIVES AND CONTROL LABORATORY	L	T	P	J	C
		0	0	4	0	2

PRE–REQUISITES:

- U21EC101: Introduction to Electrical and Electronics Engineering

COURSE OBJECTIVES:

- To acquire the knowledge on DC/AC machines, power semiconductor devices and drives
- To understand the characteristics of DC/AC machines and power semiconductor devices
- To apply the power converters for industrial applications

COURSE OUTCOMES:

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

CO1: Infer the performance and characteristics of DC/AC machines and starters (Understand)
CO2: Demonstrate the speed control methods of DC shunt motor (Understand)
CO3: Understand the VI and switching characteristics of power semiconductor devices (Understand)
CO4: Examine the performance of DC motor and induction motor drives (Apply)
CO5: Analyze the performance of servomotor using controller (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	–	–	–	–	2	–	–	1	1	1
CO2	3	2	1	2	–	–	–	–	2	–	–	1	2	1
CO3	3	2	1	2	–	–	–	–	2	–	–	1	2	1
CO4	3	2	1	2	–	–	–	–	2	–	–	1	2	2
CO5	3	2	1	2	2	–	–	–	2	–	–	1	2	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

LIST OF EXPERIMENTS

1. Study of three–point, four–point, Star – Delta and DoL starters
2. Load test on DC shunt motor
3. Load test on three phase induction motor
4. Speed control of DC shunt motor
5. VI and Switching characteristics of SCR and TRIAC
6. VI and Switching characteristics of MOSFET
7. VI and Switching characteristics of IGBT
8. DSP based control of induction motor drives
9. DSP based control of DC motor drives
10. Simulation of Closed loop V/f control of induction motor
11. Speed control of DC servomotor using PID controller

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Contact Periods:

Lecture: – Periods Tutorial: – Periods Practical: 60 Periods Project – Periods

Total 60 Periods

TEXTBOOKS:

1. Lab Manual

EVALUATION PATTERN:

Continuous Internal Assessments		**End Semester Examinations**
Evaluation of Laboratory Observation, Record **(Rubrics Based Assessments)**	Test	
75	25	
100		100
60		40
100		

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER III

		Category: EEC				
		L	T	P	J	C
U21MI308	DESIGN STUDIO – I	0	0	0	2	1

PRE–REQUISITES:

- U21ECG03: Engineering Studio

COURSE OBJECTIVES:

- To inculcate the problem–solving and Innovation mindset
- To provide a platform for self–learning, experimenting, solving the real–world problems and to develop a product
- To enable hands–on experience for active learning

COURSE OUTCOMES:

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

CO1: Understand Design thinking, system thinking, mapping the problem statements to UNSDG (Understand)
CO2: Apply the design thinking steps "Empathize, Define, ideate and prototype" (Apply)
CO3: Create Experimental proof of concept (Create)
CO4: Demonstrate teamwork, project management, technical report writing and presentation skills (Apply)

CO–PO MAPPING:

POs / Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	–	3	3	3	3	3	3	3	3	–	–	–	2	1
CO2	3	3	3	3	3	3	3	3	3	–	2	1	2	3
CO3	3	3	3	3	3	3	3	3	3	–	3	2	3	1
CO4	–	–	–	–	2	–	–	2	3	3	3	1	3	1
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

COURSE CONDUCTION:

- The students will be divided into batches (maximum 4 students / batch). They will be provided the space, time, resources, and a mentor.
- With the guidance of assigned mentor, the students will find & validate a problem statement, map to UNSDG, identify the skills required for the project and self–learn.
- Applying the design thinking concept, the students will provide a solution and produce the version 1 of prototype.
- The student will learn teamwork, project management, technical report writing and presentation skills through this course.

Contact Periods:

Lecture: – Periods Tutorial: – Periods Practical: – Periods Project: 30 Periods

Total: 30 Periods

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EVALUATION PATTERN:

Review 0 (Within 10 days of commencement of semester)	Review 1 (Between 35th to 40th working day)	Review 2 (Between 80th to 90th working day)	Total
0	40	60	100

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SEMESTER IV

		Category: BSC				
U21MA404	STATISTICS AND NUMERICAL METHODS (Common to EE, ME & MI)	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the concepts of probability and statistics in the field of engineering
- To understand the concepts of testing the hypothesis for large and small samples
- To understand the concepts in design of experiments in the field of engineering

COURSE OUTCOMES:

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

CO1: Apply probability axioms and the moments of discrete and continuous random variables to core engineering problems (Apply)
CO2: Analyze large and small sample tests and perform small sample tests based on Chi–square, t and F distributions (Understand)
CO3: Design an experiment with proper observations and measurement to get a valid result using various design methods (Understand)
CO4: Identify the basic concepts of solving algebraic and transcendental equations (Understand)
CO5: Solve initial value problems of ordinary differential equations using numerical techniques (Understand)

CO–PO MAPPING:

POs / Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	–	–	–	–	–	–	–	–	–	1	2	1
CO2	3	2	–	–	–	–	–	–	–	–	–	–	2	1
CO3	3	2	–	–	–	–	–	–	–	–	–	–	2	1
CO4	2	2	–	–	–	–	–	–	–	–	–	–	2	1
CO5	2	2	–	–	–	–	–	–	–	–	–	–	2	1
Correlation levels:			1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)			

SYLLABUS:

UNIT I PROBABILITY 9

Probability – Axioms of probability – Conditional probability – Total probability – Baye's Theorem – Discrete and continuous random variable

UNIT II TESTING OF HYPOTHESIS 9

Large sample test for single mean and difference of means – Small sample test: t distribution – Chi square distribution – F distribution

UNIT III DESIGN OF EXPERIMENTS 9

One way and two–way classifications – Completely randomized design – Randomized block Design – Latin square design

UNIT IV SYSTEM OF EQUATIONS 9

Newton Raphson method – Gauss elimination method – Gauss Jordon method – Iterative methods of Gauss Jacobi and Gauss Seidel

UNIT V NUMERICAL SOLUTIONS OF ORDINARY DIFFERENTIAL EQUATIONS 9

Taylor's series method – Euler method – Modified Euler method – Fourth order Runge kutta method for solving first order differential equations

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total: 45 Periods

TEXTBOOKS:

1. Johnson R A, Miller I, Freund J, Miller and Freund's, "Probability and Statistics for Engineers", 8th Edition, Pearson Education, Asia,2015
2. Grewell B S, "Numerical methods in Science and Engineering", 9th Edition, Khanna Publishers, 2015
3. Gupta S C and Kapoor V K, "Fundamentals of Mathematical Statistics", 10th Edition, Sultan Chand Publishers, 2014

REFERENCES:

1. Bali N P and Manish Goyal "A textbook of Engineering Mathematics", 12th Edition, Laxmi Publishers, 2016

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER IV

U21MI401	DYNAMICS OF MACHINERY	Category: ESC				
		L	T	P	J	C
		3	1	0	0	4

PRE–REQUISITES:

- U21ME201: Engineering Mechanics
- U21MI301: Kinematics of Machinery

COURSE OBJECTIVES:

- To understand the force–motion relationship in components subjected to external forces and analysis of standard mechanisms
- To understand the effects of unbalance and vibration resulting from prescribed motions in a mechanism
- To understand the principles in mechanisms used for speed control and stability control

COURSE OUTCOMES:

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

CO1: Interpret inertia force, torque for reciprocating mechanisms and parameters of flywheel (Apply)
CO2: Illustrate the static and dynamic unbalance of revolving and reciprocating masses (Apply)
CO3: Determine the frequencies of free and damped vibrations (Apply)
CO4: Calculate the frequencies of forced and torsional vibration systems (Apply)
CO5: Classify different types of governors used for speed control of an engine and apply the principles of gyroscopic effects for stability control on various transport vehicles (Understand)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	–	–	–	–	–	–	–	2	3	2
CO2	3	2	1	1	–	–	–	–	–	–	–	2	3	2
CO3	3	2	1	1	–	–	–	–	–	–	–	2	3	2
CO4	3	2	1	1	–	–	–	–	–	–	–	2	3	2
CO5	3	2	1	1	–	–	–	–	–	–	–	2	2	1
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I FORCE ANALYSIS **9 + 3**

Dynamic force analysis – Inertia force and Inertia torque – D Alembert's principle – Dynamic Analysis in reciprocating engines – Gas forces – Inertia effect of connecting rod – Bearing loads – Crank shaft torque – Turning moment diagrams – Fly Wheels – Flywheels of punching presses – Dynamics of Cam–follower mechanism.

UNIT II BALANCING **9 + 3**

Static and dynamic balancing – Balancing of rotating masses – Balancing a single cylinder engine – Balancing of Multi–cylinder inline, V–engines – Partial balancing in engines – Balancing of linkages – Balancing machines – Field balancing of discs and rotors.

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UNIT III FREE AND DAMPED VIBRATIONS **9 + 3**

Basic features of vibratory systems – Degrees of freedom – Single degree of freedom – Free vibration – Equations of motion – Natural frequency – Types of Damping – Free vibration with viscous damping, critically damped system, under damped system

UNIT IV FORCED AND TORSIONAL VIBRATIONS **9 + 3**

Response of one degree freedom systems to periodic forcing – Harmonic disturbances –Disturbance caused by unbalance – Support motion – Transmissibility – Vibration isolation vibration measurement – Torsional systems – Natural frequency of single, two and three rotor systems, Torsionally Equivalent System – Stepped shaft and Geared shaft

UNIT V MECHANISM FOR CONTROL **9 + 3**

Governors – Types – Centrifugal governors – Gravity controlled and spring controlled centrifugal governors – Characteristics – Effect of friction – Controlling force curves. Gyroscopes – Gyroscopic forces and torques – Gyroscopic stabilization – Gyroscopic effects in Automobiles, ships and airplanes.

Contact Periods:

Lecture: 45 Periods Tutorial: 15 Periods Practical: – Periods Project – Periods

Total 60 Periods

TEXTBOOKS:

1. Rattan, S.S, "Theory of Machines", 4th Edition, Tata McGraw–Hill, New Delhi, 2017.
2. Khurmi, R.S and Gupta, K, "Theory of Machines", 14th Revised Edition, S. Chand & Co. Ltd, New Delhi, 2020.

REFERENCES:

1. Uicker, J.J., Pennock G.R and Shigley, J.E., "Theory of Machines and Mechanisms", 4th Edition, Oxford University Press, England, 2014.
2. Singh, V.P., "Theory of Machines", 6th Edition, Dhanpat Raj & Co., New Delhi, 2017
3. https://nptel.ac.in/courses/112104114

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER IV

		Category: PCC				
U21MI402	CONTROL SYSTEMS ENGINEERING	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- U21MA201: Laplace Transforms and Complex Variables

COURSE OBJECTIVES:

- To introduce knowledge on system modelling and response
- To understand the behavior of system in time domain and frequency domain
- To understand the concept of stability analysis, controllers, compensators and state variable approach

COURSE OUTCOMES:

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

CO1: Determine the transfer function of electrical and mechanical systems (Understand)
CO2: Analyze the performance of Linear Time Invariant (LTI) system using time domain approach (Understand)
CO3: Analyze the response of LTI system using frequency domain approach (Apply)
CO4: Interpret the stability of LTI system using Routh Hurwitz criterion, Root locus and Nyquist stability criterion (Apply)
CO5: Analyze the performance of system using state space approach (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	–	–	–	–	–	–	–	1	2	1
CO2	3	2	1	1	–	–	–	–	–	–	–	1	2	1
CO3	3	2	1	1	1	–	–	–	–	–	–	1	3	1
CO4	3	2	1	1	1	–	–	–	–	–	–	1	3	1
CO5	3	2	1	1	–	–	–	–	–	–	–	1	2	1
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I SYSTEM MODELING AND REPRESENTATION 9

Control system – Basic elements – Feed forward and feedback control theory – Electrical and mechanical transfer function models – Block diagram reduction – Signal flow graph

UNIT II TIME RESPONSE ANALYSIS 9

Transient response – Steady state response –Type and order – Performance of first order and second order system – Effect of an additional zero and pole – Steady state error – Study of PD, PI and PID control

UNIT III FREQUENCY RESPONSE ANALYSIS 9

Frequency response – Frequency domain specifications – Bode plot – Polar Plot – Design of compensators using Bode plot – Lag, lead and lag – lead compensation

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UNIT IV STABILITY ANALYSIS 9

Concept of stability – Characteristic equation – Routh Hurwitz criterion – Relative stability – Root locus concept – Nyquist stability criterion

UNIT V STATE VARIABLE ANALYSIS 9

State variable representation – Physical, phase and canonical variable – Conversion of state variable model to transfer function and transfer function to state variable model – Concept of controllability and observability

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Norman S. Nise, "Control System Engineering", 6th Edition, John Wiley & Sons, 2018
2. Ogata K, "Modern Control Engineering", 5th Edition, PHI, 2012

REFERENCES:

1. Nagrath J and Gopal M, "Control System Engineering", 5th Edition, New Age International Publishers, 2007
2. Benjamin C Kuo, "Automatic Control Systems", 7th Edition, Prentice Hall of India, 1995
3. Bhattacharya S K, "Control System Engineering", 3rd Edition, Pearson education, 2013

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	**End Semester Examinations**
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER IV

U21MI403	PROGRAMMABLE AUTOMATION CONTROLLERS	Category: PCC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- U21MI302: Sensors and Signal Processing
- U21MI304: Electrical Drives and Controls

COURSE OBJECTIVES:

- To understand the need for automation, I/O devices, PLC architecture and working
- To develop PLC ladder logic programming for various case studies
- To understand the SCADA functions, DCS, communication protocols, HMI and Industry 4.0

COURSE OUTCOMES:

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

CO1: Explain the input/output devices and PLC architecture (Understand)
CO2: Apply basics programming knowledge to perform simple ladder logic Programming (Apply)
CO3: Develop ladder logic Program using Timer/Counter, Data manipulation instructions and interface HMI for given application case studies (Apply)
CO4: Understand the Concepts of SCADA and DCS (Understand)
CO5: Infer different communication protocols (Understand)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	1	3	1	–	–	–	–	–	–	2	2	1
CO2	3	3	3	3	3	–	–	–	–	–	–	2	3	1
CO3	3	3	2	3	3	–	–	–	–	–	–	2	3	1
CO4	3	3	2	3	2	–	–	–	–	–	–	2	2	1
CO5	3	3	2	3	2	–	–	–	–	–	–	2	2	1
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I AUTOMATION AND PLC 9

Introduction to Automation, Discrete and Analog I/O devices, Relay Vs PLC, PLC: Definition and Architecture, Types of PLC, I/O Modules, Special I/O Modules, PLC Scan cycle. Selection, Installation, Maintenance and troubleshooting of PLC

UNIT II BASIC PLC PROGRAMMING 9

Programming languages of PLC– Introduction to Ladder logic programming: NO & NC connections, Latching, and Interlocking– Conversion of Relay ladder logic to PLC ladder logic programming. Editing, Compiling and Running of PLC ladder programming– I/O Addressing– Sourcing and sinking–Ladder logic programming for Discrete I/O's

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UNIT III ADVANCED PLC PROGRAMMING 9

Programming using Timer and counter instructions– Data manipulation Instructions: Arithmetic, Comparison, Scaling and move functions– Ladder logic programming for Analog I/O's– Developing PLC Ladder logic programming for given application case studies– HMI

UNIT IV SCADA AND DCS 9

Introduction to SCADA system: Architecture and Generations, Remote terminal units, Master and Slave Station of SCADA– Tagging, Graphics, Alarming and data logging, Trending chart, History of data, Report generation– Distributed Control System: Overview, Architecture, Features and Advantages – DCS applications and Case Study

UNIT V COMMUNICATION PROTOCOLS 9

Industrial Data Communications– Modbus– HART– Device Net– Profibus– Field bus– Serial communication– Modbus/ Modbus TCP/IP– Mechatrolink– CAN– Ether CAT– Human machine interfaces– Industry 4.0

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Petruzella Frank D., "Programmable Logic Controllers", 5th Edition, McGraw–Hill, New York, 2019.
2. Stuart Boyer A, "SCADA Supervisory Control and data acquisition", 4th Edition, ISA, France, 2016.

REFERENCES:

1. John W. Webb, Ronald A. Reis, "Programmable Logic Controllers Principles and Applications", 5th Edition, PHI publication, 2002.
2. Stuart G McCrady, "Designing SCADA application software –A Practical Approach", Elsevier, Netherlands, 2013.
3. Moustafa Elshafei, "Modern Distributed Control Systems: A comprehensive coverage of DCS technologies and standards", CreateSpace Independent Publishing Platform, 1st Edition, 2016.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER IV

		Category: PCC				
U21MI404	MICROCONTROLLER AND EMBEDDED SYSTEMS	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- U21MI305: Electronic Devices and Digital Circuits

COURSE OBJECTIVES:

- To familiarize the architecture and assembly language programming of microprocessor and microcontroller
- To perform embedded C programming using PIC 18 microcontroller's architecture
- To interface peripherals and external I/o's with the microcontroller using embedded C programming

COURSE OUTCOMES:

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

CO1: Interpret the basic concepts of 8085 microprocessor and 8051 Microcontroller (Understand)
CO2: Develop assembly language programming for 8051 Microcontroller (Apply)
CO3: Infer the architecture and functions of PIC 18 Microcontroller (Understand)
CO4: Perform embedded C programming using PIC 18 microcontroller (Apply)
CO5: Develop the embedded C program for the peripheral and external I/O's (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	1	–	–	–	–	–	–	2	2	1
CO2	3	2	1	2	3	–	–	–	–	–	–	2	3	2
CO3	3	2	3	3	3	–	–	–	–	–	–	2	3	2
CO4	3	2	3	3	3	–	–	–	–	–	–	2	3	3
CO5	3	2	3	3	3	–	–	–	–	–	–	2	3	3
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I INTRODUCTION TO MICROPROCESSOR AND MICROCONTROLLER **9**

8085 Microprocessor Architecture and Pin diagram – Addressing modes – Registers – ALU, Bus systems – Instruction sets – Interrupts – Microprocessor Vs Microcontroller – 8051 Microcontroller Architecture – Features and Specifications.

UNIT II ASSEMBLY LANGUAGE PROGRAMMING **9**

Fundamentals of Assembly Language Programming – Instruction to Assembler – Basic Arithmetic and Logical Programming – Interfacing and Programming of Serial Communication – Stepper motor interfacing of 8051 Microcontroller.

UNIT III PIC 18 MICROCONTROLLER **9**

Architecture of PIC 18 – Pin Description – Memory organization: Program memory – Data Memory – I/O Ports – Timers – Counters – External hardware interrupts– USART – ADC.

UNIT IV EMBEDDED C PROGRAMMING USING PIC 18 MICROCONTROLLER **9**

Introduction to Embedded C Programming – Assembly language programming Vs Embedded C programming – Programming Structure – Data types – memory models – Infinite loops and interrupts

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handling – I/O port programming – Timer programming – Counter programming – Serial communication.

UNIT V PERIPHERAL INTERFACING 9

Switch keypad – LCD – LED – ADC and DAC – I/O Programming – Sensors – Relays – Solenoid Valve and Heater – Stepper Motors – PWM Programming – Closed Loop Control Programming of DC Motors – Traffic Light control.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

TEXTBOOKS:

1. Ramesh Goankar, "Microprocessor 8085 Architecture, Programming and Interfacing", 6th Edition, Penram International publishers, Mumbai, 2013.
2. Mazidi, Muhammad Ali, Mckinlay, Rolin D. & Causey Danny, "PIC Microcontroller and Embedded Systems using Assembly and C for PIC 18", 2nd Edition, Pearson Education Asia, Noida, 2021.

REFERENCES:

1. Frank Vahid and Tony Givagis, "Embedded System Design", 2018, Wiley.
2. Wayne Wolf, "Computers as Components: Principles of Embedded Computer Systems Design", Elsevier, 2013.
3. Muhammad Ali Mazidi, Janice Gillipse Mazidi, Rolin D. Mckinlay, "The 8051 Microcontroller and Embedded Systems using Assembly and C", 2nd Edition, Pearson Education India, 2007.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER IV

		Category: HSMC				
U21SSG01	SOFT SKILLS – I	L	T	P	J	C
		0	0	2	0	1

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To inculcate potential skills and to work as a team effectively.
- To develop confidence and enhance interpersonal skills.

COURSE OUTCOMES:

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

CO1: Enhance decision making and negotiation skills (Analyze)
CO2: Maintain open, effective, and Professional Communication (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	–	–	–	–	–	–	–	–	–	3	–	2	–	–
CO2	–	–	–	–	–	–	–	–	2	3	–	1	–	–
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I VERBAL COMPETENCE **10**

Verbal Analogy – Spotting Errors – Ordering of Sentences – Cloze Test – Effective Listening – Reading Comprehension

UNIT II EFFECTIVE COMMUNICATION **10**

Overcoming Communication Barriers – Body Language and its Etiquettes – Contextual Communication – 7C's of Communication – Listening to Documentaries

UNIT III INTERPERSONAL SKILLS **10**

Group Decision Making – Paralanguage – Negotiation Skills – Preparation & Planning, Bargaining & Problem Solving –Self Grooming – SWOT Analysis

Contact Periods:

Lecture:	– Periods	Tutorial:	– Periods	Practical	30 Periods	Project	– Periods
						Total	30 Periods

TEXTBOOKS:

1. Prashant Sharma, "Soft Skills: Personality Development for Life Success", 1st Edition, BPB Publications,2022
2. Suresh Kumar E, Sreehari P and Savithri J, "Communication Skills and Soft Skills: An Integrated Approach", 1st Edition, Dorling Kindersley, 2011.

REFERENCES:

1. Jeff Butterfield, "Problem Solving and Decision Making", 2nd Edition, Course Technology, 2010.

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2. Wushow Bill Chou, "Fast–Tracking your Career: Soft Skills for Engineering and IT Professionals", 1st Edition, IEEE Press, 2013.

EVALUATION PATTERN:

Continuous Internal Assessments	Marks
Test – I	50
Test – II	50
Total	100

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SEMESTER IV

		Category: PCC				
U21MI405	PROGRAMMABLE AUTOMATION CONTROLLERS LABORATORY	L	T	P	J	C
		0	0	4	0	2

PRE–REQUISITES:

- U21MI306: Sensors and Signal Processing Laboratory
- U21MI307: Electrical Drives and Controls Laboratory

COURSE OBJECTIVES:

- To familiar and exercise the relay ladder logic program and wire the field devices for the given applications
- To control and monitor the field devices using PLC and HMI for the given applications
- To design the SCADA screen and display the essential parameters for the real–world applications

COURSE OUTCOMES:

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

CO1: Demonstrate Relay ladder logic program for the given application (Apply)
CO2: Interpret PLC ladder logic program and wire the Discrete I/O's with PLC (Apply)
CO3: Develop PLC ladder logic program for the Analog I/O's (Apply)
CO4: Monitor and control the real–world application case studies using PLC and HMI programming (Apply)
CO5: Develop SCADA screen and supervise the real–world application case studies (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	3	–	–	–	2	1	–	2	3	2
CO2	3	2	1	2	3	–	–	–	2	1	–	2	3	2
CO3	3	2	2	2	3	–	–	–	2	1	–	2	3	2
CO4	3	2	1	2	3	–	–	–	2	1	–	2	3	2
CO5	3	2	2	2	3	–	–	–	2	1	–	2	3	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

LIST OF EXPERIMENTS

1. Develop the relay ladder logic program for the sequence:
   a. Using NO& NC pushbutton and indicator lamb, perform the 2 input Logic Gate function such as AND, OR, NOT, NOR, NAND, EX–OR and EX–NOR.
   b. When the start push button is pressed, light should turn ON continuously until the stop push button is pressed.
   c. When the start push button 1 & 2 are pressed turn on Light 1 & 2 continuously, then Interlock the light 1 and light 2.
2. Using the timer and counter perform the relay logic operation:
   a. When the proximity sensor senses a metal object switch on the light after 10 Sec.
   b. Switch on the Contactor after the lever switch senses 5 objects.
3. Design and simulate a given application using PLC ladder logic program.

4. Develop the PLC program and wire the discrete I/O components with the PLC for the given case study by Implementing Timer, Counter, Compare and Math instructions.
5. Develop the PLC Program to Control Traffic Light and display the status of the traffic light in HMI.
6. Control and monitor the Temperature of water using PLC and HMI.
7. Develop the PLC ladder logic program to control the speed of the of AC motor using PLC and display the high, low and current speed of the motor using HMI.
8. Develop and perform the position control of the servo motor using PLC.
9. Develop the SCADA screen to graphically represent the entire system, which shows the status of I/O's, events, alarm function to continuously monitor and control the given application.
10. Design the SCADA screen for the given application which consist of trend chart, data logging and report generation.

Additional experiments:

1. Develop the PLC program to control the speed of the motor based on the input light intensity.
2. Perform the unwinding and rewinding application using AC drive panel.

Contact Periods:

Lecture: – Periods Tutorial: – Periods Practical: 60 Periods Project – Periods

Total 60 Periods

TEXTBOOKS:

1. Laboratory manual.

EVALUATION PATTERN:

Continuous Internal Assessments		**End Semester Examinations**
Evaluation of Laboratory Observation, Record **(Rubrics Based Assessments)**	Test	
75	25	
100		100
60		40
100		

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER IV

		Category: PCC				
U21MI406	MICROCONTROLLER AND EMBEDDED SYSTEMS LABORATORY	L	T	P	J	C
		0	0	4	0	2

PRE–REQUISITES:

- U21MI306: Sensors and Signal Processing Laboratory

COURSE OBJECTIVES:

- To learn about microcontroller and Embedded programming
- To develop assembly language and Embedded C programming to perform I/O interfacing
- To control the real–world application using Embedded C programming

COURSE OUTCOMES:

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

CO1: Perform the arithmetic and logical operations using microprocessors and microcontroller by means of assembly language programming (Apply)
CO2: Simulate embedded C program for given applications (Apply)
CO3: Interface the sensors, actuators and other I/O's with microcontrollers (Apply)
CO4: Design, monitor and logging the sensory data's using microcontrollers (Apply)
CO5: Develop the application to acquire and transfer of data using IoT platform (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	2	–	–	–	2	–	–	2	3	2
CO2	3	2	2	1	2	–	–	–	2	–	–	2	3	2
CO3	3	2	2	1	2	–	–	–	2	–	–	2	3	2
CO4	3	2	2	1	2	–	–	–	2	–	–	2	3	2
CO5	3	2	2	1	2	–	–	–	2	–	–	2	3	2
Correlation levels:			1: Slight (Low)			2: Moderate (Medium)				3: Substantial (High)				

LIST OF EXPERIMENTS

1. Arithmetic functions using 8085 Microprocessor using Assembly language programming
2. Sorting an array of data into ascending and descending order using 8085 Microprocessor using assembly language programming
3. Interfacing of switch and LED with 8051 Microcontroller using assembly language programming
4. Study on editing, debugging and simulation of Embedded C programming in software platform
5. Interfacing of stepper motor to rotate in clockwise and anti–clockwise using Embedded C programming
6. Development of Embedded C Programming to Interface LCD Screen
7. Detection and counting of the object using Embedded C Programming
8. Data logging of Real time temperature data using Embedded C programming
9. Development of Embedded C Program for the actuation of pneumatic cylinders for required sequence

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10. Development of Embedded C Program to monitor the level of water and transfer the data using IoT module

Additional Experiments:

1. Traffic light programming
2. PID controller

Contact Periods:

Lecture: – Periods Tutorial: – Periods Practical: 60 Periods Project – Periods

Total 60 Periods

TEXTBOOKS:

1. Laboratory Manual

EVALUATION PATTERN:

Continuous Internal Assessments		End Semester Examinations
Evaluation of Laboratory Observation, Record **(Rubrics Based Assessments)**	Test	
75	25	
100		100
60		40
100		

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER IV

U21MI407	DESIGN STUDIO – II	Category: EEC				
		L	T	P	J	C
		0	0	0	2	1

PRE–REQUISITES:

- U21MI308: Design Studio – I

COURSE OBJECTIVES:

- To inculcate the problem–solving and Innovation mindset
- To provide a platform for self–learning, experimenting, solving the real–world problems and to develop a product.
- To enable hands–on experience for active learning.

COURSE OUTCOMES:

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

CO1: Apply the problem–solving techniques (Design thinking and system thinking)
CO2: Create and validate low fidelity prototype / Experimental proof of concept. (TRL 4)
CO3: Demonstrate teamwork, project management, technical report writing and presentation skills

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	3	3	3	3	–	2	1	–	–
CO2	3	3	3	3	3	3	3	3	3	–	3	2	–	–
CO3	–	–	–	–	2	–	–	2	3	3	3	1	–	–
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)				3: Substantial (High)						

COURSE CONDUCTION:

- The students will be divided into batches (maximum 4 students / batch). They will be provided the space, time, resources, and a mentor for this design clinic 2 course.
- With the guidance of assigned mentor, the students will find & validate a problem statement, map to UNSDG, identify the skills required for the project and self–learn.
- Applying design thinking & system thinking concept the students will solve the problem and produce the version 1 of prototype. (TRL 4)
- The student will learn teamwork, project management, technical report writing and presentation skills through this course.

Contact Periods:

Lecture: – Periods Tutorial: – Periods Practical: – Periods Project 30 Periods

Total 30 Periods

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EVALUATION PATTERN:

Review 0 (Within 10 days of commencement of semester)	Review 1 (Between 35th to 40th working day)	Review 2 (Between 80th to 90th working day)	Total
0	40	60	100

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SEMESTER V

U21MI501	ROBOTICS AND AUTOMATION	Category: PCC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- U21MI301: Kinematics of Machinery
- U21MI401: Dynamics of Machinery

COURSE OBJECTIVES:

- To learn about basics of robots and their classifications
- To understand the robot kinematics and dynamics in various planar mechanisms
- To know about the various forms of automation

COURSE OUTCOMES:

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

CO1: Interpret the features, basic concepts and end effectors of robots (Understand)
CO2: Know the procedures for forward and inverse kinematics for industrial robots (Apply)
CO3: Derive the forward and inverse kinematics, dynamics for industrial robots (Apply)
CO4: Apply the various programming techniques in industrial applications (Apply)
CO5: Analyze the suitable applications for specific operations (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	1	–	–	–	–	–	–	2	3	2
CO2	3	3	2	2	1	–	–	–	–	–	–	2	3	2
CO3	3	3	2	2	1	–	–	–	–	–	–	2	3	2
CO4	3	3	2	2	1	–	–	–	–	–	–	2	3	2
CO5	3	3	2	2	1	–	–	–	–	–	–	2	3	2
Correlation levels:			1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)			

SYLLABUS:

UNIT I BASICS OF ROBOTICS 9

History of robotics – Components of industrial robot – Joint notation scheme – Classification of robots – Robot specifications – Precision of movements – End Effectors: Types of end effectors – Mechanical Gripper: Gripper force analysis – Vacuum cup – Magnetic gripper – Special types of grippers –. Programming modes – Robot applications

UNIT II ROBOT KINEMATICS 9

Introduction– Matrix representation – rigid motion & homogeneous transformation – Representation: Translation, Rotational and Combined transformation – Simple problems. Denavit – Hartenberg representation – forward & inverse kinematics of 2DOF and 3 DOF planar and spatial mechanisms

UNIT III ROBOT DYNAMICS 9

Linear and angular velocities of a rigid body – Velocity propagation – Derivation of Jacobian for serial manipulator – Acceleration of a rigid body – Inertia of a link – Equation of motion: Legrangian formulation – Newton Euler formulation

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UNIT IV TRAJECTORY, PATH PLANNING AND PROGRAMMING 9

Trajectory Planning – Joint space and Cartesian space technique – techniques of robot control – Robot programming and Languages – VAL Programming – Motion Commands, Sensor Commands, End effector commands, and Simple programs

UNIT V AUTOMATION 9

Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System – Robot Drives, Actuators and Control – Mechanization and Automation, Types of Automation, Assembly Automation Equipment, Robot Applications

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total: 45 Periods

TEXTBOOKS:

1. Saeed B. Niku, "Introduction to Robotics: Analysis, Control, Applications", 3rd Edition, Wiley India Pvt. Ltd., Noida, 2024
2. John.J.Craig, " Introduction to Robotics: Mechanics and Control", 4th Edition, Pearson Publication, 2018
3. Rajput R K, "Robotics and Industrial Automation", S Chand and Publishers, Chennai, 2018

REFERENCES:

1. Groover M.P., Weiss M. , Nagal R. N. and Odrey N.G., "Industrial Robotics – Technology, programming and Applications" Tata , McGraw–Hill Education Pvt Limited 2nd Edition, 2022
2. Jazar, "Theory of Applied Robotics: Kinematics, Dynamics and Control", Springer, 2nd Edition, 2020
3. Saha S. K, "Introduction to Robotics", Tata McGraw–Hill, ISBN: 9789332902800, 2nd Edition, 2014
4. Sathya Ranjan Deb, "Robotics Technology & flexible Automation" 2nd Edition, TataMcGraw–Hill Publication, 2009

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose anyone / two components based on the nature of the course.

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SEMESTER V

		Category: PCC				
U21MI502	HYDRAULICS AND PNEUMATICS SYSTEMS	L	T	P	*J	C
		2	0	2	0	3

PRE–REQUISITES:

- U21MI201: Manufacturing and Automation Practices

COURSE OBJECTIVES:

- To learn the fundamentals of hydraulic and pneumatic components
- To construct the hydraulic and pneumatic circuits using simulation software
- To develop the hydraulic and pneumatic circuits for real time application

COURSE OUTCOMES:

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

CO1: Identify fluid power components and their symbols as used in industry and select suitable hydraulic components for different industrial applications (Understand)
CO2: Select pneumatic components and fluid power actuators for low–cost automation (Understand)
CO3: Design and construct a fluid power circuits real time applications (Apply)
CO4: Design, construct, and test fluid power circuits with pneumatic, electrical, PLC and logic control for low–cost automation (Apply)
CO5: Develop and simulate fluid power circuits using simulation software for industrial applications (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	–	–	1	1	–	–	–	1	1	2	2
CO2	2	2	3	1	2	1	1	–	–	–	2	2	3	3
CO3	2	3	3	1	2	1	1	–	–	–	2	2	3	3
CO4	2	3	3	–	3	–	–	–	–	–	2	2	3	3
CO5	2	2	3	–	3	–	–	–	–	–	2	2	3	3
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)					

SYLLABUS:

UNIT I FLUID POWER SYSTEM AND HYDRAULIC PUMPS 6

Basics of fluid power system – Advantages and applications of Fluid power systems – Fluid properties – Pascal's Law and its application – Fluid power symbols – Hydraulic pumps: Gear, Vane and Piston pumps, Pump performance, Characteristics and Selection – Sizing of pumps (Numerical problems in Pumps).

UNIT II CONTROL COMPONENTS OF HYDRAULIC SYSTEM 6

Direction control valves: Three–way valve, Four–way valve, Check valve and shuttle valve – Actuation mechanisms in DCV – Pressure control valves: Pressure relief, Pressure Reducing, Counter balance, Sequencing and Unloading Valves – Flow control valves and its types – Proportional Valves – Servo valves: Mechanical type and Electrohydraulic servo valves.

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UNIT III PNEUMATIC SYSTEM AND ACTUATORS 6

Compressors: piston, screw and vane compressor – Fluid conditioning elements: Filter Regulator and Lubricator unit, Pneumatic silencers, After coolers, Air dryers – Air control valves – Fluid power actuators: Linear and Rotary actuators – types – Cushioning mechanism in cylinders – Sizing of actuators (Numerical problems in Actuators).

UNIT IV FLUID POWER CIRCUIT DESIGN 6

Basic pneumatic circuits – Pneumatic vacuum systems –Electrical components and electrical controls for Fluid power circuits – Cascade Circuit design method (two / three–cylinder circuits) – Accumulator – Types and application circuits – Pressure intensifier circuits – PLC applications in Fluid power circuit.

UNIT V INDUSTRIAL CIRCUITS AND MAINTENANCE 6

Industrial circuits: Speed control circuits – Regenerative cylinder circuits – Pump unloading circuit – Double pump circuit – Counterbalance valve circuit – Hydraulic cylinder sequencing circuit – Automatic cylinder reciprocating circuit – Cylinder synchronizing circuits – Fail safe circuits – Sealing devices: Types and materials – Installation, Maintenance and troubleshooting of Fluid Power systems.

LIST OF EXPERIMENTS

1. Design and testing of Meter–In & Meter–Out hydraulic Circuits using automation studio software
2. Design and testing of electro pneumatic operation of a double acting cylinder using SR and SS valves using automation studio software
3. Design and testing of door opening and closing circuit operations
4. Design and simulation of single cycle automation and multi cycle Automation of a double acting cylinder using electro pneumatics using automation studio software
5. Design and testing of sequencing of two double acting cylinders (A+B+A–B–)
6. Design, testing and simulation of cascading of three double acting cylinders (A+B+C+C–B–A–)
7. Design and testing of electro–hydraulic circuits (i) with pressure sequence valve (ii) with hydraulic motor

Contact Periods:

Lecture: 30 Periods Tutorial: – Periods Practical: 30 Periods Project: – Periods

Total: 60 Periods

TEXTBOOKS:

1. Esposito Anthony, "Fluid Power with Applications", 7th Edition, Pearson Higher Education, New York, 2015
2. Jegadeesa T., "Hydraulics and Pneumatics", I.K International Publishing House Pvt. Ltd., New Delhi, 2015
3. Lab Manual

REFERENCES:

1. Majumdar S.R., "Oil Hydraulic Systems – Principles and Maintenance", 2nd Edition, Tata McGraw–Hill, New Delhi, 2017
2. Majumdar S.R., "Pneumatic Systems – Principles and Maintenance", 2nd Edition, Tata McGraw–Hill, New Delhi, 2017

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EVALUATION PATTERN:

<table>
<tr><td colspan="4">Continuous Internal Assessments</td><td colspan="2">End Semester Examinations</td></tr>
<tr><td colspan="2">Assessment I
(Theory)
(100 Marks)</td><td colspan="2">Assessment II
(Practical)
(100 Marks)</td><td rowspan="2">Theory Examinations
(Examinations will be conducted for 100 Marks)</td><td rowspan="2">Practical Examinations
(Examinations will be conducted for 100 Marks)</td></tr>
<tr><td>*Individual Assignment / Case Study / Seminar / Mini Project / MCQ</td><td>Written Test</td><td>Evaluation of Laboratory Observation, Record
(Rubrics Based Assessments)</td><td>Test</td></tr>
<tr><td>40</td><td>60</td><td>75</td><td>25</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td colspan="2">25</td><td colspan="2">25</td><td>25</td><td>25</td></tr>
<tr><td colspan="4">50</td><td colspan="2">50</td></tr>
<tr><td colspan="6">Total: 100</td></tr>
</table>

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose anyone / two components based on the nature of the course.

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SEMESTER V

		Category: PCC				
U21MI503	UNMANNED AERIAL VEHICLE TECHNOLOGY	L	T	P	J	C
		2	0	2	0	3

PRE–REQUISITES:

- U21MI302: Sensors and Signal Processing
- U21MI402: Control Systems Engineering
- U21MI404: Microcontroller and Embedded Systems

COURSE OBJECTIVES:

- To understand the concepts needed in modelling and analyzing an unmanned system
- To acquire the knowledge on different types of aircraft systems
- To design and develop the drone system

COURSE OUTCOMES:

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

CO1: Infer the basic concepts of UAV system (Understand)
CO2: Prepare preliminary design requirements for an unmanned aerial vehicle (Apply)
CO3: Compare different hardware for UAV (Analyze)
CO4: Perform system testing for unmanned aerial vehicles (Apply)
CO5: Develop a micro aerial vehicle system by considering practical limitations (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	–	–	–	–	–	–	–	–	–	–	2	1
CO2	3	2	1	–	–	–	–	1	2	1	–	1	2	1
CO3	3	2	1	–	–	–	–	1	2	1	–	1	2	1
CO4	3	3	2	–	–	–	–	1	2	1	–	1	2	1
CO5	3	2	1	–	–	–	–	1	2	1	–	1	2	1
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I INTRODUCTION TO UAV 6

History of UAV – Classification – Introduction to Unmanned Aircraft Systems – Models and prototypes – System Composition

UNIT II DESIGN OF UAV SYSTEMS 6

Introduction to design and selection of the System – Aerodynamics and Airframe Configurations – Characteristics of Aircraft Types – Design Standards and Regulatory Aspects – UK, USA and Europe Design for Stealth – Control surfaces – Specification

UNIT III DRONE TECHNOLOGY 6

Drone Concept – Vocabulary Terminology – History of drone – Types of current generation of drones based on their method of propulsion – Drone technology impact on the businesses

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UNIT IV DRONE DESIGN, FABRICATION AND PROGRAMMING 6

Classifications of the UAV –Overview of the main drone parts– Technical characteristics of the parts – Function of the component parts –Assembling a drone– The energy sources– Level of autonomy– Drones configurations –The methods of programming drone

UNIT V DRONE FLYING AND OPERATIONS 6

Concept of operation for drone – Flight modes– Operate a small drone in a controlled environment– Drone controls Flight operations –management tool

LIST OF EXPERIMENTS

1. Calculate the thrust developed by the following propellers using thrust measurement device and plot the graph percentage of throttle input vs thrust output (in grams)
   a. 9–inch propeller
   b. 10–inch propeller
2. Calculate the rpm of the motor for the following propellers using laser tachometer and compare the results with the manual calculations. Plot a graph between the experimental rpm and theoretical rpm and theoretical rpm Vs percentage of throttle input
   a. BLDC 1400KV
   b. BLDC 1000KV
3. Perform the integration to receive wireless HD video in a ground display (7 inch)/ LED TV unit using a video transmitter and receiver 5.8GhZ 200mW
4. Perform binding of a transmitter and receiver of a fly sky 6channel transmitter with receiver
5. Perform the Motor–ESC calibration for the BLDC 1400KV motor with 30A ESC using a fly sky 6–channel transmitter with receiver.
6. Calibration and integration of Pixhawk controller with the aircraft model to deflect the primary control surface.

Contact Periods:

Lecture: 30 Periods Tutorial: – Periods Practical: 30 Periods Project: – Periods

Total: 60 Periods

TEXTBOOKS:

1. Reg Austin "Unmanned Aircraft Systems UAV design, development and deployment", Wiley, 2010
2. Paul G Fahlstrom, Thomas J Gleason, "Introduction to UAV Systems",4th Edition, 2012
3. Daniel Tal and John Altschuld, "Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation", 2021 John Wiley & Sons, Inc.
4. Lab Manual

REFERENCES:

1. Kimon P. Valavanis, "Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy", Springer, 2007
2. Dr. Armand J. Chaput, "Design of Unmanned Air Vehicle Systems", Lockheed Martin Aeronautics Company, 2001
3. John Baichtal, "Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs", Que Publishing, 2016
4. Terry Kilby and Belinda Kilby, "Make: Getting Started with Drones", Maker Media, Inc, 2016

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EVALUATION PATTERN:

Continuous Internal Assessments				End Semester Examinations	
Assessment I (Theory) (100 Marks)		**Assessment II (Practical) (100 Marks)**		**Theory Examinations (Examinations will be conducted for 100 Marks)**	**Practical Examinations (Examinations will be conducted for 100 Marks)**
*Individual Assignment / Case Study / Seminar / Mini Project / MCQ	Written Test	Evaluation of Laboratory Observation, Record **(Rubrics Based Assessments)**	Test		
40	**60**	**75**	**25**		
25		**25**		**25**	**25**
50				**50**	
Total: 100					

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose anyone / two components based on the nature of the course.

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SEMESTER V

U21SSG02	SOFT SKILLS – II	Category: HSMC				
		L	T	P	J	C
		0	0	2	0	1

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the importance of communication and enhance self confidence
- To acquire employability skills

COURSE OUTCOMES:

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

CO1: Actively participate in Group Discussion (Analyze)
CO2: Enhance interview skills and make effective Presentation (Apply)

CO–PO MAPPING:

POs / Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	–	–	–	–	–	–	–	–	2	3	–	–	–	–
CO2	–	–	–	–	–	–	–	–	2	3	–	–	–	–
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I PRESENTATION SKILLS **10**

Presentation Techniques – Time Management Techniques – Body language – Managerial Skills – Making Effective Presentation

UNIT II GROUP DISCUSSION AND PUBLIC SPEAKING **10**

Introduction to Group Discussion – Understanding Group Dynamics – Group Discussion Strategies– Activities to Improve GD Skills – Public Speaking Techniques – Public Speaking Activiti

UNIT III INTERVIEW SKILLS **10**

Listening to Interviews – Preparation for the Interview – Interview Techniques and Etiquettes –Handling Stress Interview – Mock Interview – Online Interview Techniques

Contact Periods:

Lecture: –Periods Tutorial: –Periods Practical: 30 Periods Project – Periods
Total 30 Periods

TEXTBOOKS:

1. Prashant Sharma, "Soft Skills: Personality Development for Life Success", BPB Publications, 1st Edition, 2022
2. Leader Interpersonal and Influence Skills: The Soft Skills of Leadership." Routledge Publications, 2014
3. Lab Manual

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REFERENCES:

1. Ghosh B N, "Managing Soft Skills for Personality Development", 1st Edition, Tata McGraw–Hill, 2012
2. Nitin Bhatnagar and Mamta Bhatnagar, "Effective Communication and Soft Skills Strategies for Success", 1st Edition, Pearson Education, 2012

EVALUATION PATTERN:

Continuous Internal Assessments	Marks
Test – I	50
Test – II	50
Total	100

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose anyone / two components based on the nature of the course.

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SEMESTER V

U21MI504	ROBOTICS AND AUTOMATION LABORATORY	Category: PCC				
		L	T	P	J	C
		0	0	4	0	2

PRE–REQUISITES:

- U21MI306: Sensors and Signal Processing Laboratory
- U21MI406: Microcontroller and Embedded Systems Laboratory

COURSE OBJECTIVES:

- To provide a practical realization of industrial robot and mobile robot for real time applications
- To realize the transport system of a production line of the industry environment
- To analyze the working of various types of elements of automation used in Industries and their practice

COURSE OUTCOMES:

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

CO1: Analyze the industrial robot problems and develop robot programming through ON/OFF line mode (Apply)
CO2: Develop an embedded programming for autonomous mobile robot (Apply)
CO3: Create a path and navigate the AGV based on the industrial operations (Apply)
CO4: Identify and measure the physical parameters using sensors and signal conditioning units (Apply)
CO5: Program the sequence of functions of several automation units (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	–	–	–	3	2	–	2	3	3
CO2	3	3	3	2	2	–	–	–	3	2	–	2	3	3
CO3	3	3	3	2	2	–	–	–	3	2	–	2	3	3
CO4	3	3	3	2	2	–	–	–	3	2	–	2	3	3
CO5	3	3	3	2	2	–	–	–	3	2	–	2	3	3
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

LIST OF EXPERIMENTS

1. Interpret the functions of Universal Robot, KUKA, Gantry and 4–Axis Handling Industrial robots: components, drive system and end effectors
2. Creation of Tool Centre Point (TCP) and Work Object using Universal Robot (Robotiq) / KUKA Industrial Robot
3. Robot programming exercises: Point–to–point, continuous path programming and pick and place operation in teach mode using Universal Robot (Robotiq)
4. Robot programming exercises: Point–to–point, continuous path programming and pick and place operation in teach mode using KUKA Industrial Robot
5. To develop the pick and place program for part assembly using 4–axis handling robot mover
6. To develop the stacking program for the finished workpieces using 3–axis gantry robot

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7. Development of embedded programming for motion and velocity control using Fire Bird – V robot.
8. To perform the assembled part drop–off and hands over the workpiece carrier to another conveyor belt system using Automated Guided Vehicle and Cyber Physical System
9. To regulate the sequential control of two double–acting cylinders using electro pneumatic module
10. To test the logics/ traffic light control/ seven segment displays using PLC module

Contact Periods:

Lecture: – Periods Tutorial: – Periods Practical: 60 Periods Project: – Periods

Total: 60 Periods

TEXTBOOKS:

1. Gupta A. K., Arora S. K. and Westcott J. R. "Industrial Automation and Robotics", Mercury Learning and Information, USA, 2017.
2. M.P. Groover, M. Weiss, R.N. Nagal, N.G. Odrey, "Industrial Robotics – Technology, programming and Applications" Tata, 2nd Edition, McGraw–Hill Education Pvt Limited, 2022
3. Lab Manual

REFERENCES:

1. Jazar, "Theory of Applied Robotics: Kinematics, Dynamics and Control", 2nd Edition, Springer, 2020
2. S K Saha, "Introduction to Robotics", 2nd Edition, Tata McGraw–Hill, ISBN: 9789332902800, 2014.
3. Laboratory Manual
4. Lab Soft X User Manuals

EVALUATION PATTERN:

Continuous Internal Assessments		End Semester Examinations
Evaluation of Laboratory Observation, Record (Rubrics Based Assessments)	Test	
75	25	
100		100
40		60
100		

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose anyone / two components based on the nature of the course.

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SEMESTER V

U21MI505	CNC AND METROLOGY LABORATORY	Category: PCC				
		L	T	P	J	C
		0	0	4	0	2

PRE–REQUISITES:

- U21MI303: Manufacturing Processes

COURSE OBJECTIVES:

- To provide exposure to various measuring instruments
- To provide hands on training experience for dimensions and surface finish measurement
- To provide hands on experience on CNC manufacturing processes

COURSE OUTCOMES:

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

CO1: Identify the various instruments used for measuring dimensions and surface finish (Understand)
CO2: Perform measurements using various profile projectors, CMM, comparators and roughness testers (Apply)
CO3: Perform measurement of force, torque and temperature (Apply)
CO4: Fabricate a part using CNC Lathe machine with turning and threading operations (Apply)
CO5: Perform drilling and milling operations using CNC Milling machine (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	–	1	–	1	–	1	1	–	1	2	1
CO2	3	1	1	–	3	–	1	–	2	1	–	2	2	2
CO3	3	1	1	–	1	–	1	–	3	2	–	1	2	2
CO4	3	1	1	–	1	–	1	–	3	2	–	1	2	2
CO5	3	1	1	–	1	–	1	–	3	2	–	1	2	2

Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

LIST OF EXPERIMENTS

1. Study of Measuring Instruments – Vernier Caliper, Micrometer, Vernier Height Gauge, Digital Height Gauge
2. Optical Measurement using Profile Projector
3. Measurement of Dimensions using Floating Gauge Micrometer and Comparators
4. Measurement of Dimensions using Coordinate Measuring Machine
5. Measurement of Surface Finish Measurement using Surface Roughness Tester
6. Measurement of Force, Torque and Temperature
7. Turning, Taper Turning and Treading using CNC Lathe
8. Drilling and Grooving using CNC Lathe with Canned Cycle
9. Pocketing and Contour Milling using CNC Milling Machine
10. Drilling and Tapping using CNC Milling Machine

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Contact Periods:

Lecture: – Periods | Tutorial: – Periods | Practical: 60 Periods | Project: – Periods | Total: 60 Periods

TEXTBOOKS:

1. S.P. Venkateshan, "Mechanical Measurements", 2nd Edition, Springer Cham, 2022
2. Micheal Fitzpatrick, "Machining and CNC Technology", 4th Edition, McGraw Hill, 2018
3. Peter Smid, "CNC Programming Handbook", 3rd Edition, Industrial Press, Inc., 2007
4. Lab Manual

REFERENCES:

1. Jain R.K., "Engineering Metrology", 20th Edition, Khanna Publishers, 2009
2. Beckwith, Marangoni, Leinhard, "Mechanical Measurements", Pearson Education, 2014
3. P.N. Rao, "Manufacturing Technology Metal Cutting and Machine Tools", 3rd Edition. Tata McGraw Hill, 2013

EVALUATION PATTERN:

Continuous Internal Assessments		**End Semester Examinations**
Evaluation of Laboratory Observation, Record **(Rubrics Based Assessments)**	Test	
75	25	
100		100
40		60
100		

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose anyone / two components based on the nature of the course.

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SEMESTER V

U21MI506	PROTO STUDIO I	Category: EEC				
		L	T	P	J	C
		0	0	0	2	1

PRE–REQUISITES:

- U21MI407: Design Studio II

COURSE OBJECTIVES:

- To inculcate the problem–solving and Innovation mindset
- To provide a platform for self–learning, experimenting, solving the real–world problems and to develop a product.
- To enable hands–on experience for active learning.

COURSE OUTCOMES:

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

CO1: Apply the problem–solving techniques (Design thinking and system thinking) (Apply)
CO2: Create Minimum Viable Product (TRL 5) (Analyze)
CO3: Analyze product to technology fit (Analyze)
CO4: Demonstrate teamwork, project management, technical report writing and presentation skills (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	3	3	3	3	–	2	1	2	2
CO2	3	3	3	3	3	3	3	3	3	–	3	2	2	2
CO3	3	3	3	3	3	3	3	3	3	–	3	2	2	2
CO4	–	–	–	–	2	–	–	2	3	3	3	1	2	2
Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)														

Course conduction:

- The students will be divided into batches (maximum 4 students / batch). They will be provided the space, time, resources, and a mentor for this Proto clinic 1 course.
- With the guidance of assigned mentor, the students will find & validate a problem statement, map to UNSGD, identify the skills required for the project and self–learn.
- The students will learn and apply design thinking, system thinking concept to solve the problem and produce the version 1 of MVP. (TRL 5)
- The student will learn teamwork, project management, product development, technical report writing and presentation skills through this course.

Contact Periods:

Lecture: – Periods Tutorial: – Periods Practical: – Periods Project 30 Periods

Total 30 Periods

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EVALUATION PATTERN:

Review 0 (Within 10 days of commencement of semester)	Review 1 (Between 35th to 40th working day)	Review 2 (Between 80th to 90th working day)	Total
0	40	60	100

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose anyone / two components based on the nature of the course.

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SEMESTER VI

U21MI601	MECHATRONICS SYSTEM DESIGN	Category: PCC				
		L	T	P	J	C
		3	1	0	0	4

PRE–REQUISITES:

- U21MI304: Electrical Drives and Control
- U21MI402: Control Systems Engineering

COURSE OBJECTIVES:

- To learn about Mechatronics system design and simulation, ergonomics and safety
- To learn the real time interfacing software and man machine interface
- To know about the various applications of Mechatronics system

COURSE OUTCOMES:

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

CO1: Recognize the basic concepts of Integration and familiar the elements of mechatronics (Understand)
CO2: Develop the system models and familiar the Mechatronics design process (Apply)
CO3: Apply Real–Time Mechatronics system integration (Apply)
CO4: Realize the data acquisition for Real Time application (Apply)
CO5: Analyze the various Mechatronics system (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	1	–	–	–	–	–	–	2	3	3
CO2	3	2	2	2	1	–	–	–	–	–	–	2	3	3
CO3	3	3	3	2	1	–	–	–	–	–	–	2	3	3
CO4	3	3	3	2	1	–	–	–	–	–	–	2	3	3
CO5	3	3	3	2	1	–	–	–	–	–	–	2	3	3

Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SYLLABUS:

UNIT I INTRODUCTION TO DESIGN OF MECHATRONICS SYSTEM **9**

Key elements – Mechatronics design process – design parameters – mechatronics and traditional design – Advanced approaches in mechatronics design – Introduction to industrial design, modelling, simulation and analysis – Ergonomics and safety

UNIT II BASIC SYSTEM MODELLING **9**

Introduction – model categories – fields of application – model development – Simulation using software – verification and validation – Mathematical modelling: Basic system modelling – mechanical electrical, fluid and thermal – Domain independent description forms: Bond graph and Block Diagram – Simulator coupling

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UNIT III MECHATRONIC SYSTEM MODELLING 9

Engineering systems: Rotational, translational, electro–mechanical, pneumatic–mechanical, hydraulic–mechanical, micro electromechanical system – Dynamic responses of system: first order, second order system – Performance measures

UNIT IV REAL TIME INTERFACING 9

Introduction – Selection of interfacing standards– elements of data acquisition and control systems – Overview of I/O process – general purpose I/O cards and its installation – Data conversion process – Application software – Man machine interface

UNIT V CASE STUDIES ON DESIGN OF MECHATRONICS SYSTEM 9

Motion control using DC Motor, AC Motor and Servomotor – Temperature control of hot/cold reservoir using PID – Pick and place robot – Car parking barriers – Motion and temperature control of washing machine – Auto focus camera – Electronics engine management system – Autonomous mobile robot

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total: 45 Periods

TEXTBOOKS:

1. Devdas Shetty, Richard A. Kolk, "Mechatronics System Design", 2nd Edition, Cengage Learning 2012
2. Georg Pelz, "Mechatronic Systems: Modeling and simulation" with HDL's, John Wiley and sons Ltd, 2003

REFERENCES:

1. Bolton W., "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering", 6th Edition, Pearson Education Limited, New York, 2015
2. Robert H. Bishop, "The Mechatronics handbook. Fundamentals and Modelling", 2nd Edition, CRC Press, London, 2008
3. Bradley, D. Dawson, N.C. Burd and A.J. Loader, "Mechatronics: Electronics in Products and Processes", CRC Press, First Indian print 2010

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER VI

U21MI602	ELECTRIC AND HYBRID VEHICLE TECHNOLOGIES IN AUTOMOBILES	Category: PCC				
		L	T	P	J	C
		2	0	4	0	4

PRE–REQUISITES:

- U21MI302: Sensors and Signal Processing
- U21MI304: Electrical Drives and Control
- U21MI404: Microcontroller and Embedded Systems

COURSE OBJECTIVES:

- To learn the various categories of automobile and their operations
- To understand the advanced motion control technologies in automobiles
- To acquire the knowledge for safely handing a hybrid and electric vehicle in case of a mishap

COURSE OUTCOMES:

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

CO1: Understand the petrol, diesel, and electric vehicle development over the time (Understand)
CO2: Analyze the operation and architecture of electric and hybrid vehicles (Apply)
CO3: Explain the characteristics of fuel cell electric vehicle (Apply)
CO4: Analyze the performance of various battery technologies for EV (Apply)
CO5: Infer the relationship between vehicle braking and energy recovery during braking (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	–	3	2	–	–	–	–	2	2	2
CO2	3	2	2	1	–	3	2	–	–	–	–	2	2	2
CO3	3	2	2	1	–	3	2	–	–	–	–	2	2	2
CO4	3	2	2	1	–	3	2	–	–	–	–	2	2	2
CO5	3	2	2	1	–	3	2	–	–	–	–	2	2	2
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)			3: Substantial (High)								

SYLLABUS:

UNIT I HISTORY AND ENVIRONMENTAL IMPACT OF MODERN TRANSPORTATION 6

History of EVs, HEVs, and Fuel Cell Vehicles – Air Pollution – Importance of Different Transportation Development Strategies – Operating Principles & Parameters: SI Engine, CI Engine – Emission Control

UNIT II ELECTRIC AND HYBRID ELECTRIC VEHICLE 6

Configurations of EVs – Performance of EVs: Tractive Effort, Traction Motor Characteristics and Vehicle Performance – Energy Consumption – Hybrid EV Drivetrain – Architecture of HEV Drivetrain – Series Hybrid and Parallel Hybrid – Mild Hybrid Systems

UNIT III FUEL CELL ELECTRIC VEHICLE 6

Operating Principles – Electrode Potential and Current–Voltage Curve – Fuel and Oxidation Consumption – Fuel Cell System Characteristics – Fuel Cell Technologies: Proton Exchange

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Membrane FC, Alkaline FC, Phosphoric FC, Molten Carbonate FC, Solid Oxide FC and Direct Methanol FC – Fuel Supply

UNIT IV ENERGY STORAGES AND PEAK POWER SOURCES 6

Electrochemical Batteries: Specific Energy, Specific Power, and Battery Technologies – Ultracapacitors: Features, Principle, Performance and Ultracapacitor Technologies – Ultra–High–Speed Flywheels: Operating Principles and Power Capacity – Hybridisation of Energy Storages

UNIT V FUNDAMENTALS OF REGENERATIVE BRAKING 6

Braking Energy Consumed in Urban Driving, Braking Energy versus: Vehicle Speed, Braking Power, Vehicle Deceleration Rate – Braking Power versus Vehicle Speed – Brake Systems of EV, HEV and FCV

LIST OF EXPERIMENTS

1. Study the energy flow in EV, HEV and FCV
2. Study the effect of the road profile in the HV system
3. Perform the task to determine the SoC and current f low between the battery and the inverter
4. Analyze the networking of the HV system's individual control units with each other
5. Perform the experiment to measure the HV voltage in the DC link while HV system is being started
6. Analyze the influence of 12V electrical system on the HV system

Contact Periods:

Lecture: 30 Periods Tutorial: – Periods Practical: 30 Periods Project: – Periods

Total: 60 Periods

TEXTBOOKS:

1. Mehrdad Ehsani, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles", 2nd Edition, CRC Press, 2010
2. William B. Ribbens, "Understanding Automotive Electronics", 8th Edition, Elsevier, 2017.
3. David A. Crolla, "Automotive Engineering – Powertrain, Chassis System and Vehicle Body", 1st Edition, Elsevier, 2009.
4. Lab Manual

REFERENCES:

1. Barry Hollembeak, "Automotive Electricity, Electronics & Computer Controls", Delmar Publishers, 7th Edition, 2019
2. Tom Denton, "Automobile Electrical and Electronics Systems", Edward Arnold Publishers, 2000. 2022

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EVALUATION PATTERN:

<table>
<tr><td colspan="4">Continuous Internal Assessments</td><td colspan="2" rowspan="2">End Semester Examinations</td></tr>
<tr><td colspan="2">Assessment I
(Theory)
(100 Marks)</td><td colspan="2">Assessment II
(Practical)
(100 Marks)</td></tr>
<tr><td>*Individual Assignment / Case Study / Seminar / Mini Project / MCQ</td><td>Written Test</td><td>Evaluation of Laboratory Observation, Record
(Rubrics Based Assessments)</td><td>Test</td><td>Theory Examinations
(Examinations will be conducted for 100 Marks)</td><td>Practical Examinations
(Examinations will be conducted for 100 Marks)</td></tr>
<tr><td>40</td><td>60</td><td>75</td><td>25</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td colspan="2">25</td><td colspan="2">25</td><td>25</td><td>25</td></tr>
<tr><td colspan="4">50</td><td colspan="2">50</td></tr>
<tr><td colspan="6">Total: 100</td></tr>
</table>

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER VI

		Category: PCC				
U21MI603	SMART HOME AND BUILDING AUTOMATION	L	T	P	J	C
		2	0	4	0	4

PRE–REQUISITES:

- U21MI302: Sensors and Signal Processing
- U21MI403: Programmable Automation Controllers

COURSE OBJECTIVES:

- Providing an in–depth understanding of smart home automation and building automation systems including principles, components, and applications
- Integration of various technologies and protocols to create efficient and sustainable automated environments
- Enable learners with skills to design, implement, and troubleshoot home automation and building automation systems

COURSE OUTCOMES:

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

CO1: Understand the fundamental concepts and principles of smart home automation and building automation systems (Understand)
CO2: Explore the components and architecture of smart home and building automation systems (Apply)
CO3: Learn about communication protocols and standards employed in automation systems (Understand)
CO4: Study energy management techniques and sustainable practices in building automation (Apply)
CO5: Develop the skills to design, implement, and troubleshoot home automation systems (Create)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	1	1	–	–	1	1	–	–	2	2
CO2	3	3	3	2	1	1	–	–	1	1	–	–	3	2
CO3	2	3	2	2	1	1	–	–	1	1	–	–	2	2
CO4	3	3	2	2	1	1	–	–	1	1	–	–	3	2
CO5	3	3	3	2	1	1	–	–	1	1	–	–	3	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I INTRODUCTION TO SMART HOME AUTOMATION 6

Definition and scope of smart home automation, Evolution and trends in automation systems, Comparison between conventional wiring and automated home wiring, Design considerations for automated home wiring, home automation protocols, Selection of home automation protocol, standards used in home automation system

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UNIT II COMPONENTS AND COMMUNICATION PROTOCOLS IN HOME AUTOMATION 6

Sensors and actuators, Controllers and gateways, Human–machine interfaces, Networking infrastructure, Wired, and wireless protocols (e.g., KNX, Zigbee, Z–Wave, BACnet), Interoperability and integration challenges

UNIT III KNX AND AUTOMATION SYSTEM ARCHITECTURE 6

Home Automation using KNX Protocol, Advantages of KNX System, ETS – KNX Programming Tool, KNX Base Components, Communications that support KNX, Standards for home automation using KNX, Control strategies and decision–making algorithms, Data acquisition and processing, Emerging Trends and Future Directions– Artificial intelligence and machine learning in automation, Voice control and natural language processing

UNIT IV BUILDING AUTOMATION SYSTEM (BAS) 6

Definition and scope of Building Automation System, Benefits, and challenges of implementing BAS, Architecture of latest building automation system, Hardware and software components, Field–level automation–level, and enterprise–level integration, Data acquisition and processing, Building Management Systems (BMS), Energy Management in Building Automation

UNIT V DESIGN AND INSTALLATION OF BUILDING AUTOMATION SYSTEMS 6

User interfaces and dashboards, Reporting and analytics, System design considerations, Wiring, and cabling requirements, Maintenance and Optimization of BAS

List of Practical Experiments

1. Program and configure KNX Switching actuator and 2 gang push buttons
2. Program and configure KNX Dimming actuator and 2 gang push buttons
3. Program and configure KNX Blind actuator and 2 gang push buttons
4. Program and configure KNX argus sensor and Switching actuator
5. Program and configure KNX argus sensor and Dimming actuator
6. Program and configure KNX touch pad and Switching actuator
7. Program and configure KNX touch pad and Dimming actuator
8. Program and configure KNX touch pad and Blind actuators
9. Program and configure KNX touch pad and all actuators

Contact Periods:

Lecture: 30 Periods Tutorial: – Periods Practical: 30 Periods Project – Periods

Total: 60 Periods

TEXTBOOKS:

1. Intelligent Building Systems by Albert Ting–Pat So, WaiLok Chan, Kluwer Academic publisher,3rd ed., 2012
2. Design of Special Hazards and Fire Alarm Systems by Robert Gagnon, Thomson Delmar Learning; 2nd Edition, 2007.
3. Turner, W. C, "Energy Management Handbook", 5th Edition, 2004
4. Lab Manual

REFERENCES:

1. The High–Performance HMI Handbook 1st Edition, by Bill Hollifield (Author), Dana Oliver (Author), Ian Nimmo (Author), Eddie Habibi (Author).

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2. Understanding Building Automation Systems (Direct Digital Control, Energy Management, Life Safety, Security, Access Control, Lighting, Building Management Programs) by Reinhold A. Carlson, Robert A. Di Giandomenico, pub. by R.S. Means Company, 1991

EVALUATION PATTERN:

<table>
<tr><th colspan="4">Continuous Internal Assessments</th><th colspan="2">End Semester Examinations</th></tr>
<tr><td colspan="2">Assessment I
(Theory)
(100 Marks)</td><td colspan="2">Assessment II
(Practical)
(100 Marks)</td><td rowspan="2">Theory Examinations
(Examinations will be conducted for 100 Marks)</td><td rowspan="2">Practical Examinations
(Examinations will be conducted for 100 Marks)</td></tr>
<tr><td>*Individual Assignment / Case Study / Seminar / Mini Project / MCQ</td><td>Written Test</td><td>Evaluation of Laboratory Observation, Record
(Rubrics Based Assessments)</td><td>Test</td></tr>
<tr><td>40</td><td>60</td><td>75</td><td>25</td><td></td><td></td></tr>
<tr><td colspan="2">25</td><td colspan="2">25</td><td>25</td><td>25</td></tr>
<tr><td colspan="4">50</td><td colspan="2">50</td></tr>
<tr><td colspan="6">Total: 100</td></tr>
</table>

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER VI

U21SSG03	SOFT SKILLS – III	Category: HSMC				
		L	T	P	J	C
		0	0	2	0	1

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To improve language adeptness and to enhance fluency in language
- To gain emotional intelligence and to manage stress

COURSE OUTCOMES:

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

CO1: Write reports and make reasoning and assertions (Apply)
CO2: Overcome stress and attain work–life balance (Analyze)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	–	–	–	–	–	–	–	–	1	3	–	–	–	–
CO2	–	–	–	–	–	–	–	1	–	3	–	2	–	–

Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SYLLABUS:

UNIT I LANGUAGE ADEPTNESS **10**

Sentence Completion – Report Writing – Logical Reasoning – Cause and Effect – Assertion and Reasoning – Digital Profiling – Creative Resume

UNIT II STRESS MANAGEMENT **10**

Factors Caugin Stress – Positive and Negative Stress – Effect of Stress – Stress Overcoming Techniques – Context Based Tasks

UNIT III INTERVIEW SKILLS **10**

Leadership effectiveness – Self–awareness – Self–management – Self–motivation – Empathy and Social Skills

Contact Periods:

Lecture: –Periods Tutorial: –Periods Practical: 30 Periods Project – Periods
Total 30 Periods

TEXTBOOKS:

1. Daniela Goleman, "Emotional Intelligence: Why it Can Matter More Than IQ", 1st Edition, Bloomsbury, 2009
2. Alan Barkerm "Improve Your Communication Skill, Present with Confidence; Write with Style; Learn Skills of Persuasion", 1st Edition, Kogan Page, 2010

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REFERENCES:

1. Jeremy Stranks, "Stress at Work: Management and Prevention", 1st Edition, Butterworth–Heinemann, 2005
2. Edward J Watson, "Emotional Intelligence: Practical Guide on How to Control Your Emotions and Achieve Lifelong Social Success", 1st Edition, Amazon Digital Services LLC, 2016

EVALUATION PATTERN:

Continuous Internal Assessments	Marks
Test – I	50
Test – II	50
Total	100

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SEMESTER VI

U21MI604	MODELLING AND ANALYSIS OF MECHATRONICS SYSTEM LABORATORY	Category: PCC				
		L	T	P	J	C
		0	0	4	0	2

PRE–REQUISITES:

- U21MI301: Kinematics of Machinery
- U21MI402: Control Systems Engineering

COURSE OBJECTIVES:

- To provide the practical realization of mechatronics systems
- To design, develop and analyze the mechatronics systems for real time applications.
- To validate the motion control systems for the real world problems

COURSE OUTCOMES:

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

CO1: Model, simulate and analyze the physical systems (Apply)
CO2: analyze the various dynamics systems using simulation tools (Apply)
CO3: Design the advanced control systems for various control systems (Apply)
CO4: Validate the various motion control systems for real time applications (Apply)
CO5: Develop models for mechatronics or hybrid systems based on real world problems (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	–	–	–	3	2	–	2	3	3
CO2	3	3	3	3	3	–	–	–	3	2	–	2	3	3
CO3	3	3	3	3	3	–	–	–	3	2	–	2	3	3
CO4	3	3	3	3	3	–	–	–	3	2	–	2	3	3
CO5	3	3	3	3	3	–	–	–	3	2	–	2	3	3
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

LIST OF EXPERIMENTS

1. Model a DC Motor with PID controls in Simulink.
2. Model a DC Motor with PID controls in Simscape.
3. Model a car suspension system using Simscape.
4. Model a basic heat transfer system with conduction, convection, and radiation.
5. Model a pneumatic cylinder control – a system to control extension and retraction of a pneumatic cylinder using a valve.
6. Model an inverted pendulum with feedback control.
7. Model a simple robotic arm with two rotational joints.
8. Model a pneumatic robot actuator.
9. Create a simple model of a wheeled robot to study its motion.
10. Model and simulate a two-wheeled robot that uses control system to balance itself dynamically.

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TEXTBOOKS:

1. Devdas Shetty and Richard A. Kolk, "Mechatronics System Design", 2nd Edition,Cengage Learning 2012.
2. Georg pelz, "Mechatronic Systems: Modeling and simulation with HDL's", John wiley and sons Ltd, 2003.
3. Lab Manual

REFERENCES:

1. Bolton W., "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering", 6th Edition, Pearson Education Limited, New York, 2015.
2. Robert H. Bishop, "The Mechatronics handbook. Fundamentals and Modeling", 2nd Edition, CRC Press, London, 2008.
3. Bradley, D.Dawson, N.C. Burd and A.J. Loader, "Mechatronics: Electronics in Products and Processes", CRC Press, First Indian print 2010.
4. Laboratory Manual

EVALUATION PATTERN:

<table>
<tr><td colspan="2">Continuous Internal Assessments</td><td rowspan="2">End Semester Examinations</td></tr>
<tr><td>Evaluation of Laboratory Observation, Record
(Rubrics Based Assessments)</td><td>Test</td></tr>
<tr><td>75</td><td>25</td><td></td></tr>
<tr><td colspan="2">100</td><td>100</td></tr>
<tr><td colspan="2">40</td><td>60</td></tr>
<tr><td colspan="3">100</td></tr>
</table>

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER VI

U21MI605	PROTO STUDIO II	Category: EEC				
		L	T	P	J	C
		0	0	0	2	1

PRE–REQUISITES:

- U21MI506: Proto Studio I

COURSE OBJECTIVES:

- To inculcate the problem–solving and Innovation mindset
- To provide a platform for self–learning, experimenting, solving the real–world problems and to develop a product.
- To enable hands–on experience for active learning.

COURSE OUTCOMES:

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

CO1: Apply the problem–solving techniques (Design thinking and system thinking) (Apply)
CO2: Create Minimum Viable Product (TRL 6) (Analyze)
CO3: Analyze product to market fit (Analyze)
CO4: Develop a business model (Analyze)
CO4: Demonstrate teamwork, project management, technical report writing and presentation skills (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	3	3	3	3	–	2	1	2	2
CO2	3	3	3	3	3	3	3	3	3	–	3	2	2	2
CO3	3	3	3	3	3	3	3	3	3	–	3	2	2	2
CO4	3	3	3	3	3	3	3	3	3	–	3	2	2	2
CO5	–	–	–	–	2	–	–	2	3	3	3	1	2	2
Correlation levels:	1: Slight (Low)				2: Moderate (Medium)						3: Substantial (High)			

Course conduction:

- The students will be divided into batches (maximum 4 students / batch). They will be provided the space, time, resources, and a mentor for this Proto clinic 2 course.
- With the guidance of assigned mentor, the students will find & validate a problem statement, map to UNSGD, identify the skills required for the project and self–learn.
- The students will apply design thinking, system thinking concept to solve the problem and produce the version 2 of MVP. (TRL 5)
- The student will learn teamwork, project management, product development, technical report writing and presentation skills through this course.

Contact Periods:

Lecture: – Periods Tutorial: – Periods Practical: – Periods Project 30 Periods

Total 30 Periods

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EVALUATION PATTERN:

Review 0 (Within 10 days of commencement of semester)	Review 1 (Between 35th to 40th working day)	Review 2 (Between 80th to 90th working day)	Total
0	40	60	100

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER VII

U21MI701	ENTREPRENEURSHIP MANAGEMENT	Category: PCC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To develop and strengthen the entrepreneurial quality and motivation of learners
- To impart the entrepreneurial skills and traits essential to become successful entrepreneurs
- To apply the principles and theories of entrepreneurship and management in Technology oriented businesses

COURSE OUTCOMES:

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

CO1: Understand the importance of entrepreneurship (Understand)
CO2: Identify suitable entrepreneurial ventures and business opportunity (Understand)
CO3: Assess the components of business plan (Apply)
CO4: Interpret the accounting statements and sources of finance (Apply)
CO5: Interpret the causes of sickness of small–scale enterprises and its remedies (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	–	–	–	–	–	2	1	2	2	2	3	2	–	2
CO2	–	–	–	–	–	2	1	2	2	2	3	2	–	2
CO3	–	–	–	–	–	2	1	2	2	2	3	2	–	2
CO4	–	–	–	–	–	2	1	2	2	2	3	2	–	2
CO5	–	–	–	–	–	2	1	2	2	2	3	2	–	2
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)				3: Substantial (High)							

SYLLABUS:

UNIT I ENTREPRENEURSHIP CONCEPTS 9

Entrepreneurship– Definition, Need, Scope – Entrepreneurial Skill & Traits – Entrepreneur vs. Intrapreneur; Classification of entrepreneurs, Types of entrepreneurs –Factors affecting entrepreneurial development – Achievement Motivation – Contributions of Entrepreneurship to Economic Development

UNIT II ENTREPRENEURIAL VENTURES AND OPPORTUNITY ASSESSMENT 9

New venture creation – Bootstrapping, Mini–preneurship, Start–ups, Acquiring, Franchising & Social venturing – Venture development stages – Models of market opportunity– Opportunity assessment: Critical Factors in Opportunity Assessment, Idea vs Opportunity, Evaluation process, Global opportunities for entrepreneurs

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UNIT III BUSINESS PLAN AND MANAGEMENT 9

Designing Business Model – Business Model Canvas – Objectives of a Business Plan – Business Planning Process – Structure of a Business Plan – Technical, Marketing, Financial Feasibility assessment – Competitive analysis – Common errors in Business Plan

UNIT IV FINANCING AND ACCOUNTING 9

Forms of entrepreneurial capital – Sources of Financial capital: debt financing– Commercial banks and other sources, equity financing: Initial Public offering (IPO), Private placement – Venture capitalists – Angel investors – New forms of financing: Impact investors, Micro–financing, Peer–to–Peer Lending, Crowdfunding – Natural capital. Preparing Financial Budget, Break even analysis, Taxation–Direct and indirect taxes

UNIT V SMALL BUSINESS MANAGEMENT 9

Definition of Small–Scale Industries: Strengths and Weaknesses, Sickness in Small Enterprises: Symptoms –Causes and remedies Indian Startup Ecosystem – Institutions supporting small business enterprises, Business Incubators – Government Policy for Small Scale Enterprises – Growth Strategies in small industry – Expansion, Diversification, Joint Venture, Merger, FDI and Subcontracting

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total 45 Periods

TEXTBOOKS:

1. S.S.Khanka, "Entrepreneurial Development" S.Chand & Co. Ltd. Ram Nagar New Delhi, 2021
2. Donald F. Kuratko, "Entrepreneurship: Theory, Process, Practice", 11th Edition, Cengage Learning, Boston, 2020

REFERENCES:

1. Robert D. Hisrich, Michael P. Peters & Dean A. Shepherd, Sabyasachi Sinha, "Entrepreneurship", 11th Edition, McGraw Hill, Noida, 2020
2. Charantimath Poornima M., "Entrepreneurship Development and Small Business Enterprises", 3rd Edition, Pearson Education, Noida, 2018

EVALUATION PATTERN:

Continuous Internal Assessments				Total Internal Assessments	End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)			
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose anyone / two components based on the nature of the course.

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SEMESTER VII

U21MI702	MACHINE VISION AND IMAGE PROCESSING	Category: PCC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- U21MI302: Sensors and Signal Processing
- U21MI501: Robotics and Automation

COURSE OBJECTIVES:

- To learn the essential components to build of machine vision system
- To acquire knowledge on lighting and image processing
- To apply machine vision on inspecting defects on real time application

COURSE OUTCOMES:

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

CO1: Interpret the fundamental concepts of vision system (Understand)
CO2: Identify the suitable components for designing the machine vision system (Understand)
CO3: Illustrate the function of various lighting system and computer interfaces (Understand)
CO4: Infer the concept of image processing techniques (Apply)
CO5: Design the machine vision system for real time manufacturing applications (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	2	1	1	–	–	–	–	–	–	–	2	–
CO2	2	1	2	1	1	–	–	–	–	–	–	–	2	–
CO3	2	1	2	1	1	–	–	–	–	–	–	–	2	–
CO4	2	2	3	2	2	–	–	–	–	–	–	–	2	–
CO5	2	2	3	2	2	–	–	–	–	–	–	–	2	–
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)				3: Substantial (High)							

SYLLABUS:

UNIT I HUMAN VISUAL SYSTEM AND MACHINE VISION SYSTEM 9

Structure of eye – Adaptation to different light level –Introduction to Machine Vision Inspection– Specification – Part presentation – Performance requirement – Information interfaces– Installation space – Environment

UNIT II CAMERA AND LENS 9

Area and line scan camera– Field of view– Resolution: camera sensor resolution, Spatial resolution, Measurement of accuracy, Calculation of resolution, Resolution for a Line Scan Camera – Choice of camera, Frame grabber and hardware platform– Pixel rate– Lens design – Smart cameras.

UNIT III LIGHT AND LIGHT FILTERS & CAMERA COMPUTER INTERFACE 9

Demands on machine vision lighting – Light and light perception – Light sources for machine vision – Monochromatic light, white light, UV, IR and Polarized light – Light filters. Analog camera buses –

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Analog video signal – Parallel digital camera buses – Standard PC buses – Computer buses – Digital video transmission – Camera link – Driver software

UNIT IV DIGITAL IMAGE PROCESSING 9

Digital Image Processing – Image sampling and quantization – Image enhancement: Grey Value Transformations, Radiometric Calibration, Image Smoothing – Geometric transformation – Image segmentation – Object Recognition and Image Understanding. Feature extraction – Morphology – Edge extraction – Template matching

UNIT V APPLICATIONS AND CASE STUDIES 9

Diameter inspection of rivets – Tubing inspection – Glue check under UV Light – Completeness check of automotive control component – Check of small hybrid circuit – Pin–type verification – Type and result data management of spark plugs – Robot guidance.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Milan Sonka, "Image Processing Analysis and Machine Vision", 2007 Edition, Vikas Publishing House, India, 2007
2. Davies E.K, "Machine Vision: Theory, Algorithms, Practicalities", 3rd Edition, Elsevier, India, 2005

REFERENCES:

1. Muthukumaran Malarvel, Soumya Ranjan Nayak, Surya Narayan Panda, Prasant Kumar Pattnaik, Nittaya Muangnak, "Machine Vision Inspection Systems: Image Processing, Concepts, Methodologies, and Applications", Wiley–Scrivener, 2021
2. Alexander Hornberg, "Handbook of Machine Vision", Wiley–VCH, Germany, 2006

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose anyone / two components based on the nature of the course.

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SEMESTER VII

U21MI703	PROJECT WORK PHASE– I	Category: EEC				
		L	T	P	J	C
		0	0	0	4	2

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To identify a real–life problem and to design a solution using the concepts of mechatronics engineering
- To develop communication skills to work in a collaborative environment
- To demonstrate ethical and professional attributes

COURSE OUTCOMES:

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

CO1: Identify and formulate the problem and conceptualize the methodology of the project (Apply)
CO2: Design the components and systems using Mechatronics Principles (Analyze)
CO3: Fabricate a Mechatronics system utilizing experiment skills (Create)
CO4: Plan and Execute the project as a team (Evaluate)
CO5: Compile the findings and conclude with oral/written reports (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	2	2	2	3	3	3	2	3	3
CO2	3	3	3	3	3	2	2	2	3	3	3	2	3	3
CO3	3	3	3	3	3	2	2	2	3	3	3	2	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

EVALUATION PATTERN:

Continuous Internal Assessments (40 Marks)			End Semester Examinations (60 Marks)	
Review I	Review II	Review III	Project Report	Viva–Voice
10	15	15	20	40
Total: 100 Marks				

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose anyone / two components based on the nature of the course.

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SEMESTER VIII

U21MI801	PROJECT WORK PHASE– II	Category: EEC				
		L	T	P	J	C
		0	0	0	16	8

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To identify a real–life problem and to design a solution using the concepts of mechatronics engineering
- To develop communication skills to work in a collaborative environment
- To demonstrate ethical and professional attributes

COURSE OUTCOMES:

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

CO1: Analyze and complex engineering problem to provide appropriate research-based solution (Analyze)
CO2: Desing the components and systems using fundamental engineering principles (Analyze)
CO3: Develop/fabricate a mechatronics system utilizing experimental/analytical/simulation skills (Creating)
CO4: Plan and execute the project as a team (Evaluate)
CO5: Compile the findings and conclude with oral/written reports (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	2	2	2	3	3	3	2	3	3
CO2	3	3	3	3	3	2	2	2	3	3	3	2	3	3
CO3	3	3	3	3	3	2	2	2	3	3	3	2	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

EVALUATION PATTERN:

Continuous Internal Assessments (40 Marks)			End Semester Examinations (60 Marks)	
Review I	Review II	Review III	Project Report	Viva–Voice
10	15	15	20	40
Total: 100 Marks				

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose anyone / two components based on the nature of the course.

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PROFESSIONAL ELECTIVE COURSES

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VERTICAL 1: ROBOTICS

U21MIP01	ROBOTS AND SYSTEMS IN SMART MANUFACTURING	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To get a knowledge of working on Industrial robots and their load handling capacity
- To enlist with an application of robots and material handling system
- To impart the knowledge on robotic welding

COURSE OUTCOMES:

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

CO1: Recognize various concepts of Industrial Robot (Understand)
CO2: Select the appropriate manufacturing procedure for Robots (Understand)
CO3: Apply various manufacturing process in robot manufacturing (Understand)
CO4: Learn about the welding operation and related to programming (Apply)
CO5: Produce a manufacturing plan for developing a robot (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	3	–	–	–	–	–	–	–	3	2	3
CO2	3	2	2	3	–	–	–	–	–	–	–	3	2	3
CO3	3	2	2	3	–	–	–	–	–	–	–	3	2	3
CO4	3	2	2	3	–	–	–	–	–	–	–	3	2	3
CO5	3	2	2	3	–	–	–	–	–	–	–	3	2	3
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

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

UNIT II SELECTION OF ROBOTS AND OTHER APPLICATIONS 9

Factors influencing the choice of a robot – robot performance testing – economics of robotisation – Impact of robot on industry and society. Application of Robots in continuous arc welding – Spot welding – Spray painting –assembly operation – cleaning – robot for underwater applications

UNIT III MATERIAL HANDLING 9

Concepts of material handling – principles and considerations in material handling systems design – conventional material handling systems – industrial trucks – monorails – rail guided vehicles – conveyor systems –cranes and hoists – advanced material handling systems – automated guided vehicle systems – automated storage and retrieval systems (ASRS) – bar code technology – radio frequency identification technology –Introduction to Automation Plant design software

UNIT IV ROBOTIC WELDING 9

Robotic welding system, Programmable and flexible control facility –Introduction–Types– Flex Pendant–Lead through programming, Operating mode of robot, Jogging–Types, programming for robotic welding, Welding simulation, Welding sequences, Profile welding

UNIT V APPLICATIONS OF ROBOTS IN WELDING AND ALLIED PROCESSES 9

Application of robot in manufacturing: Exploration of practical application of robots in welding: Robots for car body's welding, robots for box fabrication, robots for microelectronic welding and soldering – Applications in nuclear, aerospace and ship building, case studies for simple and complex applications

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Richard D Klafter, Thomas Achmielewski, Mickael Negin, "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, 2019.
3. Pires J N, Loureiro A, Bolmsjo G, "Welding Robots: Technology, System Issues and Application", Springer, London, 2010.

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, Ashish Dutta , "Industrial Robotics (SIE): Technology, Programming and Applications", 2nd Edition, McGraw Hill Education India Pvt Ltd, 2012.
4. Yoram Koren, "Robotics for Engineers", McGraw–Hill, 1987.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 1: ROBOTICS

U21MIP02	ROBOT OPERATING SYSTEMS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To learn Robot Operating System and develop the Robot environment
- To obtain the simulation robots in ROS with GAZEBO
- To simulate robots with V–Rep and understand mapping, navigation and motion planning ROS with Move–it

COURSE OUTCOMES:

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

CO1: Recognize the concept of ROS and programming (Understand)
CO2: Evaluate various robot algorithms in ROS programming (Apply)
CO3: Deploy mapping, navigation and motion planning ROS with Move–it (Apply)
CO4: Simulate robots in ROS with GAZEBO and V–REP (Apply)
CO5: Program a Robot using ROS and its tool boxes (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	2	–	–	–	–	–	–	1	1	1	2
CO2	2	1	1	2	–	–	–	–	–	–	1	1	1	2
CO3	2	1	1	2	–	–	–	–	–	–	1	1	1	2
CO4	2	1	1	2	–	–	–	–	–	–	1	1	1	2
CO5	2	1	1	2	–	–	–	–	–	–	1	1	1	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I ROS ESSENTIALS **9**

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 **9**

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

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UNIT III SIMULATION ROBOTS IN ROS WITH GAZEBO 9

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 9

V–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 PLANNING ROS WITH MOVEIT 9

Move it Installation – 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

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Lentin Joseph, Jonathan Cacace, "Mastering ROS for Robotics Programming", Second Edition, Packt Publishing, 2018

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", Packt publishing, 2017

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	**End Semester Examinations**
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	**60**	**40**	**60**	**200**	**100**
Total				**40**	**60**
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 1: ROBOTICS

U21MIP03	AGRICULTURAL ROBOTICS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the global position and information system in Farming related Machines
- To know about traction and testing
- To familiarize the concept on weed management and machinery selection

COURSE OBJECTIVES:

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

CO1: Recognize the areas in agricultural process where robotics can be applied (Understand)
CO2: Integrate sensor and system for a required specific process in agricultural applications (Understand)
CO3: Apply Mechanics to the design various robot parameters (Apply)
CO4: Convert various mechanisms into robot by providing actuation at specific links and joints of the mechanism (Apply)
CO5: Develop suitable robotic system for specific agricultural tasks (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	3	–	2	1	–	–	–	–	–	2	–	3
CO2	1	2	3	–	2	1	–	–	–	–	–	2	–	3
CO3	1	2	3	–	2	1	–	–	–	–	–	2	–	3
CO4	1	2	3	–	2	1	–	–	–	–	–	2	–	3
CO5	1	2	3	–	2	1	–	–	–	–	–	2	–	3
Correlation levels:			1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)			

SYLLABUS:

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

Sensors – types and agricultural applications, Global Positioning System (GPS) – GPS for civilian use, Differential GPS, Carrier–phase GPS, Real–time kinematic GPS, Military GPS, Geographic Information System, Variable Rate Applications and Controller Area Networks

UNIT III TRACTION AND TESTING 9

Hitching– Principles of hitching, Types of hitches, Hitching and weight transfer, Control of hitches, Tires and Traction models, Traction predictor spread sheet, Soil Compaction, Traction Aids, Tractor Testing.

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UNIT IV 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 V MACHINERY SELECTION 9

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

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

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

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 1: ROBOTICS

U21MIP04	MICRO–ROBOTICS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To expose students to micro–scale technologies for fabricating small devices, bio–inspired design, and applications of the micro–robotics field
- To expose students to various Mathematical formalism for flexures, Electrostatic actuators, Piezo–electric actuators, Magneto–strictive actuator and other sensors.
- To apply micro robotics to various applications and engage students in its implementation

COURSE OUTCOMES:

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

CO1: Explain and apply the concepts of mass, energy, and momentum balance in micro–robotics (Understand)
CO2: Select the appropriate manufacturing procedure for Robots (Understand)
CO3: Apply various manufacturing process in robot manufacturing (Understand)
CO4: Learn about the welding operation and related to programming (Apply)
CO5: Produce a manufacturing plan for developing a robot (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	2	–	–	–	–	–	–	1	2	3
CO2	3	2	1	1	2	–	–	–	–	–	–	1	2	3
CO3	3	2	1	1	2	–	–	–	–	–	–	1	2	3
CO4	3	2	1	1	2	–	–	–	–	–	–	1	2	3
CO5	3	2	1	1	2	–	–	–	–	–	–	1	2	3
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)					

SYLLABUS:

UNIT I INTRODUCTION TO MICROROBOTICS 9

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 – Piezo resistivity, Piezoelectricity and Thermoelectricity

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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.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

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

REFERENCES

1. Nadim Maluf and Kirt Williams, "An Introduction to Microelectromechanical systems Engineering", 2nd Edition, Artech House, 2004.
2. Julian W Gardner, "Microsensors: Principles and Applications", 2nd Edition, Wiley, 2007.
3. Metin Sitti, "Mobile Microrobotics", MIT Press, 2017.
4. Nicolas Chaillet, Stephane Rangier, "Microrobotics for Micromanipulation", John Wiley & Sons, 2013.

EVALUATION PATTERN:

<table>
<tr><th colspan="4">Continuous Internal Assessments</th><th rowspan="2">Total Internal Assessments</th><th rowspan="3">End Semester Examinations</th></tr>
<tr><th colspan="2">Assessment I (100 Marks)</th><th colspan="2">Assessment II (100 Marks)</th></tr>
<tr><td>Individual Assignment / Seminar / MCQ</td><td>Written Test</td><td>Individual Assignment / Seminar / MCQ</td><td>Written Test</td><td></td></tr>
<tr><td>40</td><td>60</td><td>40</td><td>60</td><td>200</td><td>100</td></tr>
<tr><td colspan="4" rowspan="2">Total</td><td>40</td><td>60</td></tr>
<tr><td colspan="2">100</td></tr>
</table>

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 1: ROBOTICS

U21MIP05	COLLABORATIVE ROBOTICS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To know the fundamentals of Collaborative Robotics and trajectory planning
- To introduce Modular Robotics and its Mechanics
- To learn about various Natural models of robot collaboration and concept of Reconfigurable robot

COURSE OUTCOME:

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

CO1: Recognize the fundamentals of Collaborative Robotics (Understand)
CO2: Apply Swarm robots technology in real time applications (Apply)
CO3: Analyze and select the suitable concept of Modular Robotics and its Mechanics for modelling a collaborative robot (Apply)
CO4: Create various Natural models for robot collaboration (Apply)
CO5: Develop collaborative robots for various requirement in industrial tasks (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	1	1	–	–	–	–	–	–	2	2	1	1
CO2	1	2	1	1	–	–	–	–	–	–	2	2	1	1
CO3	1	2	1	1	–	–	–	–	–	–	2	2	1	1
CO4	1	2	1	1	–	–	–	–	–	–	2	2	1	1
CO5	1	2	1	1	–	–	–	–	–	–	2	2	1	1
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)					3: Substantial (High)						

SYLLABUS:

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 Robot Kinematics

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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.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Guilin Yang, I–Ming Chen, "Modular Robots: Theory and Practice", Springer, 2022.
2. Giandomenico Spezzano, "Swarm Robotics", Applied Sciences, MDPI, 2019.

REFERENCES:

1. Heiko Hamann, "Collective Decision–Making in Swarm Robotics: A Formal Approach", Springer, 2019.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	**End Semester Examinations**
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	**60**	**40**	**60**	**200**	**100**
Total				**40**	**60**
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 1: ROBOTICS

U21MIP06	UNDERWATER ROBOTICS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To equip the students with the basic understanding of design, construction and working of underwater robots
- To know the kinematics, modelling and robust feedback control methods of underwater vehicles
- To learn the path planning and its control for an autonomous robot

COURSE OUTCOMES:

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

CO1: Explain the principle of locomotion and describe different types of mobile robots (Understand)
CO2: Associate the degree of freedom to maneuverability of various robots (Understand)
CO3: Categorize the use of various sensors deployed in autonomous robots (Apply)
CO4: Calculate motion path planning and its control for an autonomous robot (Apply)
CO5: Explain the robust feedback control methods (Understand)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	3	–	–	–	–	–	–	–	3	2	3
CO2	3	2	2	3	–	–	–	–	–	–	–	3	2	3
CO3	3	2	2	3	–	–	–	–	–	–	–	3	2	3
CO4	3	2	2	3	–	–	–	–	–	–	–	3	2	3
CO5	3	2	2	3	–	–	–	–	–	–	–	3	2	3
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)							3: Substantial (High)			

SYLLABUS:

UNIT I FUNDAMENTALS OF MOBILE ROBOT **9**

Introduction to mobile robots – principle of locomotion – types of mobile robots: ground robot, aerial robot, underwater robot and water–surface robot – principles of underwater vehicle construction.

UNIT II KINEMATICS OF UNDERWATER VEHICLE **9**

Equations for moving frame – rigid motion in a plane – representation of a rotated frame – holonomic and non–holonomic systems – kinematic modeling with respect to global coordinates.

UNIT III SENSORS FOR ROBOT NAVIGATION **9**

Types of sensors – magnetic and optical position sensor – gyroscope – accelerometer – magnetic compass inclinometer – tactile and proximity sensor – ultrasound range finder – laser scanner, infrared range finder – visual and motion sensing systems.

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UNIT IV MOTION PATH PLANNING, CONTROL AND STABILITY 9

Path planning algorithms – collision–free path planning – sensor–based obstacle avoidance – motion control methods: kinematic control, dynamic control, controllability and stability about a point and trajectory.

UNIT V ROBUST FEEDBACK CONTROL DESIGN 9

Based on kinematic model: input uncertain control model – robust control by the Lyapunov Redesign method – Based on dynamic model: robust backstepping: unmatched uncertainty – robust control: matched uncertainty – both matched and unmatched uncertainty.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Sabiha Wadoo, Pushkin Kachroo, Autonomous Underwater Vehicles, 1st Edition, CRC Press, 2011
2. Yu Junzhi, Visual Perception and Control of Underwater Robots, 1st Edition, CRC Press, 2018

REFERENCES:

1. Wheeled Mobile Robots, IITM IIT Palakkad, NPTEL.
2. Nikolaus Correll, Introduction to Autonomous Robots, 1st Edition, April 23, 2016
3. Robotics and Control: Theory and Practice, IIT Roorkee, NPTEL
4. Gerald Cook, Feitian Zhang, Mobile Robots: Navigation, Control and Sensing, Surface Robots and AUVs, 2nd Edition, Wiley Publication, 2020

EVALUATION PATTERN:

Continuous Internal Assessments					**End Semester Examinations**
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	**60**	**40**	**60**	**200**	**100**
Total				**40**	**60**
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 1: ROBOTICS

U21MIP07	MEDICAL ROBOTICS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To know basic concepts in kinematics, dynamics, and control relevant to Medical Robotics
- To develop the Analytical and Experimental skills necessary to Design and Implement robotic assistance for both minimally invasive surgery and Image guided interventions
- To be familiar with the state of the art in applied medical robotics and medical robotics research and their role in healthcare

COURSE OUTCOMES:

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

CO 1: Identify various medical robots and their potential applications (Understand)
CO 2: Recognize the position tracking and hybrid systems (Understand)
CO 3: Apply Robotics and its concepts in Medical field (Apply)
CO 4: Simulate a MIS procedure and be aware of the state of art in surgical and oncology robotics (Apply)
CO 5: Design a medical robotic system given the specific requirements for Rehabilitation and Medical care (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	–	–	–	–	–	–	–	1	2	3
CO2	3	2	1	1	–	–	–	–	–	–	–	1	2	3
CO3	3	2	1	1	–	–	–	–	–	–	–	1	2	3
CO4	3	2	1	1	–	–	–	–	–	–	–	1	2	3
CO5	3	2	1	1	–	–	–	–	–	–	–	1	2	3
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)					

SYLLABUS:

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.

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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 IN REHABILITATION AND MEDICAL CARE 9

Rehabilitation for Limbs – Brain–Machine Interfaces – Steerable Needles – Assistive robots – Robots in Physiotherapy – Case studies

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

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

REFERENCES:

1. Jaydev P Desai, Rajni V Patel, Antoine Ferreira; Sunil Kumar Agrawal, "The Encyclopaedia 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, 2022.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	**End Semester Examinations**
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	**60**	**40**	**60**	**200**	**100**
Total				**40**	**60**
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 1: ROBOTICS

U21MIP08	HUMANOID ROBOTICS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To impart knowledge in humanoid robotics and its kinematics
- To learn about the dynamics in humanoid robots
- To understand the different walking patterns and biped walking

COURSE OUTCOMES:

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

CO 1: Describe about the evolution of Humanoid robots (Understand)
CO 2: Expose the basic knowledge in kinematics of humanoids (Understand)
CO 3: Calculate the Humanoid Robot Motion and Ground Reaction Force (Apply)
CO 4: Identify Two–Dimensional Walking pattern on different terrain (Apply)
CO 5: Create the Walking Pattern models (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	–	–	–	–	–	–	1	1	2	3
CO2	3	2	1	1	–	–	–	–	–	–	1	1	2	3
CO3	3	2	1	1	–	–	–	–	–	–	1	1	2	3
CO4	3	2	1	1	–	–	–	–	–	–	1	1	2	3
CO5	3	2	1	1	–	–	–	–	–	–	1	1	2	3
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

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 ZMP 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, Angular Momentum and Inertia Tensor of Rigid Body, Calculation of Robot's Center of Mass, Link Speed and Angular Velocity, Calculation of Robot's Momentum and Angular Momentum

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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 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.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

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, Vadakkepat Prahlad, "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, 2000.
4. Jean–Claude Latombe, "Robot Motion Planning", Kluwer Academy Publishers, 2004.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 2: DESIGN AND MANUFACTURING

U21MIP09	ROBOT AND MACHINE ELEMENTS DESIGN	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To provide the systematic knowledge about the various machine elements and transmission elements for suitable product/process development
- To learn the modelling of various components required for the implementation of robots
- To know the selection of robot end effectors based on the real–world applications

COURSE OUTCOMES:

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

CO1: Design robust and reliable robotic structures with factors of safety principles. (Apply)
CO2: Apply engineering principles to select rolling contact bearings based on load, speed, and environmental factors (Apply)
CO3: Analyze and design shafts for mechanical systems considering strength, rigidity, and critical speed (Apply)
CO4: Ensure efficient power transmission and reliability in shaft design based on critical considerations (Apply)
CO5: Develop miniature and micro grippers tailored for delicate handling and medical applications (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	2	–	–	–	–	–	–	3	3	2
CO2	3	3	3	3	2	–	–	–	–	–	–	3	3	2
CO3	3	3	3	3	2	–	–	–	–	–	–	3	3	2
CO4	3	3	3	3	2	–	–	–	–	–	–	3	3	2
CO5	3	3	3	3	2	–	–	–	–	–	–	3	3	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)					

SYLLABUS:

UNIT I FUNDAMENTAL CONCEPTS IN DESIGN 9

Introduction to Robots – Factors influencing robot design, Selection of materials based on mechanical properties – Modes of failure – Factor of safety – Stresses due to bending and torsion moment – Eccentric loading, Design against fluctuating loads – theories of failures

UNIT II DESIGN OF FLEXIBLE ELEMENTS AND BEARINGS 9

Introduction to flexible elements, Design of belt drives – Flat, Vee, and Timing Belts, Design of chain drives – Sliding contact and rolling contact bearings – Hydrodynamic journal bearings, Somerfield Number, Raimondi & Boyd graphs – Selection of Rolling Contact bearings

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UNIT III DESIGN OF SHAFTS AND THREADED FASTENERS 9

Shafts and Axles – Design of solid and hollow shafts based on strength, rigidity, and critical speed – Keys and splines, Threaded fasteners – Bolted joints – Simple and eccentrically loaded bolted joints

UNIT IV DESIGN OF GEARS AND GEARBOXES 9

Design of Gears (Spur, Helical and Bevel) – Geometric progression – Standard step ratio – Ray diagram, kinematic layout – Design of sliding mesh gear box – Design of multi speed gear box for machine tool applications

UNIT V DESIGN OF ROBOT GRIPPERS AND END EFFECTORS 9

Types of End Effectors and Gripper Mechanisms, Force analysis, Miniature Grippers and Micro Grippers, Compliance, Selected case studies – Sheet metal handling, pretension of cuboid / cylindrical / objects, coils, irregular surfaces and flexible objects, handling castings, and medical applications

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Bhandari. V.B, "Design of Machine Elements", Tata McGraw–Hill Education, 5th Edition, 2020
2. Joseph Edward Shigley, Charles R. Mischke, "Mechanical Engineering Design", McGraw Hill, 11th Edition, 2020
3. Gareth J.Monkman, Stefan Hesse, Ralf Steinmann, HenrikSchunk, "Robot Grippers", Wiley, 2007

REFERENCES:

1. Sundararajamoorthy T. V, Shanmugam N, "Machine Design", Anuradha Publications, 2015
2. Robert L. Norton, "Machine Design – An Integrated Approach", Prentice Hall International Edition, 5th Edition, 2018
3. Sharma. C.S., Purohit. K.," Design of Machine Elements", Prentice–Hall of India, 2003

EVALUATION PATTERN:

Continuous Internal Assessments					End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 2: DESIGN AND MANUFACTURING

U21MIP10	DESIGN FOR X	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To introduce the economic process selection principles and general design principles for manufacturability in the development and design of products for various engineering applications.
- To learn the design consideration principles of forming in the design of cast, extruded, stamped, forged, turned, drilled, milled, planed, shaped, slotted, and ground products.
- To learn design consideration principles of welding in the design and additive manufacturing

COURSE OUTCOMES:

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

CO1: Optimize strength and manufacturability through general design principles (Apply)
CO2: Incorporate material and manufacturing considerations in form design (Apply)
CO3: Design components with machining efficiency in mind (Apply)
CO4: Improve casting manufacturability through redesign strategies (Apply)
CO5: Utilize additive manufacturing principles for efficient part design and production (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	–	–	–	–	–	–	2	3	2
CO2	3	3	3	2	2	–	–	–	–	–	–	2	3	2
CO3	3	3	3	2	2	–	–	–	–	–	–	2	3	2
CO4	3	3	3	2	2	–	–	–	–	–	–	2	3	2
CO5	3	3	3	2	2	–	–	–	–	–	–	2	3	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I INTRODUCTION **9**

General design principles for manufacturability – strength and mechanical factors, mechanisms selection, evaluation method, Process capability – Feature tolerances Geometric Tolerances – Assembly limits –Datum features – Tolerance stacks. Design to minimize material usage – Design for disassembly – Design for recyclability – Design for manufacture – Design for energy efficiency – Design to regulations and standards

UNIT II FACTORS INFLUENCING FORM DESIGN **9**

Working principle, Material, Manufacture, Design– Possible solutions – Materials choice –Influence of materials on form design – form design of welded members, forgings and castings

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UNIT III COMPONENT DESIGN – MACHINING CONSIDERATION 9

Design features to facilitate machining – drills – milling cutters – keyways – Doweling procedures, counter sunk screws – Reduction of machined area– simplification by separation – simplification by amalgamation – Design for machinability – Design for economy – Design for clampability – Design for accessibility – Design for assembly – Product design for manual assembly – Product design for automatic assembly – Robotic assembly

UNIT IV COMPONENT DESIGN – CASTING CONSIDERATION 9

Redesign of castings based on Parting line considerations – Minimizing core requirements, machined holes, and redesigning of cast members to obviate cores. Identification of uneconomical design – Modifying the design – group technology – Computer Applications for DFMA

UNIT V DESIGN FOR ADDITIVE MANUFACTURING 9

Introduction to AM, DFMA concepts and objectives, AM unique capabilities, exploring design freedoms, Design tools for AM, Part Orientation, Removal of Supports, Hollowing out parts, Inclusion of Undercuts and Other Manufacturing Constraining Features, Interlocking Features, Reduction of Part Count in an Assembly, Identification of markings/ numbers

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. James G. Bralla, "Design for Manufacturability Handbook", McGraw Hill Professional, 2020
2. O. Molloy, E.A. Warman, S. Tilley, "Design for Manufacturing and Assembly: Concepts, Architectures and Implementation", Springer, 2012

REFERENCES:

1. Corrado Poli, "Design for Manufacturing: A Structured Approach", Elsevier, 2001
2. David M. Anderson, "Design for Manufacturability & Concurrent Engineering: How to Design for Low Cost, Design in High Quality, Design for Lean Manufacture, and Design Quickly for Fast Production", CIM Press, 2010
3. Erik Tempelman, Hugh Shercliff, Bruno Ninaber van Eyben, "Manufacturing and Design: Understanding the Principles of How Things Are Made", Elsevier, 2014
4. Boothroyd, G, Heartz and Nike, Product Design for Manufacture, Marcel Dekker, 1994

EVALUATION PATTERN:

Continuous Internal Assessments					End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 2: DESIGN AND MANUFACTURING

U21MIP11	CNC MACHINE TOOLS AND PROGRAMMING	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To impart the mechanics of metal cutting and the factors affecting machinability
- To learn the working of advanced turning machines and machine tools with reciprocating and rotating motions and abrasive finishing processes.
- To realize the constructional features of CNC machine tools, basics of CNC programming and the machine tools through planning, writing codes and, setting up CNC machine tools

COURSE OUTCOMES:

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

CO1: Understand mechanics of metal cutting and machining processess (Understand)
CO2: Familiarize with turning machines and estimation of machining parameters (Apply)
CO3: Learn reciprocating machine tools, milling operations, gear cutting, and abrasive processes (Apply)
CO4: Gain knowledge of CNC machines and their operational aspects (Apply)
CO5: Acquire skills in programming CNC machine tools for machining operations (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	–	–	–	–	–	–	2	2	2
CO2	3	3	3	3	3	–	–	–	–	–	–	2	2	2
CO3	3	3	3	3	3	–	–	–	–	–	–	2	2	2
CO4	3	3	3	3	3	–	–	–	–	–	–	2	2	2
CO5	3	3	3	3	3	–	–	–	–	–	–	2	2	2
Correlation levels:			1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)			

SYLLABUS:

UNIT I MECHANICS OF METAL CUTTING 9

Mechanics of chip formation, forces in machining, types of chip, cutting tools – Single point cutting tool nomenclature, orthogonal and oblique metal cutting, thermal aspects, cutting tool materials, tool wear, tool life, surface finish, cutting fluids and Machinability

UNIT II TURNING MACHINES 9

Centre lathe, constructional features, specification, operations – taper turning methods, thread cutting methods, special attachments, surface roughness in turning, machining time and power estimation. Special lathes – Capstan and turret lathes – tool layout – automatic lathes: semiautomatic– single spindle: Swiss type, automatic screw type – multi spindle

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UNIT III RECIPROCATING MACHINE TOOLS 9

Reciprocating machine tools: shaper, planer, slotter: Types and operations– Hole making: Drilling, reaming, boring, tapping, type of milling operations–attachments– types of milling cutters–machining time calculation – Gear cutting, gear hobbing and gear shaping – gear finishing methods Abrasive processes: grinding wheel – specifications and selection, types of grinding process –cylindrical grinding, surface grinding, centreless grinding, internal grinding – micro finishing methods

UNIT IV CNC MACHINES 9

Computer Numerical Control (CNC) machine tools, constructional details, special features – Drives, Recirculating ball screws, tool changers; CNC Control systems – Open/closed, point–to point/continuous – Turning and machining centers – Work holding methods in Turning and machining centers, Coolant systems, Safety features

UNIT V PROGRAMMING OF CNC MACHINE TOOLS 9

Coordinates, axis and motion, Absolute vs Incremental, Interpolators, Polar coordinates, Program planning, G and M codes, Manual part programming for CNC machining centers and Turning centers – Fixed cycles, Loops and subroutines, Setting up a CNC machine for machining.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Kalpakjian. S, "Manufacturing Engineering and Technology", Pearson Education 8th Edition, 2022
2. Michael Fitzpatrick, "Machining and CNC Technology", McGraw–Hill Education;4th Edition, 2019

REFERENCES:

1. Roy. A. Lindberg, "Processes and materials of manufacture", Pearson India Education Services Pvt. Ltd, 4th Edition, 2015
2. Rao. P.N, "Manufacturing Technology Volume 2, Metal Cutting and Machine Tools", McGraw–Hill, New Delhi, 3rd Edition, 2013
3. A. B. Chattopadhyay, "Machining and Machine Tools", Wiley, 2nd Edition, 2017

EVALUATION PATTERN:

Continuous Internal Assessments					End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 2: DESIGN AND MANUFACTURING

U21MIP12	COMPUTER INTEGRATED SYSTEMS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To provide the overview of evolution of automation, CIM and its principles.
- To learn the various Automation tools, include various material handling systems.
- To train students to apply group technology and FMS.
- To familiarize the computer aided process planning in manufacturing.
- To introduce to basics of data transaction, information integration and control of CIM.

COURSE OUTCOMES:

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

CO1: Comprehend the integration of computer–based technologies in manufacturing (Understand)
CO2: Design and manage automated manufacturing processes (Apply)
CO3: Plan and implement flexible manufacturing systems effectively (Apply)
CO4: Select the automation process and sequence of operations for real world applications (Apply)
CO5: Interface automation hardware and software (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	2	–	–	–	1	–	–	1	2	2
CO2	3	2	2	1	2	–	–	–	1	–	–	1	2	2
CO3	3	2	2	1	2	–	–	–	1	–	–	1	2	2
CO4	3	2	2	1	2	–	–	–	1	–	–	1	2	2
CO5	3	2	2	1	2	–	–	–	1	–	–	1	2	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I INTRODUCTION 9

Introduction to CAD, CAM, CAD/CAM and CIM – Evolution of CIM – CIM wheel and cycle – Production concepts and mathematical models – Simple problems in production models – CIM hardware and software – Major elements of CIM system – Three step process for implementation of CIM – Computers in CIM – Computer networks for manufacturing – Advances in CIM

UNIT II AUTOMATED MANUFACTURING SYSTEMS 9

Automated production line – system configurations, work part transfer mechanisms – Fundamentals of Automated assembly system – System configuration, Part delivery at workstations – Design for automated assembly – Overview of material handling equipment – Consideration in material handling system design – The 10 principles of Material handling. Conveyor systems – Types of conveyors – Operations and features. Automated Guided Vehicle system – Types & applications – Vehicle guidance technology – Vehicle management and safety. Storage system performance – storage location strategies – Conventional storage methods and equipment – Automated storage/Retrieval

system and Carousel storage system – Petrinet models – Applications in Dead lock avoidance – smart manufacturing – Industry 4.0

UNIT III GROUP TECHNOLOGY AND FMS 9

Part families – Visual – Parts classification and coding – Production flow analysis – Grouping of parts and Machines by rank order clustering method – Benefits of GT – FMS layout configurations – FMS planning and implementation issues – Architecture of FMS – Composite part concept, Holier method, Key machine concept – Quantitative analysis of FMS – Bottleneck model – Sizing the FMS

UNIT IV PROCESS PLANNING 9

Process planning – Sequencing of operations according to Anteriorities – Typical process sheet – case studies in Manual process planning – Computer Aided Process Planning – Process planning module and data base – Variant process planning – Two stages in VPP – Generative process planning – Semi generative process planning– Comparison of CAPP and Manual PP

UNIT V PROCESS CONTROL AND DATA ANALYSIS 9

Linear feedback control systems – Optimal control – Adaptive control –Sequence control and PLC& SCADA. Computer process control – Computer process interface – Interface hardware – Computer process monitoring – Direct digital control and Supervisory computer control – Bar code technology – Automatic data capture technologies – Quality management (SPC) and automated inspection

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Shivanand H K, Benal M M and Koti V, Flexible Manufacturing System, New Age, 2016
2. August Wilhelm Scheer, "CIM: Computer Integrated Manufacturing: Computer Steered Industry", Springer Verlag, 2012

REFERENCES:

1. Venkateshwaran, Computer Integrated Manufacturingll, PHI Learning Pvt. Ltd., New Delhi, 2013
2. Mikell P. Groover, Automation, Production system and Computer integrated Manufacturing, Prentice Hall of India Pvt. Ltd., 4th Edition, 2014

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 2: DESIGN AND MANUFACTURING

U21MIP13	ADVANCED MANUFACTURING SYSTEMS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- The objective of this course is to teach the lean tools and the various smart manufacturing techniques to attain optimum level in quality
- To enhance the ability to make decisions for new product development
- Aims to develop the students to conserve energy and natural resources, and to ensure that they have minimal impact on the environment and society

COURSE OUTCOMES:

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

CO1: Demonstrate on basic lean manufacturing (Apply)
CO2: Integrate the knowledge on agile manufacturing (Apply)
CO3: Formulate strategy in sustainable manufacturing Apply)
CO4: Apply artificial intelligence (AI) and fuzzy techniques to improve the efficiency of manufacturing systems (Apply)
CO5: Exposure to smart manufacturing and its various techniques (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	1	–	1	–	–	–	–	2	2	1
CO2	3	2	2	2	1	–	1	–	–	–	–	2	2	2
CO3	3	2	2	2	1	–	1	–	–	–	–	2	2	2
CO4	3	2	2	2	1	–	1	–	–	–	–	2	2	1
CO5	3	2	2	2	1	–	1	–	–	–	–	2	2	1
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)			3: Substantial (High)								

SYLLABUS:

UNIT I INTRODUCTION TO LEAN MANUFACTURING **9**

Objectives of lean manufacturing–key principles and implications of lean manufacturing – traditional Vs lean manufacturing– flow–continuous improvement/Kaizen –worker involvement5S principles elements of JIT – uniform production rate – Kanban system – Lean implementation, Reconciling lean with other systems – lean six sigma– lean and ERP – lean with ISO 9001:2000.

UNIT II AGILE MANUFACTURING **9**

Agile Manufacturing Vs Mass Manufacturing – Agile practice for product development – Manufacturing agile practices – Implementing new technology – A checklist, technology applications that enhance agility – agile technology make or buy decisions. – Costing for Agile Manufacturing practices.

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UNIT III SUSTAINABLE MANUFACTURING 9

Concepts of competitive strategy and manufacturing strategies and development of a strategic improvement programme – Business success strategy formation and formulation – Structured strategy formulation – Sustainable manufacturing system design options – Approaches to strategy formulation – Realization of new strategies/system designs.

UNIT IV INTELLIGENT MANUFACTURING 9

Introduction to intelligent manufacturing- fundamentals of artificial intelligence-AI in manufacturing processes- introduction to fuzzy logic-applications of fuzzy logic in manufacturing- integrating AI and fuzzy logic in production planning-real-time decision-making case studies and practical applications-emerging trends and future directions

UNIT V SMART MANUFACTURING 9

Introduction to various Smart Manufacturing Techniques–Supply chain management–Block chain of inventory management–Plant digitization –Predictive maintenance – Supply chain visibility–Warehouse–Cost reduction – Waste management–Automated systems–Applications

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Lonnie Wilson, "How to Implement Lean manufacturing", McGraw–Hill Professional; 2nd Edition, 2015
2. Ibrahim Garbie, "Sustainability in Manufacturing Enterprises Concepts, Analyzes and Assessments for Industry 4.0", Springer International Publishing., United States, 2016

REFERENCES:

1. Black J.T. and Kohser R.A, "DeGarmo's Materials and Processes in Manufacturing", Published by Wiley, 11th Edition, 2011.
2. Seliger G., "Sustainable Manufacturing: Shaping Global Value Creation", Springer, United States, 2012, ISBN 978–3–642–27289–9
3. Rao R. V, "Advanced Modeling and Optimization of Manufacturing Processes", 2nd Edition, 2006.
4. Kutz M., "Environmentally Conscious Mechanical Design", John Wiley & Sons., United States, 2007, ISBN: 978–0–471–72636–4.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 2: DESIGN AND MANUFACTURING

U21MIP14	MECHATRONIC SYSTEMS IN ADDITIVE MANUFACTURING	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To introduce the development of Additive Manufacturing (AM), various business opportunities and applications
- To familiarize various software tools, processes and techniques to create physical objects that satisfy product development / prototyping requirements, using AM.
- To be acquainted with vat polymerization and direct energy deposition processes
- To be familiar with powder bed fusion and material extrusion processes.
- To gain knowledge on applications of binder jetting, material jetting and sheet lamination processes

COURSE OUTCOMES:

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

CO1: Recognize the development of AM technology (Understand)
CO2: Acquire knowledge on process of transforming a concept into the final product (Understand)
CO3: Elaborate the vat polymerization and direct energy deposition processes (Apply)
CO4: Acquire knowledge on process and applications of powder bed fusion and material extrusion (Understand)
CO5: Evaluate the advantages, limitations, applications of binder jetting, material jetting and sheet lamination processes (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	1	2	2	–	–	–	-	–	–	2	2	2
CO2	2	3	1	2	2	–	–	–	-	–	–	2	2	2
CO3	2	3	1	2	2	–	–	–	-	–	–	2	2	2
CO4	2	3	1	2	2	–	–	–	-	–	–	2	2	2
CO5	2	3	1	2	2	–	–	–	-	–	–	2	2	2
Correlation levels:			1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)			

SYLLABUS:

UNIT I INTRODUCTION 9

Overview – Rapid Prototyping Rapid Tooling – Rapid Manufacturing – Additive Manufacturing. AM Process Chain– ASTM/ISO 52900 Classification – Benefits. Applications: Building Printing – Bio Printing – Food Printing Electronics Printing. Business Opportunities and Future Directions – Case studies: Automobile, Aerospace, Healthcare

UNIT II DESIGN FOR ADDITIVE MANUFACTURING (DfAM) 9

Concepts and Objectives – AM Unique Capabilities – Part Consolidation – Topology Optimization Generative design – Lattice Structures – Multi–Material Parts and Graded Materials – CAD Model

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Preparation – STL–Problems with STL– AMF Design for Part Quality Improvement: Part Orientation – Support Structure – Slicing – Tool Path Generation – Design rules for Extrusion based AM

UNIT III VAT POLYMERIZATION AND DIRECTED ENERGY DEPOSITION 9

Stereolithography Apparatus (SLA) – Digital Light Processing (DLP) – Continuous Liquid Interface Production (CLIP) Technology – Laser Engineered Net Shaping (LENS)

UNIT IV POWDER BED FUSION AND MATERIAL EXTRUSION 9

Selective Laser Sintering (SLS) – Powder Fusion Mechanism – Materials and Application – Selective Laser Melting (SLM) – Electron Beam Melting (EBM) – Fused Deposition Modeling (FDM)

UNIT V OTHER ADDITIVE MANUFACTURING PROCESSES 9

Three-Dimensional Printing –: Multi jet Modeling – Laminated Object Manufacturing (LOM) – Gluing or Adhesive Bonding – Thermal Bonding– Materials

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Ian Gibson, David Rosen, Brent Stucker, Mahyar Khorasani "Additive manufacturing technologies". 3rd Edition Springer Cham, Switzerland. (2021). ISBN: 978–3–030–56126–0 2.
2. Andreas Gebhardt and Jan–Steffen Hötter "Additive Manufacturing: 3D Printing for Prototyping and Manufacturing", Hanser publications, United States, 2015, ISBN: 978–1–56990–582–1.

REFERENCES:

1. Andreas Gebhardt, "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing", Hanser Gardner Publication, Cincinnati., Ohio, 2011, ISBN :9783446425521.
2. Milan Brandt, "Laser Additive Manufacturing: Materials, Design, Technologies, and Applications", Woodhead Publishing., United Kingdom, 2016, ISBN: 9780081004333.
3. Amit Bandyopadhyay and Susmita Bose, "Additive Manufacturing", 1st Edition, CRC Press., United States, 2015, ISBN–13: 978–1482223590.

EVALUATION PATTERN:

Continuous Internal Assessments				Total Internal Assessments	End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)			
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 2: DESIGN AND MANUFACTURING

U21MIP15	ELECTRONICS MANUFACTURING TECHNOLOGY	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To impart knowledge on wafer preparation and PCB fabrication
- To introduce Through Hole Technology (THT) and Surface Mount Technology (SMT) with various types of electronic components
- To be acquainted with various testing and inspection methods of populated PCBS

COURSE OUTCOMES:

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

CO1: Perform the process of wafer preparation and PCB fabrication (Apply)
CO2: Recognize the importance of Through Hole Technology (THT) and Surface Mount Technology (SMT) (Understand)
CO3: Demonstrate various steps in Surface Mount Technology (SMT) (Apply)
CO4: Identify various testing and inspection methods of populated PCBS (Apply)
CO5: Discuss various techniques in repair, quality and reliability of electronic assemblies (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	3	2	1	–	–	–	–	–	–	2	2	2
CO2	2	3	3	2	1	–	–	–	–	–	–	2	2	2
CO3	2	3	3	2	1	–	–	–	–	–	–	2	2	2
CO4	2	3	3	2	1	–	–	–	–	–	–	2	2	2
CO5	2	3	3	2	1	–	–	–	–	–	–	2	2	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I INTRODUCTION TO ELECTRONICS MANUFACTURING **9**

History, Definition, Wafer Preparation by Growing, Machining, And Polishing, Diffusion, Microlithography, Etching And Cleaning, Printed Circuit Board – Fabrication, Types, Single Sided, Double Sided, Multi–Layer And Flexible Printed Circuit Board

UNIT II COMPONENTS AND PACKAGING **9**

Introduction to packaging, types–Through hole technology (THT) and Surface mount technology (SMT), Through hole components – axial, radial, multi leaded, odd form Surface–mount components–active, passive. Interconnections – chip to lead interconnection, die bonding, wire bonding, TAB, flip chip, chip on board, multi-chip module, direct chip array module, leaded, leadless, area array and embedded packaging, miniaturization and trends

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UNIT III SURFACE MOUNT TECHNOLOGY 9

SMT Process – Moisture Sensitivity And ESD, Safety And Precautions Needed, IPC And Other Standards, Stencil Printing Process – Solder Paste Material, Storage And Handling, Stencils And Squeegees, Process Parameters, Quality Control. Component Placement– Equipment Type, Flexibility, Accuracy Of Placement, Throughput, Packaging Of Components For Automated Assembly, Soldering– Wave Soldering, Reflow Process, Process Parameters, Profile Generation And Control, Adhesive, Underfill And Encapsulation Process

UNIT IV INSPECTION AND TESTING 9

Inspection Techniques, Equipment And Principle– Aoi, X–Ray. Defects And Corrective Action – Stencil Printing Process, Component Placement Process, Reflow Soldering Process, Electrical Testing Of Pcb Assemblies– In Circuit Test, Functional Testing, Fixtures And Jigs.

UNIT V REPAIR, REWORK, QUALITY AND RELIABILITY OF ELECTRONICS ASSEMBLIES 9

Repair And Rework Of PCB– Coating Removal, Base Board Repair, Conductor Repair, Thermomechanical Effects And Thermal Management, Reliability Fundamentals, Reliability Testing, Failure Analysis, Design For Manufacturability, Assembly, Reworkability, Testing, Reliability, And Environment.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Prasad R., "Surface Mount Technology – Principles and practice",2nd Edition, Chapman and Hall., New York, 1997, ISBN 0–41–12921–3.
2. Tummala R.R., "Fundamentals of microsystem packaging", Tata McGraw Hill Co. Ltd., New Delhi, 2001, ISBN 00–71–37169–9.

REFERENCES:

1. Puligandla Viswanadham and Pratap Singh., "Failure Modes and Mechanisms in Electronic Packages", Chapman and Hall., New York, 2008, N.Y. ISBN 0–412–105591–8. Science and Technology, United Kingdom, 1997, ISBN 0750698756.
2. Totta P., Puttlitz K. and Stalter K., "Area Array Interconnection Handbook", Kluwer Academic Publishers, Norwell, MA, United States, 2001, ISBN 0–7923–7919–5.

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EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	**End Semester Examinations**
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	**60**	**40**	**60**	**200**	**100**
Total				**40**	**60**
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 2: DESIGN AND MANUFACTURING

		Category: PEC				
U21MIP16	COMPUTER AIDED INSPECTION AND TESTING	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To familiar the measurement standards and to know the instruments used and various errors in measurements
- To learn the applications of opto–electronics device for measurements
- To gain knowledge on computer aided inspection and advances in metrology

COURSE OUTCOMES:

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

CO1: Understand the significance of standards of measurement in metrology (Understand)
CO2: Examine the evolution, types, and classifications of linear measuring instruments (Understand)
CO3: Explain the role of optoelectronics in tool wear measurements and surface roughness analysis (Understand)
CO4: Analyze the principles and functioning of interferometers, interference microscopes, and optical flats (Apply)
CO5: Examine the applications of laser metrology in machine tool inspection and online inspection (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	–	–	–	–	–	–	–	1	2	2
CO2	3	2	1	1	–	–	–	–	–	–	–	1	2	2
CO3	3	2	1	1	–	–	–	–	–	–	–	1	2	2
CO4	3	2	1	1	–	–	–	–	–	–	–	1	2	2
CO5	3	2	1	1	–	–	–	–	–	–	–	1	2	2
Correlation levels:			1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)			

SYLLABUS:

UNIT I FUNDAMENTALS AND CONCEPTS IN METROLOGY **9**

Standards of Measurement – Analog and Digital Measuring Instruments – Comparators – Limits, Fits and Tolerances – Gauge Design –Surface Roughness – Form Errors and Measurements.

UNIT II INSPECTION AND GENERAL MEASUREMENTS **9**

Linear Measuring Instruments – Evolution – Types – Classification – Limit Gauges – Gauge Design – Terminology – Procedure – Concepts of Interchange Ability and Selective Assembly – Angular Measuring Instruments – Types – Bevel Protractor Clinometers Angle Gauges, Spirit Levels Sine Bar – Angle Alignment Telescope – Autocollimator – Applications – Inspection of Gears And Threads – Tool Makers' Microscope – Universal Measuring Machine

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UNIT III OPTO ELECTRONICS IN ENGINEERING INSPECTION 9

Use of Optoelectronics in Tool Wear Measurements – Microhole Measurement and Surface Roughness – Applications in In–Process Measurement and On–Line Inspection.

UNIT IV LASER METROLOGY 9

Precision instrument based on Laser – Use of Lasers – Principle –Interferometers, Interference microscope –Optical flats – Laser Interferometer – Application in Linear and Angular measurements – Testing of machine tools using Laser Interferometer. Use of Laser Interferometer in Machine Tool Inspection – Uses of Laser in On–Line Inspection – Laser Micrometer – Laser Alignment Telescope.

UNIT V COMPUTER AIDED INSPECTION AND ADVANCES IN METROLOGY 9

Precision instrument based on Laser – Use of Lasers – Principle –Interferometers, Interference microscope –Optical flats – Laser Interferometer – Application in Linear and Angular measurements – Testing of machine tools using Laser Interferometer. Use of Laser Interferometer in Machine Tool Inspection – Uses of Laser in On–Line Inspection – Laser Micrometer – Laser Alignment Telescope..

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Anil. K. Jain, "Fundamentals of Digital Image Processing", Prentice Hall of India Pvt. Ltd., 2006.
2. Alan S. Morris, "The Essence of Measurement", Prentice Hall of India, 2002.
3. Beckwith, Marangoni, Lienhard, "Mechanical Measurements", Pearson Education, 2014

REFERENCES:

1. Charles Reginald Shotbolt, "Metrology for Engineers", Cengage Learning EMEA,5th Edition, 1996.
2. Jain R.K., "Engineering Metrology", Khanna Publishers, 2012.
3. Robert G. Seippel, "Opto–Electronics for Technology and Engineering", Prentice Hall, 1989.
4. Robert J. Hocken, Paulo H. "Coordinate Measuring Machines and Systems", CRC Press, 2nd Edition, 2016.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 3: AUTOMOTIVE ENGINEERING & TECHNOLOGY

U21MIP17	FUNDAMENTALS OF AUTOMOTIVE ENGINEERING AND TECHNOLOGY	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- NIL

COURSE OBJECTIVES:

- To impart the fundamentals of ICE engine and its supporting systems
- To equip the students with knowledge of transmission system of traditional vehicles
- To learn the importance of various braking and suspension systems

COURSE OUTCOMES:

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

CO1: Interpret the fundamental operation of an internal combustion engine (Understand)
CO2: Discover the importance of air–fuel mixture in both petrol and diesel engine (Analyze)
CO3: Identify the role of lubrication and coolant for engine operation (Apply)
CO4: Identify the behaviour of clutch and gear in automotive transmission system (Apply)
CO5: Classify the effect various types of suspension and braking systems on the vehicle (Analyze)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	1	–	–	–	–	–	–	2	2	2
CO2	3	2	2	2	1	–	–	–	–	–	–	2	2	2
CO3	3	2	2	2	1	–	–	–	–	–	–	2	2	2
CO4	3	2	2	2	1	–	–	–	–	–	–	2	2	2
CO5	3	2	2	2	1	–	–	–	–	–	–	2	2	2
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)				3: Substantial (High)							

SYLLABUS:

UNIT I INTRODUCTION TO AUTOMOTIVE ENGINES 9

Fundamental of Engine Operations – Engine Types and Classification – Engine Construction – Camshafts and its timing – Valves and Valve–Train Components

UNIT II AUTOMOTIVE FUEL INJECTION SYSTEMS 9

Fuels and Combustion – Air Intake, Mixture and Exhaust – Stoichiometric Ratio – Carburetor and its Types – Petrol and Diesel Fuel Injection Systems – Superchargers and Turbochargers

UNIT III AUTOMOTIVE ENGINE LUBRICATING AND COOLING SYSTEMS 9

Engine Oil – Lubricating Systems and Indicators – Antifreeze and Cooling System Components – Cooling and Lubrication System Diagnosis

UNIT IV AUTOMOTIVE DRIVETRAINS 9

Clutch: Construction and Operation – Gears and Gearing, Transmission and Transaxle: Construction and Operation – Driveshafts, Universal Joints, Differentials and Drive Axles – Types of Drives and Coupling, Torque Convertor and Automatic Transmission

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UNIT V AUTOMOTIVE CHASSIS SYSTEMS 9

Suspension System: MacPherson Strut, Ball Joint, Torsion Bar and Active Suspension – Steering Systems: Recirculating Ball, Rack and Pinion, Power Steering, Steering Geometry – Braking Systems: Drum and Disc Brakes, Valves and Master Cylinder, Antilock Braking System (ABS) and Traction Control System (TCS) – Tires: Identification, Construction and Speed Rating

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Dr. Kirpal Singh, "Automobile Engineering", 13th Edition, Vol 1 & 2, Standard Publishers, New Delhi, 2020
2. N. K. Giri, "Automobile Mechanics", 5th Edition, Khanna Publishers, 2014
3. William H Crouse, Donald L Anglin, "Automotive Mechanics", 10th Edition, McGraw–Hill, 2012

REFERENCES:

1. James E Duffy, "Modern Automotive Technology", 8th Edition, Goodheart – Willcox, US, 2013
2. Bosch Automotive Handbook, 10th Edition, Wiley publications, 2018
3. Jack Erjavec, Martin Restoule, Stephen Leroux, Rob D. Thompson, "Automotive Technology – A Systems Approach", Nelson Education Limited, Canada, 2015
4. James D. Halderman, "Automotive Chassis Systems", 7th Edition, Pearson Publishers, US, 2016
5. K.V. Fadadu, B.H.Kadiya, "Vehicle Testing And Homologation", 1st Edition, Books India Publications, 2016
6. David A. Crolla, "Automotive Engineering – Powertrain, Chassis System and Vehicle Body", 1st Edition, Elsevier, 2009.

EVALUATION PATTERN:

Continuous Internal Assessments					End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 3: AUTOMOTIVE ENGINEERING & TECHNOLOGY

U21MIP18	AUTOMOTIVE ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- NIL

COURSE OBJECTIVES:

- To study the basics of electrical, electronics and control systems used in automobiles
- To understand the various starting and operational systems for automobiles
- To acquire knowledge of the advanced vehicle motion control systems

COURSE OUTCOMES:

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

CO1: Categorize the evolving laws on emission and its impact on development on modern engine control system (Analyze)
CO2: Distinguish the charging, starting and ignition system of a vehicle (Analyze)
CO3: Identify the control systems deployed to monitor the fuel supply (Apply)
CO4: Outline the type of automotive data and the medium of its output (Understand)
CO5: Examine the modern motion control systems in automobile (Analyze)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	–	–	–	–	–	–	–	1	2	2
CO2	3	3	2	2	–	–	–	–	–	–	–	1	2	2
CO3	3	2	1	2	–	–	–	–	–	–	–	1	2	2
CO4	3	1	–	1	–	–	–	–	–	–	–	1	2	2
CO5	3	3	2	2	–	–	–	–	–	–	–	1	2	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I BASICS OF ELECTRONIC ENGINE CONTROL **9**

Emission laws – Introduction to Euro I, Euro II, Euro III, Euro IV, Euro V standards – Equivalent Bharat Standards – Engine Performance Terms – Microprocessor and Microcontroller – Sensors and Actuators – Measurement Tools and Equipment – On–Board Diagnostics and Procedures – Control Theory: Open and Closed–Loop, Stability of Control Systems, Filtering – Electronic Devices: Semiconductors, Transistor, Operational Amplifiers, Logic Circuits, Synchronous Counter

UNIT II CHARGING, STARTING AND IGNITION SYSTEM **9**

12V Batteries: Construction, Chemistry, Maintenance and Advancements in Electrical Storage – Requirements of Charging System – Alternators and Charging Circuits, Diagnosis and Advancements – Requirements of Starting System – Starter Motor and Circuits, Diagnosis and Advancements – Ignition System: Electronic Ignition Control, Programmed, Distributerless, and Direct Ignition, Diagnosis and Advancements

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UNIT III ENGINE MANAGEMENT AND FUEL CONTROL SYSTEM 9

Fuel Injection – Electronic Control of Carburetor – Exhaust Emission Control – Digital Engine Control – Control Modes for Fuel – Discrete Time Idle Speed Control – EGR Control – Variable Valve Timing Control – Integrated Engine Control System

UNIT IV AUTOMOTIVE INSTRUMENTATION AND TELEMATICS 9

Input and Output Signal Conversion: Multiplexing and Multirate Sampling – Display Devices: LED, LCD, VFD – Measurement Systems: Fuel, Coolant Temperature, Oil Pressure, Vehicle Speed – High–Speed Digital Communication (CAN) – Telematics – GPS System Structure – Signalling Circuits – Other Auxiliary Systems

UNIT V VEHICLE MOTION CONTROL SYSTEMS 9

Cruise Control System and Electronics: Vacuum–Operated Throttle Actuator, Stepper Motor–Based Actuator, Digital and Analog Cruise Control System – Antilock Braking System – Electronic Suspension Systems: Variable Damping and Variable Spring Rate – Electronic Steering Control System – Traction Control System – Advanced Chassis Technologies

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Tom Denton, "Automobile Electrical and Electronics Systems", Edward Arnold Publishers, 2022
2. William B. Ribbens, "Understanding Automotive Electronics", 8th Edition, Elsevier, 2017.
3. Mehrdad Ehsani, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles", 2nd Edition, CRC Press, 2010.

REFERENCES:

1. AK Babu, "Automotive Electrical and Electronics", 2nd Edition, Khanna Publishing, 2016
2. Barry Hollembeak, "Automotive Electricity, Electronics & Computer Controls", Delmar Publishers, 7th Edition, 2019
3. Barry Hollembeak, "Automotive Electricity, Electronics & Computer Controls", Delmar Publishers, 2001
4. Richard K. Dupuy, "Fuel System and Emission controls", Check Chart Publication, 2000. 5.
5. Ronald. K. Jurgon, "Automotive Electronics Handbook", McGraw–Hill, 1999.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 3: AUTOMOTIVE ENGINEERING & TECHNOLOGY

U21MIP19	AUTOMOTIVE THERMAL MANAGEMENT SYSTEMS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- NIL

COURSE OBJECTIVES:

- To apply the laws of thermodynamics and describe their significance
- To impart a comprehensive knowledge of various modes of heat transfer
- To study the various systems developed to manage heat produced from engines and batteries

COURSE OUTCOMES:

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

CO1: Apply the laws of thermodynamics and entropy principles for engineering systems (Apply)
CO2: Analyze the steady and unsteady heat conduction and convection processes (Analyze)
CO3: Identify the various components used in engine cooling system (Apply)
CO4: Identify the various components used in automotive cabin cooling, heating and ventilation (Apply)
CO5: Infer the importance of cooling system for efficient operation of battery (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	–	–	–	–	–	–	–	1	2	2
CO2	3	3	2	2	–	–	–	–	–	–	–	1	2	2
CO3	3	2	1	2	–	–	–	–	–	–	–	1	2	2
CO4	3	2	–	1	–	–	–	–	–	–	–	1	2	2
CO5	3	2	2	2	–	–	–	–	–	–	–	1	2	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I INTRODUCTION TO THERMODYNAMICS 9

Laws of Thermodynamics: Zeroth Law, First Law, Second Law and Third Law – Principles of Thermometry – Steady Flow Energy Equation – Entropy, Availability and Irreversibility – Maxwell Relations, Gibbz and Helmholtz Functions – Phase Transformation – Ideal, Real and Perfect Gas – Equation of State – Theory of Psychrometry

UNIT II INTRODUCTION TO HEAT TRANSFER 9

Various Modes of Heat Transfer – Governing Laws and Equation for Different Modes of Heat Transfer – Combined Mode, Conductivity and Film Coefficient of Heat Transfer – Thermal Diffusivity, Overall Heat Transfer Coefficient, Thermal Resistance and Conductance – Numerical – Cooling of Electrical Equipment – Predicting the Junction Temperature of Device and Transistor – Conduction Cooling of PCBs

UNIT III TYPES OF ENGINE COOLING SYSTEM 9

Components of Engine Cooling Systems: Coolant, Water Pumps – By–pass – Radiator – Radiator Pressure Caps, Filler Caps, Fan and Fan Drives, Thermostats – Air Cooling System – Forced

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Circulation Water Cooling System – Air Cooled Engine – Heat Conduction in Cylinders – Critical Radius of Insulation – Heat Transfer from Finned Surfaces

UNIT IV AUTOMOTIVE AIR CONDITIONING 9

Introduction to Heating and Ventilation – Basic Theory of Cooling – Vapor Compression Refrigeration – Air Conditioning Systems – Expansion Valve System – Fixed Orifice Valve System – Dual Air–Conditioning – Evaporator – Condenser – Classification of Fluid Flows: Laminar and Turbulent Flows –Differential Convection Equations – Laminar and Turbulent Flow in Tubes

UNIT V BATTERY MANAGEMENT SYSTEMS 9

Li–ion Batteries and BMS: Function, Capacity, SOC, DOD, SOH and Measurement – Functionality of BMS – BMS Technology: Simple (Analog) and Sophisticated (Digital) – Topology: Centralized, Modular, Master–Slave, and Distributed

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Cenegel Yunus A and Boles Michael, A, "Thermodynamics", Tata Mcgraw–Hill, New Delhi, 2011.
2. Yunus Cengel and Afshin Ghajar, "Heat and Mass Transfer", Tata Mcgraw Hill Education Pvt Ltd, New Delhi, 2011
3. William H Crouse, Donald L Anglin, "Automotive Mechanics", 10th Edition, McGraw–Hill, 2012
4. Steven Daly, "Automotive Air conditioning and climate control systems", Elsevier Ltd., United Kingdom, 2006.
5. Davide Andrea, "Battery Management Systems for Large Lithium–Ion Battery Packs", Arctech House Publishers, Unabridged Edition, USA, 2010

REFERENCES:

1. Nag P K, "Engineering Thermodynamics", Tata McGraw–Hill, New Delhi, 2006
2. N. K. Giri, "Automobile Mechanics", New Delhi, 2008.
3. Ibrahim Dincer, "Thermal Management of Electric Vehicle Battery Systems", Jhon Wiley and Sons Ltd, United Kingdom, 2017.
4. W P Jones, "Air conditioning Engineering", Elsevier Ltd., United Kingdom, 2005.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
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Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 3: AUTOMOTIVE ENGINEERING & TECHNOLOGY

U21MIP20	VEHICLE BODY DYNAMICS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- NIL

COURSE OBJECTIVES:

- To introduce the different sources of vibration and its effect on vehicle dynamics
- To familiarize longitudinal, lateral and vertical dynamics of vehicle system
- To provide an insight knowledge on control mechanism of steering and suspension systems

COURSE OUTCOMES:

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

CO1: Identify and Analyze the various sources of vibration (Analyze)
CO2: Develop mathematical models to Analyze vehicle ride comfort (Analyze)
CO3: Investigate the vehicle performance and its control during braking and acceleration (Analyze)
CO4: Evaluate the steady state and transient response of vehicle during cornering and its stability (Evaluate)
CO5: Develop the methods of improving the stability, safety and comfort associated with a vehicle from an aerodynamics view–point (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	–	–	–	–	–	–	–	1	2	2
CO2	3	3	2	2	–	–	–	–	–	–	–	1	2	2
CO3	3	2	1	2	–	–	–	–	–	–	–	1	2	2
CO4	3	3	3	2	–	–	–	–	–	–	–	1	2	2
CO5	3	2	3	2	–	–	–	–	–	–	–	1	2	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I VIBRATIONS **9**

Basic Concepts of Vibration – Classification of Vibration, Vibrational Analysis Procedure, Single DOF Undamped and Damped Free Vibration and Forced Vibration, Vibration Isolation, Force and Displacement Transmissibility, Forced Vibration due to Rotating Unbalance – 2 DOF System – MDOF Systems – Continuous System Approach

UNIT II VEHICLE RIDE DYNAMICS **9**

Rolling Resistance, Longitudinal Slip, Skid – Julien's Theory for Tractive Effort– Cornering Force – Camber Angle, Camber Thrust, Aligning Torque – Temple and Von Schlippe Methods for Tire Cornering Force – Friction Ellipse Concept – Magic Formula Basic Tire Model – Tire Performance on Wet Surfaces – Hydroplaning – Quarter Car Model, Pitch And Bounce Model– Suspension Travel And Road Holding – Surface Elevation Profile as A Random Function – Road and Vehicle Power Spectral Density Functions

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UNIT III VEHICLE PERFORMANCE AND CONTROL 9

Vehicle Axis System – Vehicle Free Body Diagram and Maximum Tractive Effort – Aerodynamic Forces and Moments – Vehicle Power Train and Transmission – Prediction of Vehicle Performance: Acceleration, Time and Distance – Gradability – Braking Performance – Tire Dynamics for Antilocking Braking Systems and Traction Control System

UNIT IV VEHICLE HANDLING AND STABILITY 9

Ackermann Steering Geometry – Bicycle Model – Steer Conditions – Handling– Yaw Velocity Response – Lateral Acceleration Response and Curvature Response – Handling Tests – Vehicle Stability Using Bicycle Model – Routh's Stability Criterion – Solid Axle and Independent Suspension – Effect of Suspension on Vehicle Roll – Active And Semi–Active Suspension Systems – Steering Linkages – Steering Geometry – Steering System Forces and Moments

UNIT V VEHICLE AERODYNAMICS 9

Drag – Flow Field around Car – Optimization of Car Bodies for Low Drag – Vehicle Dynamics Under Side Wind – Wind Noise – Air Flow Around Individual Components – Principles of Wind Technology – Measuring Equipment And Transducers: Pressure and Velocity Measurements – Flow Visualization Techniques – Road Testing Methods – Wind Noise Measurements

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Singiresu S. Rao, "Mechanical Vibrations", 6th Edition, Pearson Education.Inc. Prentice Hall, 2018
2. Thomas D Gillespie, "Fundamentals of Vehicle Dynamics", 2nd Revised Edition, SAE International, Warrendale, 2021
3. J.Y. Wong, "Theory of Ground Vehicle, Fourth Edition, John Wiley & Sons", Inc. New York, 2008
4. Yomi Obidi, "Theory and Applications of Aerodynamics for Ground Vehicles", SAE Publications, 2014

REFERENCES:

1. Rao V. Dukkipati, Jian Pang, "Road Vehicle Dynamics problems and solution", SAE, 2010
2. Reza N Jazar "Vehicle Dynamics: Theory and Application", 3rd Edition, Springer International Publishing AG, Switzerland, 2017
3. Hans Pacejka, "Tire and Vehicle Dynamics", 3rd Edition, Elsevier, Butterworth–Heinemann, 2012
4. Hans B. Pacejka, "Tire and Vehicle Dynamics", 3rd Edition, Butterworth–Heinemann, 2012

EVALUATION PATTERN:

Continuous Internal Assessments				Total Internal Assessments	End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)			
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 3: AUTOMOTIVE ENGINEERING & TECHNOLOGY

		Category: PEC				
U21MIP21	AUTONOMOUS VEHICLE SYSTEMS	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- NIL

COURSE OBJECTIVES:

- To impart the required fundamentals of autonomous vehicles design and test
- To provide an exposure about sensors and sensor fusion technology in automotive systems
- To develop design skills in autonomous vehicle systems

COURSE OUTCOMES:

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

CO1: Understand the required fundamentals of Autonomous Driving (Understand)
CO2: Categorize the autonomous vehicle localization (Analyze)
CO3: Inspect the perception system for autonomous driving (Analyze)
CO4: Analyze the autonomous vehicles decision, planning and control (Analyze)
CO5: Organize the issues and their solution involved in the complex traffic environments (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	–	–	–	–	–	–	–	–	–	–	1	2	2
CO2	3	2	1	2	1	–	–	–	–	–	–	1	2	2
CO3	3	2	1	2	1	–	–	–	–	–	–	1	2	2
CO4	3	2	1	2	2	–	–	–	–	–	–	1	2	2
CO5	3	1	1	2	1	–	–	–	–	–	–	1	2	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)					

SYLLABUS:

UNIT I AUTONOMOUS DRIVING SENSORS AND SENSOR FUSION TECHNOLOGY 9

Autonomous Driving Algorithms – Sensing, Perception, Object Recognition And Tracking, And Action – Autonomous Driving Client System – Robot Operating System (ROS) And Hardware – Autonomous Driving Cloud Platform – Simulation, HD Map Production And Deep Learning Model Training – Lidar, RADAR, IMU Sensors, GNSS And Cameras – Sensors Calibration – Sensor Fusion – Classical Sensor Fusion Algorithms and Deep Learning Sensor Fusion Algorithms

UNIT II AUTONOMOUS VEHICLE LOCALISATION 9

Localization With GNSS – Localization With Lidar And HD Maps: Lidar Overview, HD Maps Overview, Localization With Lidar And HD Map – Visual Odometry: Stereo Visual Odometry, Monocular Visual Odometry, and Visual Interial Odometry – Dead Reconning and Wheel Odometry – Wheel Encoders, Wheel Odometry Errors and Reduction Of Wheel Odometry Errors

UNIT III PERCEPTION, PREDICTION AND ROUTING 9

Introduction – Datasets – Detection – Segmentation – Stereo, Optical Flow, and Scene Flow – Tracking – Deep Learning in Autonomous Driving Perception – Planning and Control Overview – Traffic

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Prediction – Behavior Prediction – Lane Level Routing – Route Construction using Weighted Directed Graph – Typical Routing Algorithms and Routing Graph Cost

UNIT IV DECISION, PLANNING AND CONTROL 9

Behavioral Decisions – Markov Decision Process Approach – Motion Planning – Vehicle Model, Road Model, And SL Coordination System – Motion Planning with Path Planning and Speed Planning, Motion Planning With Longitudinal Planning And Lateral Planning – Feedback Control – Bicycle Model And PID Control – Complex Traffic Environments – Perception – Prediction, Decision And Planning – Safety And Security Strategies – Simulation – End Monitoring – Remote Monitoring

UNIT V ADVANCED DRIVER ASSISTANCE SYSTEMS & IMPAIRED DRIVER TECHNOLOGY 9

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) – Front Collision Warning System (FCWS) – Front Vehicle Departure Warning (FVDW) – Adaptive Lighting – Driver Drowsiness Detection – Hill Decent Control – Rear Cross Traffic – 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

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean–Luc Gaudiot, "Creating Autonomous Vehicle Systems", Morgan and Claypool Publishers
2. Tim Schule, "Advanced Microsystems for Automotive Applications: Smart Systems for Green and Automated Driving", 2015, Springer Publishers, USA

REFERENCES:

1. O. Vermesan, "Internet of Things – Converging Technologies for Smart Environments and Integrated Ecosystems", 2015, River Publishers, The Netherlands
2. Vermesan, "Digitizing the Industry: Internet of things connecting Physical, Digital and Virtual Worlds", Jan 2016, River Publishers, The Netherlands
3. Intelligent Transportation Systems and Connected and Automated Vehicles", Transportation Research Board, 2016.
4. Radovan Miucic, "Connected Vehicles: Intelligent Transportation Systems", Springer, 2019

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 3: AUTOMOTIVE ENGINEERING & TECHNOLOGY

U21MIP22	DESIGN PRINCIPLES OF HYBRID AND ELECTRIC VEHICLES	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- NIL

COURSE OBJECTIVES:

- To acquire the knowledge of the various hybrid and electric vehicles
- To outline the design procedure of various configurations of hybrid electric vehicles
- To provide exposure to the plug–in and mild hybrid electric drive train

COURSE OUTCOMES:

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

CO1: Understand the various configurations of hybrid and electric vehicles (Understand)
CO2: Analyze the power design for the series hybrid drive train (Apply)
CO3: Analyze the power design for the parallel hybrid drive train (Apply)
CO4: Analyze the power design for the series–parallel hybrid drive train (Apply)
CO5: Compare the energy management of hybrid electric vehicle (Understand)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	–	–	–	–	–	–	–	–	–	–	1	2	2
CO2	3	2	1	2	–	–	–	–	–	–	–	1	2	2
CO3	3	2	1	2	–	–	–	–	–	–	–	1	2	2
CO4	3	2	1	2	–	–	–	–	–	–	–	1	2	2
CO5	3	1	1	1	–	–	–	–	–	–	–	1	2	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I ELECTRIC VEHICLES AND HYBRID ELECTRIC VEHICLES **9**

Environmental Impact – History of Modern Transportation – Configurations of EV's – Performance of EV's – Tractive Effort and Energy Consumption – Architecture of Hybrid Electric Drive Trains – Series and Parallel – Peaking Power Sources and Energy Storages – DC Motor Drives: Multi–Quadrant Control of Chopper–Fed DC Motor Drives – Induction Motor Drives: Field Operational Control – Permanent Magnetic BLDC Motor Drives: Extend Speed Technology and Sensor less Techniques – SRM Drives: Design and Self–Tuning

UNIT II DESIGN PRINCIPLE OF SERIES HYBRID ELECTRIC DRIVE TRAIN **9**

Operation Patterns – Control Strategies: Max. SOC–of–PPS and Engine On–Off Control Strategy – Power Rating Design – Traction motor – Engine/ Generator – Design of Peaking Power Source – Design of Gear Ratio – Design of Traction Motor Size – Verification of Acceleration Performance and Gradeability– Gradeability – Engine/ Generator Size – Design of the Power and Energy Capacity of PPS

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UNIT III DESIGN PRINCIPLE OF PARALLEL HYBRID ELECTRIC DRIVE TRAIN 9

Drivetrain Configurations – Control Strategies: Max. SOC–of–PPS, Engine On–Off, Fuzzy Logic, Dynamic Programming – Parametric Design: Engine Power Design, Transmission Design, Electric Motor Drive Power Design, Peak Power Source Design

UNIT IV DESIGN PRINCIPLE OF SERIES–PARALLEL HYBRID ELECTRIC DRIVE TRAIN 9

Drivetrain Configurations: Speed Coupling Analysis, Drive Train Configuration – Control Methodology – Engine Speed Control Approach – Traction Torque Control Approach – Regenerative Braking Control – Drivetrain Parameters Design – Control Strategy for: Engine Speed, Traction Control and Regenerative Braking

UNIT V DESIGN PRINCIPLE OF PLUG–IN AND MILD HYBRID ELECTRIC DRIVE TRAIN 9

Statistics Of Daily Driving Distance – Energy Management Strategy – AER Focused Control Strategy – Blende Control Strategy – Energy Consumed in Braking and Transmission – Parallel Mild Hybrid Drivetrain – Configuration – Operating Modes – Performance and Drive Train Design – Series–Parallel Mild Hybrid Electric Drive Train – Configuration of Drive Train with a Planetary Gear unit – Operating Modes: Speed–Coupling, Torque–Coupling, Engine–Alone, Motor–Alone, Regenerative Braking, Engine Starting

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Mehrdad Ehsani, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles", 2nd Edition, CRC Press, 2010.
2. David A. Crolla, "Automotive Engineering – Powertrain, Chassis System and Vehicle Body", 1st Edition, Elsevier, 2009.

REFERENCES:

1. Barry Hollembeak, "Automotive Electricity, Electronics & Computer Controls", Delmar Publishers, 7th Edition, 2019
2. Tom Denton, "Automobile Electrical and Electronics Systems", Edward Arnold Publishers, 2022
3. William B. Ribbens, "Understanding Automotive Electronics", 8th Edition, Elsevier, 2017.

EVALUATION PATTERN:

Continuous Internal Assessments					End Semester Examinations
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40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 3: AUTOMOTIVE ENGINEERING & TECHNOLOGY

U21MIP23	ENERGY STORAGE AND MANAGEMENT FOR ELECTRIC VEHICLES	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- NIL

COURSE OBJECTIVES:

- To familiarize with the fundamentals of energy storage systems (battery) and its management
- To gain the knowledge of battery failures and safety measures
- To model and analyze the energy storage system in view of environmental sustainability

COURSE OUTCOMES:

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

CO1: Classify the energy storage systems in hybrid and electric vehicle (Understand)
CO2: Examine the requirement of battery health monitoring (Analyze)
CO3: Outline the effects of faults in battery (Understand)
CO4: Compare the methods used to model the battery (Analyze)
CO5: Examine the effect of batteries on environment, its method of recycling and prospective of alternate source of energy like hydrogen (Analyze)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	–	–	–	–	–	–	–	–	–	–	1	2	2
CO2	3	2	1	2	1	–	–	–	–	–	–	1	2	2
CO3	3	1	–	2	1	–	–	–	–	–	–	1	2	2
CO4	3	2	1	2	2	–	–	–	–	–	–	1	2	2
CO5	3	2	1	2	1	–	–	–	–	–	–	1	2	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I ENERGY STORAGE SYSTEMS AND TYPES **9**

Mechanical, Electrical, Electro Chemical Storage Systems – Parameters of Energy Storage, Energy Density, Time Factors, Depth of Discharge, Electrochemical Storage Components: Cells, Battery and Battery Pack – Battery Selection, Types of Battery – Lead Acid Battery, Sodium Based Batteries, Lithium Based Batteries: Li–Ion Phosphate (LFP), Lithium–Ion Nickel–Manganese–Cobalt (NMC), Lithium Titanate (LTO), Li–Cobalt (LCO) Batteries, Li Based other Batteries – Metal Air Battery, Zinc Chloride Battery – Supercapacitors, Ultra Capacitors: Types and Characteristics

UNIT II BATTERY MANAGEMENT SYSTEM **9**

Cell and Battery Voltage – Charge Capacity – Energy Stored: Charging Efficiency, Energy Efficiency, Self–Discharge Rates, Battery Geometry – BTMS: Use of PCM For BTMS, Battery Life and Number of Cycles of Different Battery Types – Requirement of Battery Monitoring – Battery SOC & SOH – Estimation Methods, Battery Cell Equalization: Thermal Control, Protection Interface, Energy & Power Estimation – Battery Pack Safety

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UNIT III BATTERY FAILURES AND SAFETY MEASURES 9

Battery Maintenance – Battery Abuse – Battery Leakage: Ruptures, Explosions, Thermal Runaway, Environment and Human Health Impact Assessments of Batteries – Battery Packaging – Failure Mitigation

UNIT IV BATTERY MODELLING AND CHARGING STATIONS 9

Concepts of Battery Modelling: Equivalent Circuit Modelling, Electrochemical Modelling – Battery Pack Structure Design: Use of Computational Software Tools – Conventional Grid Charging – Smart Grid (V To X, X To V)) – Microgrid – Charging with PV Systems – Fast or Rapid Charging – Challenges and Solutions – Case Studies – Hybridization, Battery Swapping, Advanced Charging Systems Management

UNIT V HYDROGEN, FUEL CELL AND ENVIRONMENTAL SUSTAINABILITY 9

Hydrogen, Fuel Cell and Environmental Sustainability Hydrogen Energy Storage for Fuel Cell: Compressed, Liquefied, Metal Hydride Hydrogen Storage – Processes and Safety Aspects in Storage, Microbial Fuel Cell and Solar Based Energy Storage – Limitations for Transport and Storage of Batteries, Disposal, General Recycling Issues, Methods of Recycling and Reuse.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Alfred Rufer, "Energy Storage Systems and Components" , CRC Press, 2018
2. Ibrahim Dincer, "Thermal Management of Electric Vehicle Battery Systems", John Wiley, 2017

REFERENCES:

1. H.J. Bergveld, "Battery Management Systems Design", Springer Nature, 2020
2. Krishnan S. Hariharan, Piyush Tagade, Sanoop Ramachandran, "Mathematical Modelling of Lithium Batteries", Springer, 1st Edition, 2018
3. David Linden & Thomas B Reddy, "Handbook of batteries", 3rd Edition, McGraw Hill
4. Jürgen Garche, Bruno Scrosati, Werner Tillmetz, "Advances in Battery Technologies for electric vehicles", Woodhead publishing, 1st Edition, 2015

EVALUATION PATTERN:

Continuous Internal Assessments					End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 3: AUTOMOTIVE ENGINEERING & TECHNOLOGY

U21MIP24	AUTOMOTIVE FAULT DIAGNOSTICS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- NIL

COURSE OBJECTIVES:

- To learn the safe working practices and diagnostic techniques
- To acquire the knowledge of the various automotive components
- To recognize the fault and implement the diagnostic techniques for the respective automotive components

COURSE OUTCOMES:

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

CO1: Recognize the tools and equipment used for vehicle diagnosis (Understand)
CO2: Understand the various automotive fault diagnostic techniques (Understand)
CO3: Outline faults and its diagnosis related to the automobile engine (Understand)
CO4: Outline faults and its diagnosis related to the chassis and transmission systems (Understand)
CO5: Outline faults and its diagnosis related to the automotive electrical systems (Understand)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	–	–	–	–	–	–	–	–	–	–	1	2	2
CO2	3	2	–	2	–	–	–	–	–	–	–	1	2	2
CO3	3	2	–	2	3	–	–	–	–	–	–	1	2	2
CO4	3	2	–	2	3	–	–	–	–	–	–	1	2	2
CO5	3	2	–	2	3	–	–	–	–	–	–	1	2	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I DIAGNOSTICS TECHNIQUES – TOOLS AND EQUIPMENT **9**

Safe Working Practices – Diagnosis Process – Mechanical Diagnostics Techniques – Electrical Diagnostics Techniques – Fault Codes – Systems and Data Sources – Pico Oscilloscope Kits – Scanners – Emission Testing – Pressure Testing

UNIT II OSCILLOSCOPE AND ON–BOARD DIAGNOSTICS **9**

Sensors – Actuators – Waveforms – On–Board Diagnosis – Petrol OBD Monitors – Component Monitoring – Circuit Testing – Catalyst Monitor – Fuel System Monitor – Exhaust System Monitoring – Misfire Detection – Driving Cycles – Europe and United States – Future Developments in Diagnostic Systems

UNIT III ENGINE SYSTEMS **9**

Engine Operations – Diagnostics – Engine – Fuel system and its Diagnostics – Ignition systems and its Diagnostics – Emission and its Diagnostics – Fuel Injection and its Diagnostics – Engine management and Fault finding – Diagnostics of Air and Exhaust Supply – Cooling System and its

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Diagnostics – Lubrication system and its Diagnostics – Batteries and related faults – Starting and Cargin systems diagnosis.

UNIT IV CHASSIS AND TRANSMISSION SYSTEMS 9

Brakes and its Diagnostics – ABS and its Diagnostics – Traction Control System and its Diagnostics – Steering and its Diagnostics – Suspension and its Diagnostics – Manual Transmission and its Diagnostics – Automatic Transmission and its Diagnostics.

UNIT V ELECTRICAL SYSTEMS 9

Multiplexing and its Diagnostics – Lighting and its Diagnostics – Auxiliary System and its Diagnostics – In–car Entertainment – Security & Communications and its Diagnostics – Body Electrical System and its Diagnostics – Instrumentation and its Diagnostics – HVAC System and its Diagnostics – Cruise Control and its Diagnostics – Airbags & belt tensioners and its Diagnostics.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Tom Denton, "Advanced Automotive Fault Diagnosis", 4th Edition, Routledge, 2017.
2. Tim Gilles, "Automotive Engines Diagnosis, Repair and Rebuilding", 8th Edition, Cengage, 2019

REFERENCES:

1. William B. Ribbens, "Understanding Automotive Electronics", 8th Edition, Elsevier, 2017.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 4: INTELLIGENT SYSTEMS

U21MIP25	APPLIED SIGNAL PROCESSING	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the characteristics of various types of signals and carry out the preprocessing of continuous time signals and systems.
- To learn DTFT, FFT and Z–Transform methods in signals processing.
- To design digital IIR, FIR filters for signal processing.

COURSE OUTCOMES:

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

CO1: Illustrate the characteristics of various types of signals. (Understand)
CO2: Contrast the properties of different continuous time signals and systems. (Apply)
CO3: Apply DTFT, FFT and Z–Transform methods in signals processing (Understand)
CO4: Design digital IIR, FIR filters for signal processing. (Apply)
CO5: Analyze various signal processors and its applications of signals. (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	–	2	–	–	–	–	–	–	–	2	2	1
CO2	3	3	–	2	–	–	–	–	–	–	–	2	2	1
CO3	3	3	–	2	–	–	–	–	–	–	–	2	2	1
CO4	3	2	2	2	–	–	–	–	–	–	–	2	2	1
CO5	3	2	2	2	–	–	–	–	–	–	–	2	2	1
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

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 transform 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

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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 – DTMF Tone Detection – Speech enhancement and recognition

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total 45 Periods

TEXTBOOKS:

1. Alan V Oppenheim, Alan S Willsky, Hamid Nawab S, "Signals and Systems", 2nd Edition, 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. Haykin S, Barry Van Veen, "Signals and Systems", John Wiley and sons, New Delhi, 2016.
3. Vinay K Ingle, John G Proakis , "Digital Signal Processing using MATLAB", Cengage Learning, New Delhi, 2012.
4. Rao, K. Deergha, and Swamy, M.N.S.Digital Signal Processing: Theory and Practice. Germany, Springer Nature Singapore, 2018.

EVALUATION PATTERN:

Continuous Internal Assessments				Total Internal Assessments	End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)			
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 4: INTELLIGENT SYSTEMS

U21MIP26	APPLIED IMAGE PROCESSING	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To introduce various image processing, feature detection, preprocessing techniques.
- To learn about segmentation using Image processing techniques.
- To learn about computational photography and image recognition using Image processing techniques

COURSE OUTCOMES:

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

CO1: Understand various image processing and preprocessing techniques (Understand)
CO2: Design a feature detection algorithm for given application (Apply)
CO3: Make use of various segmentation algorithms for given application (Apply)
CO4: Utilize various techniques for computational photography (Apply)
CO5: Design an image recognition for given application (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	–	2	2	–	–	–	–	–	–	2	2	1
CO2	3	2	–	2	2	–	–	–	–	–	–	2	2	1
CO3	3	2	–	2	2	–	–	–	–	–	–	2	2	1
CO4	3	2	–	2	2	–	–	–	–	–	–	2	2	1
CO5	3	2	–	2	2	–	–	–	–	–	–	2	2	1
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)							3: Substantial (High)			

SYLLABUS:

UNIT I IMAGE FORMATION AND PROCESSING 9

Introduction – Geometric primitives and Transformations – Photometric Image formation – The digital camera. Introduction to image processing – point – spatial – Fourier Transform – Pyramids and wavelets – Geometric transformations – global optimization

UNIT II FEATURE DETECTION AND MATCHING 9

Introduction – Points and patches – Feature detectors – Feature Descriptors – SIFT – PCA SIFT – Gradient location orientation histogram

UNIT III SEGMENTATION 9

Active contours – Snakes – Scissors – Level sets – Split and merge – Watershed – Region splitting – region merging – and graph–based segmentation – mean shift and mode finding – Normalized cuts – graph cuts and energy–based methods

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UNIT IV COMPUTATIONAL PHOTOGRAPHY 9

Photometric calibration – Radiometric response function – Noise level estimation – Vignetting – Optical blur – High dynamic range imaging – Super resolution and blur removal – Color image demosaicing

UNIT V IMAGE RECOGNITION 9

Object detection – Face recognition – Instance recognition – category recognition – Bag of words – Part based models – context and scene understanding– Application: Image search

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total 45 Periods

TEXTBOOKS:

1. Szeliski, Richard. Computer Vision: Algorithms and Applications. Switzerland, Springer International Publishing, 2022
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

EVALUATION PATTERN:

<table>
<tr><th colspan="4">Continuous Internal Assessments</th><th rowspan="3">Total Internal Assessments</th><th rowspan="3">End Semester Examinations</th></tr>
<tr><th colspan="2">Assessment I
(100 Marks)</th><th colspan="2">Assessment II
(100 Marks)</th></tr>
<tr><th>Individual Assignment / Seminar / MCQ</th><th>Written Test</th><th>Individual Assignment / Seminar / MCQ</th><th>Written Test</th></tr>
<tr><td>40</td><td>60</td><td>40</td><td>60</td><td>200</td><td>100</td></tr>
<tr><td colspan="4" rowspan="2">Total</td><td>40</td><td>60</td></tr>
<tr><td colspan="2">100</td></tr>
</table>

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 4: INTELLIGENT SYSTEMS

U21MIP27	COMPUTER VISION AND DEEP LEARNING	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To familiarize with the fundamentals of image processing, functioning of camera, three–dimensional structure and motions.
- To learn the visual servicing for robotic applications
- To understand the fundamentals of Neural network and develop the deep learning networks for image processing

COURSE OUTCOMES:

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

CO1: Process and practice the basic images (Apply)
CO2: Develop the 3–Dimensional structures and motions (Apply)
CO3: Model the visual serving for robotic applications (Apply)
CO4: Acquire and practice the basic neural networks (Apply)
CO5: Develop and train the deep learning networks for image processing (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	–	2	2	–	–	–	–	–	–	2	2	–
CO2	3	2	–	2	2	–	–	–	–	–	–	2	2	–
CO3	3	2	–	2	2	–	–	–	–	–	–	2	2	–
CO4	3	2	–	2	2	–	–	–	–	–	–	2	2	–
CO5	3	2	–	2	2	–	–	–	–	–	–	2	2	–
Correlation levels:		1: Slight (Low)		2: Moderate (Medium)				3: Substantial (High)						

SYLLABUS:

UNIT I IMAGE FORMATION AND CAMERA CALIBRATION 9

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

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

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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 BASICS OF NEURAL NETWORK 9

Introduction to Neural Networks, Basic architecture of neural networks–types of networks–practical issues in neural network training–architecture for binary classification models–least square regression–backpropagation–Radial basis function networks

UNIT V DEEP LEARNING 9

Convolutional Neural Networks – Convolution, Pooling, Activation Functions, Initialization – Deep Learning Hardware – CPU, GPU and TPU –Tuning Neural Networks – Training Neural Networks, Data Augmentation – Popular CNN Architectures for Image Classification – Alexnet, Resnet.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total 45 Periods

TEXTBOOKS:

1. Boguslaw Cyganek, 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

REFERENCES:

1. Aggarwal, Charu C. "Neural Networks and Deep Learning: A Textbook", Springer International Publishing, Germany, 2018
2. Rafael C. Gonzales, Richard. E. Woods, "Digital Image Processing", 3rd Edition, Gatesmark Publishing, Tenessee 2020
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

EVALUATION PATTERN:

Continuous Internal Assessments					End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 4: INTELLIGENT SYSTEMS

U21MIP28	IMMERSIVE TECHNOLOGIES AND HAPTICS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To identify the terminologies of haptic devices and understand the structure of haptic system
- To acquire the knowledge on modelling for haptic system development relevant to the human.
- To emphasize the significance of knowledge in virtual, augmented and mixed reality

COURSE OUTCOMES:

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

CO1: Recognize the haptic technology and its concepts in various haptic systems. (Understand)
CO2: Choose the elements of haptics system and tele–operation controllers. (Apply)
CO3: Make use of signal processing techniques for human haptic applications. (Apply)
CO4: Combine and build the virtual and augmented reality–based models. (Apply)
CO5: Develop the design and model the hardware of mixed reality. (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	2	–	–	–	–	–	–	2	2	1
CO2	3	2	1	2	2	–	–	–	–	–	–	2	2	1
CO3	3	2	1	2	2	–	–	–	–	–	–	2	2	1
CO4	3	2	1	2	2	–	–	–	–	–	–	2	2	1
CO5	3	2	1	2	2	–	–	–	–	–	–	2	2	1
Correlation levels:			1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)			

SYLLABUS:

UNIT I INTRODUCTION TO HAPTICS 9

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

UNIT II KINESTHETIC HAPTIC DEVICES AND TELEOPERATION 9

Mechatronics in Haptics System – Haptic Kinematics – Haptic Dynamics – Existing Kinesthetic Devices – Haptic Device Static Rendering – Haptic Device Dynamic Rendering–Types of Sensors – Measurement of Haptic Parameters – Types of Actuators –Genesis of Tele–Operation

UNIT III HUMAN HAPTICS PLATFORM 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

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UNIT IV VIRTUAL AND AUGMENTED REALITY 9

The Reality – Virtuality Continuum – Virtual Reality Definitions – Software, Hardware, Sensation and Perception – System Architecture of Virtual Reality – 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 – Haptic Control Panel – Performance of an Interaction Techniques – Design and Implementation of an Immersive User Experience – Case Study for MR

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total 45 Periods

TEXTBOOKS:

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. 718735, 2008

REFERENCES:

1. 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
2. MacLean K. E, "Haptic Interaction Design for Everyday Interfaces: Reviews of Human Factors and Ergonomics", 4:149194, 2008
3. Weir D. W and Colgate J. E "Stability of Haptic Display: Haptic Rendering: Foundations, Algorithms, and Applications". AK Peters, 2008
4. Sherman, William R. and Alan B. Craig. "Understanding Virtual Reality – Interface, Application, and Design" 2nd Edition, Morgan Kaufmann, Cambridge U.S 2019
5. Yuichi Ohta, Hideyuki Tamura, "Mixed Reality: Merging Real and Virtual Worlds", Springer Verlag, Berlin, 2014

EVALUATION PATTERN:

Continuous Internal Assessments				Total Internal Assessments	End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)			
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 4: INTELLIGENT SYSTEMS

U21MIP29	SYSTEM MODELLING AND SIMULATION	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To introduce the characteristics of system modelling and the importance of simulation.
- To model the solutions using queuing theory.
- To teach the generation of data for simulation.

COURSE OUTCOMES:

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

CO1: Understand the characteristics of system modelling and the importance of simulation (Understand)
CO2: Design system model using various approaches (Apply)
CO3: Apply queuing theory to various systems (Apply)
CO4: Generate data for simulation (Understand)
CO5: Model and Analyze a given system using simulation tools (Analyze)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	–	2	2	–	–	–	–	–	–	2	2	–
CO2	3	2	–	2	2	–	–	–	–	–	–	2	2	–
CO3	3	2	–	2	2	–	–	–	–	–	–	2	2	–
CO4	3	2	–	2	2	–	–	–	–	–	–	2	2	–
CO5	3	2	–	2	2	–	–	–	–	–	–	2	2	–
Correlation levels:			1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)			

SYLLABUS:

UNIT I FUNDAMENTALS OF SIMULATION **9**

System definition – Types and characteristics – Need for modelling and simulation –Types of Simulation – Introduction to discrete event simulation – Single server – Multi server Exercises – System modelling

UNIT II MODELLING APPROACHES **9**

Modelling concurrent systems – Finite state Automata and Regular Expressions – Relationship – FSA with silent transitions – Pumping lemma for regular sets – Analysis using DFS and model checking

UNIT III QUEUING MODELS **9**

Characteristics of queuing systems – Notations – Types of Queues – Markovian model – non–Markovian model – Queuing Networks – Applications of queuing systems

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UNIT IV SIMULATION DATA 9

Methods for generating random numbers – Testing of random numbers – Methods of generating random variants – Problem formulation – input modelling –Verification and Validation – Output1ZX Analysis

UNIT V CASE STUDY 9

NS2 – Simulation of Computer Systems – Simulation of Computer Networks – Simulation of Mobile Networks –Simulation of Manufacturing and Material Handling Systems

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Tota 45 Periods

TEXTBOOKS:

1. Banks, Jerry. Discrete–event System Simulation. Singapore, Prentice Hall, 2010
2. Fitzgerald, John, Larsen, PeterGorm, "Modeling Systems; Practical Tools and Techniques in software development", Cambridge University Press, 2009

REFERENCES:

1. Hopcroft, John E, Motwani, Rajeev, Ullman, Seffrey D, "Introduction to automata theory, languages and computation",3rd Edition, Pearson/Dorling Kindersley, New Delhi, 2002
2. Hamdy A Taha, "Operations Research an Introduction", 9th Edition, Pearson/Prentice Hall, New jersey, 2007
3. Donald Gross and Carl M. Harris, "Fundamentals of Queuing theory", 5th Edition, John Wiley and Sons, New York 2018

EVALUATION PATTERN:

Continuous Internal Assessments					End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 4: INTELLIGENT SYSTEMS

U21MIP30	MACHINE LEARNING FOR INTELLIGENT SYSTEMS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To introduce basics of machine learning and prediction techniques
- To learn about supervised learning, unsupervised learning and genetic algorithm
- To learn about Reinforcement learning

COURSE OUTCOMES:

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

CO1: Employ the perspectives of machine learning and formulate hypothesis (Understand)
CO2: Apply regression, decision tree and artificial neural networks for real world problems (Apply)
CO3: Utilize parametric and non–parametric algorithms for solving a given problem (Apply)
CO4: Employ the principles of unsupervised learning and genetic algorithm for optimization (Apply)
CO5: Apply the learning set methods for reinforcement learning for applications (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	2	–	–	–	–	–	–	2	2	1
CO2	3	2	1	2	2	–	–	–	–	–	–	2	2	1
CO3	3	2	1	2	2	–	–	–	–	–	–	2	2	1
CO4	3	2	1	2	2	–	–	–	–	–	–	2	2	1
CO5	3	2	1	2	2	–	–	–	–	–	–	2	2	1
Correlation levels:			1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)			

SYLLABUS:

UNIT I OVERVIEW OF MACHINE LEARNING **9**

Learning Problems – Designing a Learning System – Perspectives and Issues in Machine Learning – Concept Learning – finding maximally specific Hypotheses – version spaces and candidate elimination algorithm – inductive bias.

UNIT II PREDICTION **9**

Linear Regression – Non–Linear Regression – Decision Tree Learning: Decision Tree Representation – basic decision tree learning algorithms – Artificial Neural Networks: Introduction – Representations – Multilayer networks and back propagation algorithm

UNIT III SUPERVISED LEARNING **9**

Bayes Theorem – Concept Learning – Maximum Likelihood and Least–Squared Error Hypothesis – Bayes Optimal Classifier – Gibbs Algorithm – Naïve Bayes Classifier – Support Vector Machine. Instance Based Learning: Introduction – Locally Weighted Regression – Radial Basis Functions – Case–Based Reasoning

UNIT IV UNSUPERVISED LEARNING AND GENETIC ALGORITHM 9

K– Means – K Medoids – Genetic Algorithms: Introduction – Example – Hypothesis Space Search – Genetic Programming – Models of Evolution and Learning – Parallelizing Genetic Algorithms

UNIT V LEARNING SETS OF RULES AND REINFORCEMENT LEARNING 9

Learning sets of rules: Introduction – sequential covering algorithms – First order rules – FOIL – Induction as Inverted deduction – inverting resolution – Reinforcement Learning: Introduction – Markov Decision Processes – Values – SARSA vs Q–Learning

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total 45 Periods

TEXTBOOKS:

1. Tom M. Mitchell, "Machine Learning", 1st Edition, McGraw–Hill Education, India, 2013
2. Micheal Negnevitsky, Artificial Intelligence: A Guide to Intelligent Systems, 3rd Edition, Addision Wesley, England, 2011

REFERENCES:

1. Stephen Marsland, "Machine Learning – An Algorithmic Perspective", 2nd Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014
2. Jiawei Han, Micheline Kamber, "Data Mining Concepts and Techniques", 3rd Edition, Elsevier, 2012

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 4: INTELLIGENT SYSTEMS

U21MIP31	CONDITION MONITORING AND FAULT DIAGNOSTICS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To identify the selection of condition monitoring sensors for various applications.
- To study various signal processing for condition monitoring applications.
- To know about various failure analysis, maintenance and machine learning.

COURSE OUTCOMES:

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

CO1: Understand the basics of various condition monitoring methods. (Understand)
CO2: Select suitable condition monitoring sensors for various applications. (Apply)
CO3: Recall various signals processing for condition monitoring applications. (Understand)
CO4: Know about various failure analysis, maintenance and machine learning (Apply)
CO5: Apply different fault diagnosis method for various applications. (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	2	–	–	–	–	–	–	2	2	1
CO2	3	2	1	2	2	–	–	–	–	–	–	2	2	1
CO3	3	2	1	2	2	–	–	–	–	–	–	2	2	1
CO4	3	2	1	2	2	–	–	–	–	–	–	2	2	1
CO5	3	2	1	2	2	–	–	–	–	–	–	2	2	1
Correlation levels:			1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)			

SYLLABUS:

UNIT I CONDITION MONITORING TECHNIQUES AND MACHINE CONDITION MONITORING **9**

Condition Monitoring in manufacturing industries – Noise monitoring – Cracks monitoring, Ultrasonic techniques Vibration, Acoustic emission and vibro–acoustics signal analysis – intelligent fault detection system

UNIT II SENSORS FOR FAULT DIAGNOSTICS **9**

Introduction – Contaminant monitoring sensors– Corrosion monitoring sensors – Force monitoring sensors – Gas leakage monitoring – Air pollution monitoring sensors – Liquid contamination monitoring sensors – Non–destructive testing techniques –Temperature sensing

UNIT III SIGNAL PROCESSING AND ANALYSIS **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

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UNIT IV FAILURE ANALYSIS, MAINTENANCE AND MACHINE LEARNING 9

Failure mode analysis – Equipment downtime analysis – Breakdown analysis – condition based maintenance, Vibration, acoustic emission signal analysis – Intelligent fault detection system

UNIT V MONITORING SYSTEMS CASE STUDIES 9

Marine monitoring systems – Marine turbine monitoring systems – Monitoring integrity verification – Aircraft condition monitoring – Condition monitoring – Automotive diagnostic equipment – Systematic fault monitor selection

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total 45 Periods

TEXTBOOKS:

1. Collacott, R. Mechanical Fault Diagnosis and Condition Monitoring. Netherlands, Springer Netherlands, 2012
2. Advanced Sensors for Real–Time Monitoring Applications. Switzerland: MDPI AG, 2021

REFERENCES:

1. W.H. Tang, Q.H. Wu, "Condition Monitoring and Assessment of Power Transformers Using Computational Intelligence", Springer–Verlag London

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 4: INTELLIGENT SYSTEMS

U21MIP32	OPTIMIZATION TECHNIQUES	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the various design constraints in optimization
- To learn about the linear, nonlinear and dynamic programming
- To understand the various modern methods in optimization

COURSE OUTCOMES:

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

CO1: Investigate the optimization problem and the classical optimization techniques (Apply)
CO2: Apply the linear programming model as a solution to various problems with linear functions (Apply)
CO3: Make use of non–linear programming model to solve the constrained optimization problems (Apply)
CO4: Develop optimal solutions for multistage decision problems using dynamic programming (Apply)
CO5: Apply modern optimization techniques to solve decision problems (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	–	–	–	–	–	–	2	2	1
CO2	3	2	2	2	2	–	–	–	–	–	–	2	2	1
CO3	3	2	2	2	2	–	–	–	–	–	–	2	2	1
CO4	3	2	2	2	2	–	–	–	–	–	–	2	2	1
CO5	3	2	2	2	2	–	–	–	–	–	–	2	2	1
Correlation levels:		1: Slight (Low)		2: Moderate (Medium)				3: Substantial (High)						

SYLLABUS:

UNIT I OPTIMIZATION PROBLEM 9

Design constraints – constraint surface – objective function – number of objective functions – optimization techniques –Classical optimization techniques – single–variable optimization – multivariable optimization – convex programming problems

UNIT II LINEAR PROGRAMMING 9

Geometry of linear programming problems – definitions and theorems – solution of a system of linear simultaneous equations – pivotal reduction of a general system of equations – simplex algorithm – Graphical representation – Gomory's cutting plane method

UNIT III NONLINEAR PROGRAMMING 9

Constrained optimization techniques – random search methods – sequential linear programming – transformation techniques – interior penalty function method – extrapolation techniques in the interior penalty function method – penalty function method for parametric constraints

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UNIT IV DYNAMIC PROGRAMMING 9

Multistage decision processes – sub optimization and principle of optimality – computational procedure in dynamic programming – illustrating the calculus method of solution – linear programming as a case of dynamic programming

UNIT V MODERN METHODS OF OPTIMIZATION 9

Genetic algorithms – simulated annealing – particle swarm optimization – solution of the constrained optimization problem – ant colony optimization – optimization of fuzzy systems neural–network–based optimization – metaheuristic optimization methods – multilevel and Multi objective optimization

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

TEXTBOOKS:

1. Singiresu S. Rao, "Engineering Optimization: Theory and Practice", John Wiley and Sons, 5th Edition, 2019.
2. Taha, Hamdy A.. "Operations Research: An Introduction". Germany, Pearson, 2016.

REFERENCES:

1. Pannerselvam, Operations Research: Prentice Hall of India 2010.
2. Dantzig, George B., and Thapa, Mukund N "Linear Programming 1: Introduction", Springer New York, 2013

EVALUATION PATTERN:

Continuous Internal Assessments				Total Internal Assessments	End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)			
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 5: INDUSTRIAL AUTOMATION

U21MIP33	FACTORY AUTOMATION	Category: PCC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To learn the fundamentals of factory automation
- To acquire the knowledge on automated manufacturing systems
- To apply the control and automation technologies to achieve factory automation

COURSE OUTCOMES:

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

CO1: Infer the fundamentals of factory automation (Understand)
CO2: Understand the principles and fundamentals of material handling system including their role in optimizing workflow efficiency and productivity (Understand)
CO3: Analyze manufacturing systems, implement quality control methods, and optimize processes for efficiency and compliance with industry standard (Apply)
CO4: Apply industrial control systems, distinguishing between process and discrete manufacturing and optimizing automation solutions for diverse industry needs (Apply)
CO5: Comprehensive understanding of computer–based control using various technical platforms (Understand)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	–	–	–	–	–	–	–	–	1	1	–
CO2	3	3	3	–	–	–	–	–	–	–	–	1	1	–
CO3	3	3	3	–	2	–	–	–	–	–	–	1	1	–
CO4	3	3	3	–	3	–	–	–	–	–	–	1	1	–
CO5	3	3	3	3	3	–	–	–	2	2	–	2	1	–
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I OVERVIEW OF FACTORY AUTOMATION **9**

Introduction: Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automation. Flow lines & Transfer Mechanisms, Fundamentals of Transfer Lines.

UNIT II MATERIAL HANDLING AND IDENTIFICATION TECHNOLOGIES **9**

Overview of Material Handling Systems, Principles and Design Consideration, Material Transport Systems, Storage Systems, Overview of Automatic Identification Methods

UNIT III AUTOMATED MANUFACTURING SYSTEMS **9**

Automated Manufacturing Systems: Components, Classification and Overview of Manufacturing Systems, Manufacturing Cells, GT and Cellular Manufacturing, FMS, FMS and its Planning and

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Implementation. Quality Control Systems: Traditional and Modern Quality Control Methods, SPC Tools, Inspection Principles and Practices, Inspection Technologies.

UNIT IV CONTROL TECHNOLOGIES IN AUTOMATION 9

Industrial Control Systems, Process Industries versus Discrete Manufacturing Industries. Continuous Versus Discrete Control, Computer Process and its Forms.

UNIT V COMPUTER BASED INDUSTRIAL CONTROL 9

Introduction & Automatic Process Control, Building Blocks of Automation Systems: LAN, Analog & Digital I/O Modules, SCADA Systems& RTU. Distributed Control System: Functional Requirements, Configurations – Distributed Control Systems

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

4. M.P. Groover, "Automation, Production Systems and Computer Integrated Manufacturing", 4th Edition, Pearson Education, 2016

REFERENCES:

1. Krishna Kant, "Computer Based Industrial Control", 2nd Edition, EEE–PHI, 2010
2. Tiess Chiu Chang &Richard A.Wysk. "An Introduction to Automated Process Planning Systems", Prentice Hall International, 1985
3. Viswanandham, "Performance Modeling of Automated Manufacturing Systems", Prentice Hall India Learning Pvt. Ltd., 1994

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 5: INDUSTRIAL AUTOMATION

U21MIP34	PROCESS CONTROL AND AUTOMATION	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To learn the basic concepts of process dynamics
- To acquire the knowledge in the controller tuning and industrial processes
- To apply the distributed control system for various process control applications

COURSE OUTCOMES:

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

CO1: Develop the dynamics of processes using mathematical approach and interpret the characteristics of processes (Understand)
CO2: Propose the suitable control modes and examine the tuning of controllers (Apply)
CO3: Select suitable control system for various industrial processes (Apply)
CO4: Choose the instrumentation to control the process (Apply)
CO5: Apply suitable DCS for process control application (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	–	–	–	–	–	–	2	3	2
CO2	3	2	2	2	2	–	–	–	–	–	–	2	3	2
CO3	3	3	3	2	2	–	–	–	–	–	–	2	3	2
CO4	3	3	3	2	2	–	–	–	–	–	–	2	1	–
CO5	3	3	3	2	2	–	–	–	–	–	–	2	1	–

Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SYLLABUS:

UNIT I PROCESS DYNAMICS 9

Process control – Automatic process control – Need for automatic process control in industry – Mathematical Modeling of Processes – First order process systems – level, Temperature and pressure – Second order process systems – Interacting and non–interacting systems – Batch and continuous process – Self regulation – Servo and regulatory operation.

UNIT II CONTROL CHARACTERISTICS AND TUNING 9

Automatic controller – Process characteristics – Control system parameters – Discontinuous controller modes – Continuous controller modes – Composite control modes. Evaluation criteria: Performance criteria – Controller tuning: Process reaction curve method – Ziegler–Nichols method

UNIT III CONTROL SYSTEMS WITH MULTIPLE LOOPS 9

Advanced control systems – Feed forward control – Cascade control – Ratio control – Selective control Systems – Split–Range control – Adaptive control – Inferential control – Multi variable control

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UNIT IV PROCESS INSTRUMENTATION 9

Signal converters: I/P and P/I converters – Control valves: Characteristics, Valve positioner, Selection of control valves – Introduction to transmitters, Two wire and four wire transmitters, Smart and intelligent transmitters.

UNIT V PROCESS AUTOMATION USING DCS 9

Power Plants – Water and wastewater treatment plants – Cement plants – Pulp and Paper plants – Glass –making Plants – Oil and Gas Fields.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Krishnaswamy K., "Process Control", 2nd Edition, New Age International Pvt. Ltd., New Delhi, 2013.
2. Michael P. Lukas, "Distributed Control System", Van Nostrand Reinhold Co., Canada, 2019

REFERENCES:

1. George Stephanopoulos, "Chemical Process Control–An Introduction to Theory and Practice", 1st Edition, Pearson, New Delhi, 2015.
2. Dale E. Seborg, Duncan A. Mellichamp, Thomas F. Edgar, and Francis J. Doyle, "Process Dynamics and Control", 4th Edition, John Wiley and Sons, USA, 2016.
3. Surekha Bhanot, "Process Control: Principles and Applications", 4th Edition, Oxford University Press, United Kingdom, 2017.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 5: INDUSTRIAL AUTOMATION

U21MIP35	VIRTUAL INSTRUMENTATION	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To introduce virtual instrumentation and train the VI programs
- To understand the data acquisition using VI
- To perform the Real–time application using VI–DAQ

COURSE OUTCOMES:

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

CO1: Understand virtual instrumentation concepts and applications (Understand)
CO2: Train to program virtual instrumentation software for biomedical applications (Apply)
CO3: Understand the data acquisition and control in VI (Understand)
CO4: Understand the knowledge in instrument interfaces (Understand)
CO5: Interface the sensors to build the real time applications (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	–	2	–	–	–	–	1	1	3	2
CO2	3	2	2	2	–	2	–	–	–	–	1	1	3	2
CO3	3	2	2	2	–	2	–	–	–	–	1	1	3	2
CO4	3	2	2	2	–	2	–	–	–	–	1	1	3	2
CO5	3	2	2	1	–	2	–	–	–	–	1	1	3	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

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 VIRTUAL INSTRUMENTATION ENVIRONMENT 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 – Simple problems

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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, waveform generator.

UNIT V REAL TIME APPLICATIONS 9

Instrument control: Signal processing tools – Measuring Temperature, Strain, Force, Pressure, Sound, Vibration, and Acceleration, Vision and Motion, Vision Acquisition and Vision Assistant tool.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. John Essick Dr, "Hands–On Introduction to LabVIEW for Scientists and Engineers", OUP USA, 4th Edition, 2018
2. Jeffery Travis & Jim Kring, "LabVIEW for Everyone: Graphical programming made easy and Fun", 3rd Edition, Pearson Education, India, 2009
3. Lisa K. Wells and Jeffrey Travis, "LABVIEW for Everyone", PHI, 1997

REFERENCES:

1. Skolkoff, "Basic concepts of LABVIEW 4", PHI, 1998
2. Jerome, Jovitha, "Virtual Instrumentation and LABVIEW", PHI Learning, New Delhi, 1st Edition, 2010
3. Sanjay Gupta and Joseph John, "Virtual Instrumentation using Lab VIEW", Tata Mc Graw – Hill Publishing Company Limited, New Delhi, 1st Edition, 2010

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 5: INDUSTRIAL AUTOMATION

U21MIP36	INTRODUCTION TO INDUSTRIAL INTERNET OF THINGS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the fundamentals of IoT
- To interface the sensors and actuators with IoT
- To understand the protocols and applications of IoT

COURSE OUTCOMES:

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

CO1: Comprehend the fundamentals of IIoT and its potentials in industrial environment (Understand)
CO2: Infer the various components and architecture of IIoT (Understand)
CO3: Interpret different IIoT sensors system architecture with interface standards (Apply)
CO4: Identify appropriate protocols and Cloud platforms for different IIoT challenges (Apply)
CO5: Build design thinking concepts for industrial IoT applications (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	–	–	–	–	–	–	1	2	2
CO2	2	2	2	2	3	–	–	–	–	–	–	1	2	2
CO3	2	2	2	2	3	–	–	–	–	–	–	1	2	2
CO4	2	2	2	2	3	–	–	–	–	–	–	1	2	2
CO5	3	3	3	3	3	–	–	–	–	–	–	2	3	3

Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SYLLABUS:

UNIT I INTRODUCTION TO INTERNET OF THINGS 9

Introduction to Application–based IoT Protocols–Infrastructure–based protocols– Transport protocols. Cloud Computing: Types of cloud–Business aspects of cloud–Virtualization– Key aspect of cloud computing–Mobile cloud computing– Fog Computing: Applications of Fog computing. Sensor Cloud: Applications of Sensor Cloud– Big Data.

UNIT II IIOT ARCHITECTURES 9

Overview of IOT components – Various architectures of IOT and IIOT, Industrial internet – Reference architecture; IIOT system components: Sensors– Gateways– Routers– Modem– Cloud brokers– Servers and its integration. WSN: WSN network design for IOT.

UNIT III SENSOR AND INTERFACING 9

Introduction to sensors – Transducers: Classification – Roles of sensors in IIoT– Design of sensor architecture– Special requirements for IIoT sensors– Role of actuators– Types of actuators. Protocols: HART –MODBUS–Serial and Parallel –Ethernet – BACNet – M2M.

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UNIT IV PROTOCOLS AND CLOUD 9

Introduction to Industrial data transmission – Fieldbus – Profibus – Interbus – Bitbus – CC–link – Batibus – Controller area network, DeviceNet – LonWorks – ISA 100.11a –Wireless HART –LoRa & LoRaWAN –NB–IoT– IEEE 802.11AH

UNIT V INDUSTRIAL IOT– APPLICATION DOMAINS 9

Business models for the internet of things, Smart city, Smart mobility and transport, Industrial IoT, Smart health, Environment monitoring and surveillance – Home Automation – Smart Agriculture

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

TEXTBOOKS

1. Anandarup Mukherjee, Chandana Roy, Sudip Misra,"Introduction to Industrial Internet of Things and Industry 4.0", 1st Edition, CRC Press, 2020.
2. Samuel Greengard, The Internet of Things, The MIT Press, 2015

REFERENCES

1. Perry Lea, "Internet of things for architects", Packt, 2018
2. Olivier Hersent, David Boswarthick, Omar Elloumi, "The Internet of Things – Key applications and Protocols", Wiley, 2012
3. IOT (Internet of Things) Programming: A Simple and Fast Way of Learning, IOT Kindle Edition.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 5: INDUSTRIAL AUTOMATION

U21MIP37	MOTION CONTROL SYSTEM	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To acquire knowledge on architecture of motion control system and its features
- To learn about the intelligent motors and integrated drive
- To control the motion of the actuator through motion control programming

COURSE OUTCOMES:

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

CO1: Know about the basics in motion control system (Understand)
CO2: Obtain the knowledge on architecture of motion control system (Apply)
CO3: Apply the features and specifications in motion control drives (Apply)
CO4: Obtain the concepts about on intelligent motors and integrated drive (Apply)
CO5: Apply the programming knowledge for motion controller of actuators (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	–	–	–	–	–	–	–	1	1	1
CO2	3	2	1	1	–	–	–	–	–	–	–	1	1	1
CO3	3	2	1	1	–	–	–	–	–	–	–	1	1	1
CO4	3	2	1	1	–	–	–	–	–	–	–	1	1	1
CO5	3	2	1	1	–	–	–	–	–	–	–	1	1	1
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)				3: Substantial (High)							

SYLLABUS:

UNIT I MOTION CONTROL SYSTEMS 9

Introduction to Motion Control System – Architecture of motion control – Dynamic System Modeling – Control System Design Fundamentals – Parameters in Control – Actuators and Measurement in Motion Control Systems –Multi–Body Dynamics – Need for Motion Controller – Specification of Motion Control

UNIT II MOTION CONTROL USING PLC 9

Programmable Logic Controller – Features & Specification of Motion Controllers – Digital I/O – Analog I/O – Standards in I/O – I/O Specific to Sensors – Modular and Expansion Concepts

UNIT III PROGRAMMABLE MOTION CONTROL 9

Purpose of motion control – Fundamentals of applying motion control: Introduction – Motion consideration – Building blocks of Programmable motion control system – Motion control: Hydraulic and pneumatic – Fluid control – Motion feedback devices – AC and DC Motor & drives

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UNIT IV INTELLIGENT MOTORS WITH INTEGRATED DRIVE 9

Intelligent motors – intelligent drives – features of drives – programmable I/Os– communication protocols – features – Software – Programming – current, position and speed loops – Application in robots and portable systems

UNIT V PROGRAMMING OF MOTION CONTROLLER 9

IEC 61131 standards and Its Programming Languages overview– CoDeSys Platform – status Diagram – PLC Open – Motion Planer – PID – Servo Tuning – Position– velocity, Acceleration and Torque Profiling – CAM Profiling – Multi– Axis Motion Controllers – CNC Machines – Robot case study

Contact Periods:

Lecture: 30 Periods Tutorial: – Periods Practical: 30 Periods Project: – Periods

Total: 60 Periods

TEXTBOOKS

1. M. Nakamura .S. Gata & N. Kyura, Mechatronic Servo System Control, Springer, 2004.
2. Sabanovic Asif, Motion Control Systems, John Wiley & Sons Inc, 2011

REFERENCES

1. Model 4000 indexer user Guide, Parker Hannifin Corporation, 1994.
2. 2–Axis Motion Controller User Guide, Parker Hannifin Corporation, 1995.
3. Operating instructions Compax3 T30 Programmable motion control according to IEC61131– Parker Hannifin Corporation, 2008.
4. Programming with Easy Motion Studio – User's Manual, online, technosoftmotion.com.
5. Technical Reference, IPOS4808 BX–CAT–STO Intelligent Servo Drive for Step, DC, Brushless DC and AC Motors, Techno soft, 2022.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 5: INDUSTRIAL AUTOMATION

U21MIP38	DIGITAL TWIN AND INDUSTRY 5.0	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- NIL

COURSE OBJECTIVES:

- To understand the basics concepts in digital twin
- To understand Digital Twin Driven Energy–aware Green Design
- To obtain the knowledge in industry 5.0

COURSE OUTCOMES:

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

CO1: Understand digital twin product design framework from a holistic perspective and discusses the related key processes and technologies (Understand)
CO2: Gain envisions a Digital twin driven conceptual design in terms of functional modeling, concept generation, evaluation and contradiction resolution at basic levels (Apply)
CO3: Discuss and relate digital twin (DT) to green design; proposes and emphasize DT model to energy conservation (EC) digital thread and discusses the way DT could promote green design for energy saving (Apply)
CO4: Obtain the knowledge in industry 5.0 (Apply)
CO5: Present a DT based process design evaluation and exemplify the machining process of diesel engine connecting rod (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	–	–	–	–	1	2	1	–	1	–	2	2
CO2	3	1	–	–	–	–	1	2	1	–	1	–	3	3
CO3	3	1	–	–	–	–	1	2	1	–	1	–	2	2
CO4	3	2	1	1	1	–	2	2	1	–	2	–	3	3
CO5	3	2	1	1	1	–	2	2	1	–	2	–	3	3

Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SYLLABUS:

UNIT I DIGITAL TWIN DRIVEN SMART DESIGN 9

Development of Product design and Prospect forecast–Digital Twin and its Applications– History, Concept, Applications of Digital twins–Five Dimension digital twin of a Product–physical, virtual, Digital twin data, Services and connections. –Framework for Digital twin driven smart product design–Case study: Bicycle and Landing gear.

UNIT II DIGITAL TWIN DRIVEN CONCEPTUAL DESIGN 9

Conceptual design methodology foundation of digital twin: Design theory–general, Axiomatic, systematic, Function–Behaviour structure ontology, Digital twin based conceptual design: function modeling, concept generation, concept evaluation, contradiction resolution, constraint management, complexity management, collaborative conceptual design, digital twin based design affordance. Case

study: robot vacuum cleaner (functional formulation, concept generation, constraint management, contradiction solving).

UNIT III DIGITAL TWIN DRIVEN ENERGY–AWARE GREEN DESIGN 9

Iterative optimization of energy consumption–energy consumption digital thread–product –life cycle, green design (in material selection, disassembly, supply chain and its potential applications). Energy aware five–dimension digital twin,

UNIT IV INDUSTRY 5.0: NEW ERA OF INDUSTRIAL REVOLUTION 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 APPLICATION AND CASE STUDY 9

Digital twin driven factory design: framework, functions at different stages and modular approach–case study: digital twin driven factory design of a paper cup factory, digital twin driven factory design of a nylon factory.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Fei Tao, Ang Liu, Tianliang Hu, "Digital Twin Driven Smart Design", Academic Press, Elsevier, United Kingdom, 2020.
2. Uthayan Elangovan, Industry 5.0: The Future of the Industrial Economy, CRC Press, 2022.

REFERENCES:

1. Alp Ustundag and Emre Cevikcan, "Industry 4.0: Managing the Digital Transformation", Springer Series in Advanced Manufacturing., Switzerland, 2018
2. Christoph Jan Bartodziej, "The Concept Industry 4.0 an Empirical Analysis of Technologies and Applications in Production Logistics", Springer Gambler., Germany, 2017.
3. Ibrahim Garbie, "Sustainability in Manufacturing Enterprises, Concepts, Analyzes and assessments for Industry 4.0", Springer., Switzerland, 2016.
4. Ronald R. Yager and Jordan Pascual Espada, "New Advances in the Internet of Things", Springer., Switzerland, 2018
5. Ulrich Sendler, "The Internet of Things, Industries 4.0 Unleashed", Springer., Germany, 2018

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 5: INDUSTRIAL AUTOMATION

U21MIP39	CYBER PHYSICAL SYSTEMS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To learn the fundamental concepts and components of cyber physical systems
- To acquire the knowledge in the multitasking and scheduling of CPS
- To design the mechatronics system with integration of CPS

COURSE OUTCOMES:

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

CO1: Understand the fundamentals of cyber physical systems in real–time control tasks (Understand)
CO2: Infer the different components and architecture of CPS using embedded system (Apply)
CO3: Interpret the functions of CPS multitasking and scheduling (Apply)
CO4: Classify the concepts of CPS in security and privacy aspects (Apply)
CO5: Design the mechatronics system with integration of CPS for real–time applications (Apply)

CO–PO MAPPING:

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	–	–	–	–	–	–	–	2	3	3
CO2	3	2	2	1	–	–	–	–	–	–	–	1	1	1
CO3	3	2	3	1	–	–	–	–	–	–	–	1	1	1
CO4	3	2	3	1	–	–	–	–	–	–	–	1	1	1
CO5	3	3	3	1	3	–	–	–	–	–	–	1	3	3

Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SYLLABUS:

UNIT I INTRODUCTION **9**

Cyber–Physical Systems (CPS) in the real world, Basic principles of design and validation of CPS, CPS HW platforms: Processors, Sensors, Actuators, CPS network, CPS SW stack RTOS, Scheduling real time control tasks.

UNIT II DESIGN OF EMBEDDED SYSTEMS **9**

Types of Processors – Parallelism. Memory architectures – Memory technologies – Memory hierarchy – Memory models. Input and Output – I/O Hardware – Sequential software in a concurrent world – Analog/Digital interface.

UNIT III MULTITASKING AND SCHEDULING **9**

Imperative Programs – Threads – Processes and message passing. Scheduling with fixed timing parameters– Memory effects, Multiprocessor/ Multicore scheduling– Accommodating variability and uncertainty– Managing other resources– Rhythmic tasks scheduling.

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UNIT IV SECURITY OF CYBER–PHYSICAL SYSTEMS 9

Cyber security requirements– Defining security and privacy –Attack model –Counter measures – System theoretic approaches– Examples of security and privacy in action– Approaches to secure cyber–physical systems– Ongoing security and privacy challenges for CPSs– Ethical hacking.

UNIT V CASE STUDY 9

Case Study: Suspension control, Healthcare: Artificial Pancreas/Infusion Pump/Pacemaker, Green buildings: Automated lighting, AC control, Digital twin system.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Edward A. Lee & Sanjit A. Seshia, "Introduction to Embedded Systems: A Cyber–Physical Systems Approach", 2nd Edition, MIT press, United Kingdom, 2017.
2. Song, Houbing, Glenn A. Fink, and Sabina Jeschke, eds. Security and privacy in cyber–physical systems: foundations, principles, and applications. John Wiley & Sons, 2017.

REFERENCES:

1. Rodrigues, Joel Jose PC, Ivan Stojmenovic, & Danda B. Rawat, "Cyber–physical systems: from theory to practice", CRC Press, Florida, 2015.
2. Rajeev Alu, "Principles of Cyber–Physical Systems", MIT Press, United Kingdom, 2016.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 5: INDUSTRIAL AUTOMATION

U21MIP40	INDUSTRIAL AUTOMATION PROTOCOLS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To learn the basic concepts of Industrial automation and date network fundamentals
- To acquire the knowledge of HART and MODBUS protocol
- To understand the AS–interface (AS–i), Devicenet and Industrial Ethernet protocol

COURSE OUTCOMES:

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

CO1: Interpret the basic network requirements for Industrial automation (Understand)
CO2: Infer the fundamental knowledge of data networks (Apply)
CO3: Able to identify the purpose of HART and MODBUS Protocol for Networked Industrial Automation (Apply)
CO4: Infer the FIELDBUS and PROFIBUS requirements in industrial automation network (Apply)
CO5: Classify the functions of AS–I, Device net and Ethernet in industrial network (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	–	–	–	–	–	–	–	–	2	2
CO2	3	2	2	2	–	–	–	–	–	–	–	–	2	2
CO3	3	3	2	3	1	–	–	–	–	–	–	1	3	3
CO4	3	3	2	3	1	–	–	–	–	–	–	1	3	3
CO5	3	3	2	3	1	–	–	–	–	–	–	2	3	3

Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SYLLABUS:

UNIT I NETWORKS IN INDUSTRIAL AUTOMATION 9

Information flow requirements – Hierarchical communication model – Network requirements – Data Communication basics – OSI reference model – Industry network – Recent network.

UNIT II DATA NETWORK FUNDAMENTALS 9

EIA 232 interface standard – EIA 485 interface standard – EIA 422 interface standard – Current loop and serial interface converters – Data link control protocol – Media access protocol: Command/response – Token passing and CSMA/CD – TCP/IP – Bridges – Routers – Gateways.

UNIT III HART AND MODBUS PROTOCOL 9

Introduction – Evolution of signal standard – HART communication protocol – Communication modes – HART networks– HART commands – HART applications – MODBUS protocol structure – Transmission modes – Function codes – Troubleshooting.

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UNIT IV FIELDBUS AND PROFIBUS 9

Introduction – General Fieldbus architecture, Basic requirements of Fieldbus standard, Fieldbus topology, Interoperability and Interchangeability. Profibus: Introduction, Profibus protocol stack, Profibus communication model, Communication objects, System operation and Troubleshooting – Foundation fieldbus versus Profibus.

UNIT V AS–INTERFACE (AS–I), DEVICENET AND INDUSTRIAL ETHERNET 9

Introduction, Physical layer, Data link layer and Operating characteristics. Device net: Introduction, Physical layer, Data link layer and Application layer. Industrial Ethernet: Introduction – core elements of Ethernet, Ethernet frame format, topology overview, Overview of Ethernet versions – 10Base Ethernet and 100Base Ethernet

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Bela G. Liptak & Halit Eren, "Instrument Engineers Handbook: Process Software and Digital Networks", 4th Edition, CRS Press, New York, 2011.
2. Mackay S., Wright E., Reynders D. & Park J., "Practical Industrial Data Networks: Design, Installation and Troubleshooting", Newnes Publication, Burlington, 2004.

REFERENCES:

3. Jonas Berge, "Field Buses for Process Control: Engineering, Operation, and Maintenance", ISA Press, New York, 2004.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 6: AVIONICS AND DRONE TECHNOLOGY

U21MIP41	AVIONICS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- NIL

COURSE OBJECTIVES:

- To impart basic knowledge about the avionic architecture
- To gain more knowledge on various avionics subsystems
- To understand the concepts of navigation systems

COURSE OUTCOMES:

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

CO1: Explain the fundamentals of avionics (Understand)
CO2: Summarize the different avionic bus architecture (Understand)
CO3: Describe the avionics control and display technologies (Understand)
CO4: Interpret the performance of various navigation systems (Apply)
CO5: Design autopilot for small aircrafts (Apply)

CO–PO MAPPING:

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO2	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO3	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO4	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO5	2	1	2	1	–	–	–	–	1	–	–	1	1	2
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)				3: Substantial (High)							

SYLLABUS:

UNIT I FUNDAMENTALS OF AVIONICS 9

Basics of Avionics, the cockpit environment – a historical overview–evolution and crew tasks, Need for Avionics in civil–military aircraft and space systems – Integrated Modular Avionics Architecture

UNIT II AVIONICS BUS ARCHITECTURE 9

Avionics Bus architecture – Data buses AFDX/ARINC – 664–MIL STD 1553B – ARINC 429 – ARINC 629 – ARINC 818

UNIT III FLIGHT DECK AND COCKPITS 9

Control and display technologies: Tactile control panel (TCP), Direct voice input (DVI) — Civil cockpit and military cockpit: MFDS, PFDS–HUD, HMD, HMI

UNIT IV NAVIGATION SYSTEMS 9

ADF, VOR, DME, NDB, ILS, marker beacon, RNAV architecture, INS, GPS and GNSS characteristics, Airborne surveillance systems– ACAS and TAWS

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UNIT V FLY–BY–WIRE & AUTO PILOT 9

Fly–by–wire: Basic principles and A320 detailed case study. Auto pilot – Basic principles, Longitudinal and lateral auto pilot

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. R.P.G. Collinson, "Introduction to Avionics", 3rd Edition, Chapman & Hall Publications, New York, 2011
2. Albert Helfrick.D., "Principles of Avionics", 3rd Edition, Avionics Communications Inc, USA, 2004

REFERENCES:

1. Cary R. Spitzer, "The Avionics Handbook", 1st Edition, Springer science Business media LLC, USA, 2000
2. Pallet.E.H.J., "Aircraft Instruments and Integrated Systems", Pearsons, Indian Edition 2011.

EVALUATION PATTERN:

Continuous Internal Assessments				Total Internal Assessments	End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)			
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 6: AVIONICS AND DRONE TECHNOLOGY

U21MIP42	FLUID MECHANICS AND DYNAMICS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To learn the fluid properties and their flow dynamics
- To acquire the knowledge to analyze the fluid motion
- To solve the fluid flow problems

COURSE OUTCOMES:

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

CO1: Understand the concept of fluid, its properties and measurement (Understand)
CO2: Investigate the effect of hydrostatic forces (Apply)
CO3: Evaluate the kinematic behavior of fluid flow (Apply)
CO4: Apply the equations used to study the dynamic fluid flow (Apply)
CO5: Evaluate the turbulent fluid motion (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	–	–	–	–	1	–	–	1	2	1
CO2	3	2	1	1	–	–	–	–	1	–	–	1	2	1
CO3	3	2	1	1	–	–	–	–	1	–	–	1	2	1
CO4	3	2	1	1	–	–	–	–	1	–	–	1	2	1
CO5	3	2	1	1	–	–	–	–	1	–	–	1	2	1
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)				3: Substantial (High)							

SYLLABUS:

UNIT I FUNDAMENTALS OF FLUID MECHANICS **9**

Concept of Fluid – Properties of Fluid – Viscosity – Vapor Pressure – Cavitation – Bulk Modulus – Compressibility – Meniscus Effect – Surface Tension – Pascal's Law – Measurement Of Fluid Pressure – Barometer – Piezometer – Manometer – and Mechanical Guage

UNIT II HYDROSTATIC FORCES **9**

Centre of Pressure – Vertical Plane Surface – Inclined Plane Surface – and Curved Plane Surface – D'Almbert's Principle – Fluid Masses Subjected to Acceleration Along – Horizontal – Vertical and Inclined Plane – Buoyancy – Archimedes Principle – Metacentric Height

UNIT III KINEMATICS OF FLUID FLOW **9**

Classification of Fluid Flow – Methods of Describing Fluid Motion – Continuity Equation – Boundary Surface – Intensive vs Extensive Properties – System versus Control Volume Approach – Circulation – Streamline – Potential Function – Stream Function

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UNIT IV DYNAMICS OF FLUID FLOW 9

Equation of Fluid Motion – Bernoulli's Equation – Venturimeter – Orifice Meter – Pitot Tube – Free Liquid Jet – Impulse–momentum Principle – Control Volume Approach – Navier–Stokes Equation – Laminar Flow – Viscosity Measurements

UNIT V TURBULENT FLUID FLOW 9

Turbulent Fluid Motion – Classification of Turbulence – Reynolds Stresses – Boussinesq's Theory – Prandtl's Mixing Length Theory – Reynolds Navier–Stokes Equation – Energy Equations – Measurement of Turbulence – Boundary Layer Thickness – Boundary Layer Equation – Boundary Layer Separation

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. CSP Ojha, "Fluid Mechanics and Machinery", 1st Edition, Oxford University Press, 2010
2. Frank White, "Fluid Mechanics", 7th Edition, McGraw Hill, 2010
3. Meinhard T. Schobeiri, "Fluid Mechanics for Engineers", Springer, 2010

REFERENCES:

1. Carl Schaschke, "Fluid Mechanics – Worked Examples for Engineers", IChem, 2000
2. Zoeb Husain, "Basic Fluid Mechanics and Hydraulic Machines", BS Publications, 2008

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

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VERTICAL 6: AVIONICS AND DRONE TECHNOLOGY

U21MIP43	GUIDANCE AND CONTROL OF AVIONICS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the concepts of Navigation, guidance and control
- To acquire various ways in which aerospace vehicles are guided and controlled
- To apply the control principles of rockets and missiles

COURSE OUTCOMES:

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

CO1: Formulate the navigational equations of the space vehicle (Apply)
CO2: Contrast the guidance of the vehicle with state feedback (Apply)
CO3: Explain the automatic control and guidance of the aircraft (Understand)
CO4: Evaluate the control techniques of the rockets and missiles (Apply)
CO5: Identify major maneuvers of the space aircraft (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO2	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO3	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO4	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO5	2	1	2	1	–	–	–	–	1	–	–	1	1	2
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)				3: Substantial (High)							

SYLLABUS:

UNIT I NAVIGATION 9

Introduction, Basic Principles and Definitions; Dead reckoning and Position Fixing, Celestial, Radio, Inertial Navigation; Principle and Construction of Accelerometers, Mechanical Gyros and Ring Laser Gyros, Inertial Measurement Units, Navigation Equations, Sensor Error Models, Kalman Filter, Attitude Heading Reference System, GPS, Terrain Reference Navigation

UNIT II GUIDANCE 9

Optimal Terminal Guidance of Interceptors, Optimal Terminal Guidance – planar and non–planar, Robust and Adaptive Guidance, Guidance with State Feedback, Guidance with Normal Acceleration Input, Minimum Energy Orbital Transfer

UNIT III GUIDANCE AND CONTROL OF AIRCRAFT 9

Powered Flying Controls, Helicopter Flight Controls, Fly–by–Wire Flight Control, Control laws, Redundancy and Failure Survival, Digital Implementation, Fly–by–Light Flight Control, Auto Pilot, Flight Management Systems, Unmanned Aerial Vehicle

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UNIT IV CONTROL TECHNIQUES/ CONTROL OF ROCKETS AND MISSILE 9

Open–loop and Closed Loop Control Systems, Multi–variable Optimization, Optimal Control of Dynamic Systems, Hamiltonian and Minimum Principle and Jacobi–Bellman Equation, Linear Time–Varying System with Quadratic Performance Index

UNIT V CONTROL OF SPACECRAFT 9

Launch of Satellite/ Spacecraft, Terminal Control of Spacecraft Attitude, Optimal Single–Axis Rotation of Spacecraft, Multi–axis Rotational Maneuvers of Spacecraft, Spacecraft Control Torques, Rocket Thrusters, Reaction Wheels, Momentum Wheels and Control Moment Gyros, Torque

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Tewari, A. – Advanced Control of Aircraft, Spacecraft and Rocketsll, John Wiley & Sons, Ltd, Chichester, UK, 2011
2. Nelson R. C – Flight Stability and Automatic Control, 2nd Edition, McGraw Hill, New York, 2017

REFERENCES:

1. Noton, M. —Spacecraft navigation and Guidance, Reprint, Springer–Verlag, Germany, 2011
2. Mc. Cormic, B. W – Aerodynamics, Aeronautics and Flight Mechanics, Wiley India Pvt. Ltd, USA, 2010

EVALUATION PATTERN:

Continuous Internal Assessments				Total Internal Assessments	End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)			
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 6: AVIONICS AND DRONE TECHNOLOGY

U21MIP44	COMPUTATIONAL FLUID DYNAMICS FOR DRONES	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- NIL

COURSE OBJECTIVES:

- To introduce the equations governing the dynamic fluid flow
- To acquire the knowledge for various algorithms used to predict the fluid flow
- To gain expertise in simulating a fluid flow using appropriate equation, mesh topology and boundary conditions

COURSE OUTCOMES:

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

CO1: Understand the equation governing the fluid dynamic motion (Understand)
CO2: Analyze the turbulent flow (Apply)
CO3: Select the appropriate scheme for predicting the steady flow (Apply)
CO4: Apply finite volume method for unsteady flow problems (Apply)
CO5: Outline the boundary conditions and errors related to simulating fluid dynamics (Understand)

CO–PO MAPPING:

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	–	1	–	–	–	–	–	1	2	2
CO2	3	2	1	1	–	1	–	–	–	–	–	1	2	2
CO3	3	2	1	1	–	1	–	–	–	–	–	1	2	2
CO4	3	2	1	1	–	1	–	–	–	–	–	1	2	2
CO5	3	2	1	1	–	1	–	–	–	–	–	1	2	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)					

SYLLABUS:

UNIT I INTRODUCTION **9**

Computational Fluid Dynamics – Advantages, Applications and Future, Problem Setup, Numerical Solution, Result Report and Visualization, Governing Equations, Classifications method for Partial Differential Equation and Fluid Flow Equations

UNIT II TURBULENCE MODELLING AND MESH GENERATION **9**

Characteristics and Calculations of Simple Turbulent Flows, Reynolds–averaged Navier–Stokes Equations, Large Eddy Simulations, Direct Numerical Simulation, Types of Meshes – Topology and Refinement

UNIT III FINITE VOLUME METHOD FOR STEADY FLOW **9**

FVM for One– and Two–Dimensional Steady State Flow, Properties of Discretisation Schemes, Central Differencing Schemes, Upwind Differencing Scheme, Hybrid Differencing Scheme, Power–Law Scheme, QUICK Scheme, TVD Schemes, Solution algorithms – SIMPLE, SIMPLER, SIMPLEC, PISO

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UNIT IV FINITE VOLUME METHOD FOR UNSTEADY FLOW 9

One–Dimensional Unsteady Flow – Explicit, Crank–Nicolson and Fully Implicit Scheme, Solution Analysis – Consistency, Stability, Convergence, Accuracy, Efficiency and Case Studies

UNIT V BOUNDARY CONDITIONS AND ERRORS 9

Boundary Conditions – Inlet, Outlet and Wall Boundary Conditions, Constant Pressure Boundary Conditions, Symmetry Boundary Conditions, Numerical Errors, Input Uncertainty, Physical Model Uncertainty, Verification and Validation

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Jiyuan Tu, "Computational Fluid Dynamics – A Practical Approach", 4th Edition, Butterworth–Heinemann, 2023
2. H.K. Versteeg, "An Introduction to Computational Fluid Dynamics", 2nd Edition, Pearson, 2007
3. Imane Khalil, "Computational Fluid Dynamics: An Introduction to Modelling and Applications", McGraw Hill, 2023

REFERENCES:

1. R. Panneer Selvam, "Computational Fluid Dynamics for Wind Engineering", 1st Edition, John Wiley & Sons, 2022
2. James S. Hutchinson, "Computational Fluid Dynamics: Advances in Research and Applications", Nova Science Publishers, 2021

EVALUATION PATTERN:

Continuous Internal Assessments					End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 6: AVIONICS AND DRONE TECHNOLOGY

U21MIP45	AERODYNAMICS OF DRONES	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the basic concepts of payloads in UAV
- To acquire the knowledge on various sensor system of an UAV
- To expose the concepts of fuzzy logic and artificial neural networks

COURSE OUTCOMES:

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

CO1: Describe the payloads in UAV (Understand)
CO2: Apply the concepts of sensor systems for a drone (Apply)
CO3: Predict the data fusion algorithms and architectures (Apply)
CO4: Develop a basic neural network system (Apply)
CO5: Design various network schemes (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO2	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO3	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO4	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO5	2	1	2	1	–	–	–	–	1	–	–	1	1	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)					

SYLLABUS:

UNIT I PAYLOAD FOR UAV 9

Introduction – Types – Non–dispensable Payloads – Electro–optic Payload Systems – Electro–optic Systems Integration – Radar Imaging Payloads – Other Non–dispensable Payloads – Dispensable Payloads – Payload Development

UNIT II SENSOR 9

Data fusion applications to multiple sensor systems – Selection of sensors – Benefits of multiple sensor systems – Influence of wavelength on atmospheric attenuation – Fog characterization – Effects of operating frequency on MMW sensor performance – Absorption of MMW energy in rain and fog – Backscatter of MMW energy from rain – Effects of operating wavelength on IR sensor performance – Visibility metrics – Atmospheric and sensor system computer simulation models

UNIT III DATA FUSION ALGORITHMS AND ARCHITECTURES 9

Definition of data fusion – Level 1 processing – Detection, classification, and identification algorithms for data fusion – State estimation and tracking algorithms for data fusion – Level 2, 3, and 4 processing

– Data fusion processor functions – Definition of an architecture – Data fusion architectures – Sensor–level fusion – Central–level fusion – Hybrid fusion

UNIT IV ARTIFICIAL NEURAL NETWORKS 9

Applications of artificial neural networks – Adaptive linear combiner – Linear classifiers – Capacity of linear classifiers – Nonlinear classifiers – Madaline – Feedforward network – Capacity of nonlinear classifiers – Supervised and unsupervised learning – Supervised learning rules

UNIT V FUZZY LOGIC AND FUZZY NEURAL NETWORKS 9

Conditions under which fuzzy logic provides an appropriate solution – Illustration of fuzzy logic in an automobile antilock braking system – Basic elements of a fuzzy system – Fuzzy logic processing – Fuzzy centroid calculation

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Reg Austin Aeronautical Consultant, A John "Unmanned aircraft systems UAVs design, development and deployment" Wiley and Sons, Ltd., Publication,2010
2. Martin Liggins II David Hall, James "Handbook of Multisensor Data Fusion: Theory and Practice", Second Edition (Electrical Engineering & Applied Signal Processing Series), 2008.

REFERENCES:

1. Lawrence A. Klein, "Sensor and Data Fusion: A Tool for Information Assessment and Decision Making", Second Edition, SPIE Press, 2013
2. Jitendra R. Raol, "Multi–Sensor Data Fusion with MATLAB", CRC Press, 2010.

EVALUATION PATTERN:

<table>
<tr><th colspan="4">Continuous Internal Assessments</th><th rowspan="2">Total Internal Assessments</th><th rowspan="3">End Semester Examinations</th></tr>
<tr><th colspan="2">Assessment I
(100 Marks)</th><th colspan="2">Assessment II
(100 Marks)</th></tr>
<tr><td>Individual Assignment / Seminar / MCQ</td><td>Written Test</td><td>Individual Assignment / Seminar / MCQ</td><td>Written Test</td><td></td></tr>
<tr><td>40</td><td>60</td><td>40</td><td>60</td><td>200</td><td>100</td></tr>
<tr><td colspan="4" rowspan="2">Total</td><td>40</td><td>60</td></tr>
<tr><td colspan="2">100</td></tr>
</table>

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 6: AVIONICS AND DRONE TECHNOLOGY

U21MIP46	DESIGN OF UAV	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the basic terminologies, models and prototypes of UAV systems
- To acquire the knowledge on design considerations of UAV systems
- To design the UAV system for specific requirements

COURSE OUTCOMES:

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

CO1: Explain the basic models of UAV systems (Understand)
CO2: Relate the design parameters of an unmanned aerial vehicle (Apply)
CO3: Organize the various UAV standards (Apply)
CO4: Experiment with the payloads and launch systems for UAV (Apply)
CO5: Perform system testing for unmanned aerial vehicles (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO2	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO3	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO4	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO5	2	1	2	1	–	–	–	–	1	–	–	1	1	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I BASIC MODELS OF UAV **9**

Introduction to UAV – Classification – Systematic basis of Unmanned Aircraft Systems (UAS) – System composition – Categories and Roles – Elements of UAS

UNIT II UAV SYSTEM DESIGN **9**

Design and selection of UAS – Aerodynamics and airframe configurations – Aspects of airframe design – Unmanned Aircraft characteristics – Long range, Medium and Close range UAVs – Mini and Micro UAVs

UNIT III UAV STANDARDS **9**

Unmanned Design standards and Regulatory aspects – Airframe design – Ancillary equipment – Design of Stealth

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UNIT IV UAV PAYLOADS 9

Sensors and payloads – payload types – Communications, Control and stability, Navigation – Launch and recovery

UNIT V UAV TESTING 9

Launch of HTOL & VTOL systems – recovery of HTOL & VTOL systems – Naval roles – Army roles – Civilian roles – paramedical and commercial roles – commercial applications

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Reg Austin "Unmanned Aircraft Systems UAV design, development and deployment", Wiley, 2010.
2. Paul G Fahlstrom, Thomas J Gleason, "Introduction to UAV Systems", 5th Edition, Wiley, 2022

REFERENCES:

1. Richard K. Barnhart, Stephen B. Hottman, Douglas M. Marshall, Eric Shappee, "Introduction to Unmanned Aircraft systems", CRC press, Taylor and Francis, New York, 2012
2. Dr. Armand J. Chaput, "Design of Unmanned Air Vehicle Systems", Lockheed Martin Aeronautics Company, 2001

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	**End Semester Examinations**
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	**60**	**40**	**60**	**200**	**100**
Total				**40**	**60**
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 6: AVIONICS AND DRONE TECHNOLOGY

U21MIP47	NAVIGATION AND COMMUNICATION SYSTEMS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the various types of navigation systems
- To acquire the knowledge on dead reckoning navigation system and its error correction
- To apply the satellite navigation and hybrid navigation system integration

COURSE OUTCOMES:

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

CO1: Explain the advanced concepts of Aircraft Navigation (Understand)
CO2: Model the navigation process using existing methods (Apply)
CO3: Choose the various radio communication systems based on suitable applications (Apply)
CO4: Make use of high frequency communication systems for aircraft applications (Apply)
CO5: Apply the principles of Radar and its related components (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2	1	–	–	–	–	1	–	–	1	1	2
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CO4	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO5	2	1	2	1	–	–	–	–	1	–	–	1	1	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)					

SYLLABUS:

UNIT I INERTIAL NAVIGATION SYSTEMS **9**

Introduction to navigation – Types –INS components– transfer function and errors – Earth in inertial space – Coriolis Effect – INS Mechanization. Platform and Strap down – Navigation algorithms – INS system block diagram, Different co–ordinate systems – Transformation Techniques – Schuler Tuning – compensation errors – Gimbal lock – Initial calibration and Alignment Algorithms

UNIT II RADIO NAVIGATION & SATELLITE NAVIGATION **9**

Different types of radio navigation– ADF, VOR, DME – Doppler – Hyperbolic Navigations –LORAN, DECCA and Omega – TACAN. Introduction to GPS –system description –basic principles –position and velocity determination signal Structure –DGPS, Introduction to Kalman filtering–Estimation and mixed mode navigation Integration of GPS and INS–utilization of navigation systems in aircraft

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UNIT III RADIO TRANSMITTERS AND RECEIVERS 9

Functions of a Radio transmitter, Microphones, types, Block diagram explanation of a Radio transmitter, Modulation and its types and Antenna, Antenna couplers, Qualities of a good Radio receiver, Block diagram of a simple radio receiver and super heterodyne receiver

UNIT IV AIRCRAFT COMMUNICATION SYSTEMS 9

Basics of aircraft communication system, types Very High Frequency Communication system, Description, Principle, Operation of VHF Communication system and its layout on aircraft, High Frequency communication system, Description, Principle and operation of High Frequency communication system and its layout on aircraft. Satellite communication system, Description, Operation and its layout on aircraft

UNIT V WEATHER RADAR SYSTEM AND DOME 9

Introduction, Description and types of Radar, Primary and Secondary Radar, Weather Radar Description, Analog radar Principal units of Analog radar system. Aircraft weather radar, transmitter–receiver, Indicator, Control panel, Antenna, Radome and wave guide. Radome maintenance and radar safety

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Mike Tooley and David Wyatt, "Aircraft Communications and Navigation systems", Reed Elsevier, India, Noida, 2nd Edition – 2017
2. James Powell, "Aircraft Radio system", Sterling book house, Mumbai, Indian Edition – 2006

REFERENCES:

1. Thomas K Eismin, "Aircraft Electricity and electronics", 5th Edition, McGraw– Hill Book Co, 1994

EVALUATION PATTERN:

Continuous Internal Assessments				Total Internal Assessments	End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)			
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL 6: AVIONICS AND DRONE TECHNOLOGY

U21MIP48	AIRCRAFT MECHATRONICS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To introduce the basic of avionics and its need for civil and military aircrafts
- To impart knowledge about the avionic architecture and various avionics data bases
- To analyze the application of Mechatronics in aircraft.

COURSE OUTCOMES:

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

CO1: Describe the basics in aerodynamics, aircraft propulsion, materials and controls (Apply)
CO2: Explain the various concepts used in aerodynamics (Apply)
CO3: Summarize the techniques to develop the aero system (Apply)
CO4: Design the aircraft with the use of concepts in aerodynamics, aircraft propulsion, materials and controls (Apply)
CO5: Apply the aircraft system in various applications (Apply)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO2	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO3	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO4	2	1	2	1	–	–	–	–	1	–	–	1	1	2
CO5	2	1	2	1	–	–	–	–	1	–	–	1	1	2
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)						3: Substantial (High)					

SYLLABUS:

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 thermo dynamics 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.

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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.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Dr. O. P. Sharma and Lalit Gupta, "Fundamentals of Flight – Aircraft Systems", Reprint; Jain Book Agency, 2015
2. Albert Helfrick. D., "Principles of Avionics", 3rd Edition, Airline Avionics, 2007

REFERENCES:

1. Pallet. E.H.J., "Aircraft Instruments and Integrated Systems", Pearsons, Indian Edition 2011.
2. Spitzer. C.R. "The Avionics Hand Book", CRC Press, 2000

EVALUATION PATTERN:

Continuous Internal Assessments				Total Internal Assessments	End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)			
Individual Assignment / Seminar / MCQ	Written Test	Individual Assignment / Seminar / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

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OPEN ELECTIVE COURSES

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DEPARTMENT OF MECHATRONICS ENGINEERING

SEMESTER IV

		Category: OEC				
U21MIX01	DESIGN OF MECHATRONIC SYSTEMS	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To learn about Mechatronics system design, simulation, ergonomics, and safety
- To understand theoretical and practical aspects of system modelling, interfacing, real time data acquisition and control
- To learn the real time interfacing tools and man-machine interface
- To know about the various mechatronics systems and its applications

COURSE OUTCOMES:

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

CO1: Identify the basic elements of mechatronics and its integration concepts (Understand)
CO2: Develop the system models and familiar the Mechatronics design process (Understand)
CO3: Corelate the suitable interface for mechatronics system (Understand)
CO4: Develop the physical systems based on mechatronics design process (Apply)
CO5: Build the mechatronics systems for real time applications (Apply)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	2	2	-	-	-	-	-	-	3		
CO2	3	2	3	2	2	-	-	-	-	-	-	3		
CO3	3	2	3	2	2	-	-	-	-	-	-	3		
CO4	3	2	3	2	2	-	-	-	-	-	-	3		
CO5	3	2	3	2	2	-	-	-	-	-	-	3		
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I FUNDAMENTALS OF MECHATRONICS SYSTEMS 9

Introduction - Key elements - Mechatronics design process - Types of Design: Traditional and Mechatronics design - Integrated product design - Advanced approaches in Mechatronics Design - Industrial design, modelling and analysis - Ergonomics and Safety.

UNIT II BASIC SYSTEM MODELLING 9

Introduction - Model categories - Fields of application - Model development - Model verification - Model validation - Simulators and Simulation - Design of mixed system: Electromechanical system design - Model transformation - Domain independent description forms: Bond graph and Block Diagram - Simulator coupling.

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UNIT III SYSTEM INTERFACING 9

Introduction - Elements of data acquisition and control system - Overview of I/O process -Installation of I/O card and software - TIA/EIA serial interface standards (RS232/422/485) -General Purpose Interface Bus (IEEE 488) - GUI card - Ethernet switch - Man Machine Interfaces.

UNIT IV CASE STUDY ON MECHATRONICS SYSTEMS 9

Motion control using DC Motor, AC Motor and Servomotor - Internal Combustion Engine with Drive Train - Auto focus Camera - Transducer calibration system - Strain gauge weighing system - Controlling temperature of a hot/cold reservoir using PID.

UNIT V CASE STUDY ON INTELLIGENCE SYSTEMS 9

Machine tool control system - Electronics engine management system - Pick and place industrial manipulator - Autonomous mobile robot - Artificial Intelligence in Mechatronics - Car parking barrier - Fuzzy controlled washing machine.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Devdas Shetty & Richard A. Kolk, "Mechatronics System Design", 2nd Edition, CT Cengage Learning, Stamford, 2012.
2. Bolton W., "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering", 6th Edition, Pearson Education Limited, New York, 2018.

REFERENCES:

1. Robert H. Bishop, "The Mechatronics handbook. Fundamentals and modelling", 2nd Edition, CRC Press, London, 2017.
2. Bradley D, Seward D, Dawson D & Burge S, "Mechatronics and the Design of Intelligent Machines and Systems" 1st Edition, CRC Press, London, 2017.

EVALUATION PATTERN:

<table>
<tr><th colspan="4">Continuous Internal Assessments</th><th rowspan="2">Total Internal Assessments</th><th rowspan="3">End Semester Examinations</th></tr>
<tr><th colspan="2">Assessment I (100 Marks)</th><th colspan="2">Assessment II (100 Marks)</th></tr>
<tr><td>*Individual Assignment / Case Study / Seminar / Project / MCQ</td><td>Written Test</td><td>*Individual Assignment / Case Study / Seminar / Project / MCQ</td><td>Written Test</td><td></td></tr>
<tr><td>40</td><td>60</td><td>40</td><td>60</td><td>200</td><td>100</td></tr>
<tr><td colspan="4" rowspan="2">Total</td><td>40</td><td>60</td></tr>
<tr><td colspan="2">100</td></tr>
</table>

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER IV

		Category: OEC				
U21MIX02	MODERN ROBOTICS	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To Understand the forward kinematics in space frame
- To Derive the Lagrangian equations of motion by hand for simple robot systems
- To Understand the constraints in grasping and robot manipulation

COURSE OUTCOMES:

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

CO1: Use the Modern Robotics code library and the CoppeliaSim robot simulator (Understand)
CO2: Express the joint axes of open-chain robots at the end-effector of the robot (Understand)
CO3: Apply the equation governing the kinetic energy of a robot and a rigid body (Apply)
CO4: Apply the concept of C-space obstacles in the analysis of motion planning (Apply)
CO5: Classify the contact situation between a rigid body and external contacts as a contact mode (Understand)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	3	-	-	-	-	-	-	1		
CO2	3	2	2	2	2	-	-	-	-	-	-	1		
CO3	3	2	2	2	2	-	-	-	-	-	-	1		
CO4	3	2	2	2	2	-	-	-	-	-	-	1		
CO5	3	2	2	2	2	-	-	-	-	-	-	1		
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)					

SYLLABUS:

UNIT I FOUNDATIONS OF ROBOT MOTION 9

Introduction to the specialization – Modern Robotics code library – CoppeliaSim robot simulator – light board video-generation tool - Configuration space and degrees of freedom of rigid bodies and robots

UNIT II ROBOT KINEMATICS 9

Product of exponentials formula for forward kinematics in the space frame – end -effector frame – forward kinematics – screw axis

UNIT III ROBOT DYNAMICS 9

Lagrangian formulation of dynamics – centripetal and Coriolis forces – robot mass matrix – dynamics of a rigid body – Newton-Euler inverse dynamics for an open-chain robot.

UNIT IV ROBOT MOTION PLANNING AND CONTROL 9

Overview of motion planning – C-space obstacles – graphs and trees – A* graph search – path planners – motion planning

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UNIT V ROBOT MANIPULATION AND WHEELED MOBILE ROBOTS 9

Kinematics of contact – contact types (rolling, sliding, and breaking) – graphical methods for representing kinematic constraints in the plane – form-closure grasping (complete kinematic constraint).

Contact Periods:

Lecture: 45 Periods Tutorial: - Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Kevin M. Lynch and Frank C. Park, "Modern Robotics", Cambridge University Press in May 2017, ISBN 9781107156302
2. John J. Craig, "Introduction to Robotics: Mechanics & Control", 3rd edition, McGraw-Hill Education, New Delhi, 2013

REFERENCES:

1. (https://www.coursera.org/learn/modernrobotics)
2. Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, "Robotics Modelling, Planning and Control", Springer, 2013
3. Howie Choset, Seth Hutchinson, Kevin M. Lynch, "Principles of Robot Motion Theory, Algorithms, and Implementations", ISBN 9780262033275

EVALUATION PATTERN:

<table>
<tr><th colspan="4">Continuous Internal Assessments</th><th rowspan="3">Total Internal Assessments</th><th rowspan="3">End Semester Examinations</th></tr>
<tr><th colspan="2">Assessment I (100 Marks)</th><th colspan="2">Assessment II (100 Marks)</th></tr>
<tr><th>*Individual Assignment / Case Study / Seminar / Project / MCQ</th><th>Written Test</th><th>*Individual Assignment / Case Study / Seminar / Project / MCQ</th><th>Written Test</th></tr>
<tr><td>40</td><td>60</td><td>40</td><td>60</td><td>200</td><td>100</td></tr>
<tr><td colspan="4" rowspan="2">Total</td><td>40</td><td>60</td></tr>
<tr><td colspan="2">100</td></tr>
</table>

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER V

		Category: OEC				
U21MIX03	MEMS & NEMS	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To learn about the basic concepts of MEMS and NEMS
- To familiarizes the concept of fabrication, manufacturing and packaging of Microsystem
- To know the applications of Micro and Nano product for various applications

COURSE OUTCOMES:

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

CO1: Interpret the basics of micro sensors and micro actuators (Understand)
CO2: Identify the suitable fabrication process of microsystem (Understand)
CO3: Develop the micro systems for various applications (Apply)
CO4: Elucidate the function of nanoscale materials (Understand)
CO5: Design and analyze the Nano-electronic devices (Apply)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	-	-	-	-	-	-	-	2		
CO2	3	2	2	2	-	-	-	-	-	-	-	2		
CO3	3	2	2	2	-	-	-	-	-	-	-	2		
CO4	3	2	2	2	-	-	-	-	-	-	-	2		
CO5	3	2	2	2	-	-	-	-	-	-	-	2		
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)				3: Substantial (High)						

SYLLABUS:

UNIT I MICROSYSTEMS, MICROSENSORS AND ACTUATORS 9

Overview - Microsystems - Working principle of Microsystems - Micro sensors - Micro actuation techniques - Micropump - Micromotors - Microvalves - Microgrippers.

UNIT II MICROSYSTEM FABRICATION 9

Substrates - Single crystal silicon wafer formation - MEMS materials - Photolithography - Ion implantation - Diffusion - Oxidation - CVD - Physical Vapor Deposition - Deposition by epitaxy – Etching process.

UNIT III MICROSYSTEM MANUFACTURING AND DESIGN 9

Bulk Micromanufacturing - Surface Micromachining - LIGA - SLIGA. Micro system packaging - Materials - Die level - Device level - System level - Packaging techniques - Surface bonding - Wire bonding – Sealing - Design considerations - Micro System Applications

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UNIT IV INTRODUCTION AND OVERVIEW: NANOSCALE 9

Mendeleyev's Periodic Table of Elements and Electronic Configurations - Nanoengineering and Nanoscience - Carbon Nanoelectronics: Carbon Nanotubes - Analysis of Carbon Nanotubes - Classification of Carbon Nanotubes

UNIT V MODELING OF NANO-ELECTROMECHANICAL SYSTEMS 9

Introduction to Modelling, Analysis, and Simulation of NEMS - Newtonian Mechanics - Functional Nano-Electro-mechanical Systems - Piezo actuators: Steady-state models and Characteristics.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Tai-Ran Hsu, "MEMS And Microsystems: Design and Manufacture", 1st Edition, McGraw-Hill Education Pvt. Ltd, New Delhi, 2017.
2. Lyshevski, S.E, "Nano- and Micro-Electromechanical Systems: Fundamentals of Nano- and Microengineering", 2nd Edition, CRC Press, 2005.

REFERENCES:

1. Zhang, Dan, Wei, Bin, "Advanced Mechatronics and MEMS Devices II", 1st Edition, Springer International Publishing, 2017.
2. Takahata, K, "Advances in Micro/Nano Electromechanical Systems and Fabrication Technologies" 1st Edition, InTech Pvt. Ltd, 2013.

EVALUATION PATTERN:

Continuous Internal Assessments					End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	
*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test	*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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SEMESTER V

U21MIX04	ROBOTICS PROCESS AUTOMATION	Category: OEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To provide insights on robotic process automation (RPA) technology and its value proposition
- To introduce different platforms for RPA
- To illustrate basic programming concepts and the underlying logic/structure related to RPA
- To describe the different types of variables, control flow and data manipulation techniques in RPA platform
- To describe automation to email and various types of exceptions and strategies to handle

COURSE OUTCOMES:

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

CO1: Gain insights into Robotic Process Automation Technology (Understand)
CO2: Demonstrate the underlying logic/structure related to RPA (Understand)
CO3: Classify several types of data inside a workflow and, gain skills in building workflows in RPA platform (Understand)
CO4: Comprehend different types of variables, pdf automation and data manipulation techniques (Understand)
CO5: Design automation to Email and various types of Exceptions and strategies to handle (Apply)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	2	-	-	-	-	-	-	2		
CO2	3	3	3	3	2	-	-	-	-	-	-	2		
CO3	3	3	3	3	2	-	-	-	-	-	-	2		
CO4	3	3	3	3	2	-	-	-	-	-	-	2		
CO5	3	3	3	3	2	-	-	-	-	-	-	2		
Correlation levels:		1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)			

SYLLABUS:

UNIT I INTRODUCTION TO RPA **9**

Emergence of Robotic Process Automation (RPA), Evolution of RPA, Future of RPA, Differentiating RPA from Automation, Defining Robotic Process Automation & its benefits, What RPA is Not, Types of Bots, Application areas of RPA, How Robotic Process Automation works, RPA development methodology and key considerations.

UNIT II ROBOTIC PROCESS AUTOMATION PLATFORMS **9**

Components of RPA - RPA Platforms - Types of templates, user interfaces, domain in activities, variables, arguments, imports panel and user events - About Ui Path - The future of automation - Record and Play - Downloading and installing UiPath Studio - Learning Ui Path Studio - Task recorder - Step-by step examples using the recorder.

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UNIT III TAKING CONTROL OF THE CONTROLS 9

Finding and attaching windows - Finding the control - Techniques for waiting for a control - Act on controls - mouse and keyboard activities - Working with UiExplorer - Handling events - Revisit recorder - Screen Scraping - When to use OCR - Types of OCR available - How to use OCR - Avoiding typical failure points.

UNIT IV DATA MANIPULATION AND PDF AUTOMATION 9

Data Manipulation, Automation of Virtual Machines, Introduction to Native Citrix Automation, Text and Image Automation, PDF Automation, Computer Vision.

UNIT V EXCEPTION HANDLING, DEBUGGING AND LOGGING 9

Exception Handling, Debugging, and Logging - Exception handling - Common exceptions and ways to handle them - Logging and taking screenshots - Debugging techniques - Collecting crash dumps - Error reporting - Future of RPA.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Tom Taulli , "The Robotic Process Automation Handbook: A Guide to Implementing RPA Systems", Apress publications, 2020.
2. Learning Robotic Process Automation: Create Software robots and automate business processes with the leading RPA tool - UiPath by Alok Mani Tripathi, Packt Publishing, Mumbai, 2018.

REFERENCES:

1. A Gerardus Blokdyk, "Robotic Process Automation: RPA - A Complete Guide ", 5STARCooks publishers, Toronto, 2020.
2. Richard Murdoch, "Robotic Process Automation: Guide to Building Software Robots, Automate Repetitive Tasks & Become an RPA Consultant",1st Edition, Independently published, 2018.
3. Adeel Javed, Anum Sundrani , Nadia Malik and Sidney Madison Prescott, "Robotic Process Automation using UiPath StudioX: A Citizen Developer's Guide to Hyperautomation", 1st Edition, Apress publishers, 2021.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	**End Semester Examinations**
*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test	*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test		
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Total				40	60
				100	

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SEMESTER VI

U21MIX05	PRODUCT DESIGN AND DEVELOPMENT	Category: OEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To learn about product development methods based on current innovative trends
- To understand the requirements of customers and product planning process
- To learn the product specifications and concept generation screening and testing
- To know the product architecture, industrial design considerations and prototyping

COURSE OUTCOMES:

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

CO1: Infer the basic need for new product design and development process (Understand)
CO2: Identify opportunities and customer needs for new product development (Apply)
CO3: Arrive at product specification and develop concepts for new product (Apply)
CO4: Establish the overall product architecture and assess its industrial design (Apply)
CO5: Assess the design from environmental, manufacturing and supply chain perspective and develop prototypes (Apply)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
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CO3	3	3	3	2	2	2	1	1	-	-	-	3		
CO4	3	3	3	2	2	2	1	1	-	-	-	3		
CO5	3	3	3	2	2	2	1	1	-	-	-	3		
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)					

SYLLABUS:

UNIT I DEVELOPMENT PROCESSES AND ORGANIZATIONS 9

Introduction to new product and product design - Characteristics of successful product development - The challenges in product development - Product development process - Adapting generic product development process - Product development process flows -Product development organizations.

UNIT II OPPORTUNITY IDENTIFICATION AND PRODUCT PLANNING 9

Types of opportunities - Structure of Opportunity Identification - Opportunity identification process; Product Planning Process - Four types of product development projects - Steps in Product Planning - Identifying Customer needs.

UNIT III PRODUCT SPECIFICATIONS AND CONCEPT GENERATION 9

Product Specifications - Target and final specifications. Concept generation: Five step method - Concept selection - Concept screening - Concept scoring - Concept testing.

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Tamilnadu, India

UNIT IV PRODUCT ARCHITECTURE AND INDUSTRIAL DESIGN 9

Implications of the architecture - Establishing the architecture - Delayed differentiation - Platform Planning - System level design issues. Industrial Design - Assessing the Need for Industrial Design and its impact - Industrial design process and management - Assessing the quality of Industrial Design.

UNIT V DESIGN CONSIDERATIONS AND PROTOTYPING 9

Design for environment - Design for manufacturing and supply chain; Prototyping - Principles - Technologies - Planning for prototypes - Robust design – Process flow.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Ulrich, Karl T., Eppinger, Steve D., and Yang, Maria C., "Product Design and Development", 7th Edition, McGraw-Hill Education, 2020.
2. Devdas Shetty, "Product Design for Engineers", Cengage Learning, Boston, 2016.

REFERENCES:

1. Maddock M. and Uriarte L., "Brand New: Solving the Innovation Paradox – How Great Brands Invent and Launch New Products, Services and Business Models", John Wiley & Sons, Inc., New Jersey, 2011.
2. Steven W. Trimble and Abdelrahman N. Shuaib, "Product Design and Development Handbook", Cognella, United States, 2022.

EVALUATION PATTERN:

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SEMESTER VI

U21MIX06	INTRODUCTION TO INDUSTRIAL INTERNET OF THINGS	Category: OEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To learn about the modify of existing industrial systems with IoT concepts
- To understand the importance of IIoT architecture, sensors and interfacing units
- To learn the protocols required for industrial data transmission
- To know the IIoT application domains in various industries with AR and VR technologies

COURSE OUTCOMES:

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

CO1: Comprehend the fundamentals of IIoT and its potential, challenges (Understand)
CO2: Infer the various components and architecture of IIoT (Understand)
CO3: Design the sensors based IIoT architecture with interface standards (Apply)
CO4: Realize and choose the Protocols and Cloud platforms for different IIoT solutions (Apply)
CO5: Build the concepts of Design Thinking for industrial applications (Apply)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	3	-	-	-	-	-	-	1		
CO2	3	2	2	2	3	-	-	-	-	-	-	1		
CO3	3	2	2	2	3	-	-	-	-	-	-	1		
CO4	3	2	2	2	3	-	-	-	-	-	-	1		
CO5	3	2	2	2	3	-	-	-	-	-	-	1		
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)					

SYLLABUS:

UNIT I INTRODUCTION 9

Introduction - IoT Architecture – Application-based IoT Protocols – Infrastructure-based protocols - Data protocols -Transport protocols. Cloud Computing: Types of cloud - Business aspects of cloud – Virtualization - Key aspect of cloud computing - Mobile cloud computing - Fog Computing: Applications of Fog computing. Sensor Cloud: Applications of Sensor Cloud - Big Data.

UNIT II IIOT ARCHITECTURES 9

Overview of IoT components - Various architectures of IoT and IIoT, Advantages and disadvantages, Industrial internet - Reference architecture; IIoT system components: Sensors, Gateways, Routers, Modem, Cloud brokers, servers, and its integration, WSN, WSN network design for IoT.

UNIT III SENSOR AND INTERFACING 9

Introduction to Sensors, Transducers, Classifications - Roles of sensors in IIoT - Various types of sensors - Design of sensors: sensor architecture, special requirements for IIoT sensors - Role of

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actuators - Types of actuators - Hardwire the sensors with different protocols such as HART, MODBUS - Serial and Parallel, Ethernet, BACNet and M2M.

UNIT IV PROTOCOLS AND CLOUD 9

Introduction to Industrial data transmission, Features & Components: Fieldbus, Profibus, HART, Interbus, Bitbus, CC-link, Modbus, Batibus, DigitalSTROM, Controller area network, DeviceNet, LonWorks, ISA 100.11a, Wireless HART, LoRa & LoRaWAN, NB-IoT, IEEE 802.11AH. Clouds : Types of clouds

UNIT V INDUSTRIAL IOT- APPLICATION DOMAINS 9

Healthcare, Power plants - Inventory management and quality control - Plant safety and security (Including AR and VR safety applications), Facility management - Oil - Chemical and pharmaceutical industry - Applications of UAVs in Industries.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Anandarup Mukherjee, Chandana Roy, Sudip Misra," Introduction to Industrial Internet of Things and Industry 4.0", 1st Edition, CRC Press, 2020.
2. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", 1st Edition, Apress, New York, 2017.

REFERENCES:

1. Daniel Minoli, "Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications", John Wiley& Sons publications, United Kingdom, 2013.
2. Olivier Hersent, David Boswarthic &, Omar Elloumi, "The Internet of Things: Key Applications and Protocols", 2nd Edition, Wiley publication, New Jersey, 2012.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	**End Semester Examinations**
*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test	*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test		
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Total				40	60
				100	

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SEMESTER VI

U21MIX07	GRAPHICAL SYSTEM DESIGN USING LabVIEW	Category: OEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To learn the fundamentals of graphical programming techniques with instrument interfaces
- To understand the data acquisition in real time systems
- To learn the various software and hardware tools for testing, measurement and control
- To know the signal processing and analysis tool for industrial applications

COURSE OUTCOMES:

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

CO1: Demonstrate the basic concepts of Virtual Instrumentation. (Understand)
CO2: Interpret the software tools in Virtual Instrumentation using GSD platform. (Understand)
CO3: Develop programming concepts in graphical programming environment. (Apply)
CO4: Interface data acquisition hardware with software tools. (Apply)
CO5: Develop programming concepts with advanced software tools. (Apply)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	2	-	-	-	-	-	-	2		
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CO5	3	3	3	3	2	-	-	-	-	-	-	2		
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I INTRODUCTION TO GSD 9

Historical perspectives and architecture of a virtual instrument, Graphical System Design (GSD) - G programming/ modular programming - Controls and indicators - Data flow programming using numeric, string, boolean functions - Data types - Editing, debugging and running a virtual instrument

UNIT II GSD PROGRAMMING TECHNIQUES 9

Graphical programming palettes and tools, function and libraries in GSD platform - String and file I/O: high level and low-level file I/O's to read / write a file - Sub-VI programming, Structures: FOR loops, WHILE loops, Shift Registers and CASE structures

UNIT III GSD SOFTWARE TOOLS 9

Arrays and clusters - Bundle/Unbundle and Bundle/Unbundle - Plotting data: waveform graphs and charts - Attribute nodes - Local and global variables - Formula nodes, sequence structures and timed looped structures

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UNIT IV GSD DATA ACQUISITION HARDWARE 9

Basics of DAQ hardware and software - concepts of data acquisition - Configuring and addressing the hardware - Real time data acquisition using hardware: USB based DAQ with programming - Seven-segment LED display/ motor/ buzzer/ speaker

UNIT V SIGNAL PROCESSING AND CONTROL 9

Signal processing and analysis tool: Fourier transform, power spectrum analysis - Communication protocol: TCP IP client server - Control design and simulation tool: build basic transfer function for open and closed loop system with PID controller.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total 45 Periods

TEXTBOOKS:

1. Jeffery Travis and Jim Kring, "LabVIEW for Everyone: Graphical programming made easy and Fun", 3rd Edition, Pearson Education, India, 2009.
2. Jovitha Jeroma, "Virtual Instruments using LabView", PHI Learning Pvt Ltd, New Delhi, 2010

REFERENCES:

1. Gary W. Jonson and Richard Jennings "Labview Graphical Programming", 4th Edition, McGraw Hill, New York, 2017.
2. Gupta, Joseph and John, "Virtual Instrumentation using LabVIEW", 2nd Edition, Tata McGraw Hill, 2010.

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SEMESTER VII

U21MIX08	CYBER PHYSICAL SYSTEMS	Category: OEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To acquire knowledge and skills on various hardware and software design aspects of Cyber-Physical Systems (CPS) - modeling, analysis, and design
- To understand the functions, security and privacy aspects of CPS
- To know the mechatronics system design and its integration systems

COURSE OUTCOMES:

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

CO1: Explain the fundamentals of cyber physical systems, its potential and challenges (Understand)
CO2: Infer the various components and architecture of CPS (Understand)
CO3: Interpret the functions of CPS multitasking and scheduling (Understand)
CO4: Explain the concepts of CPS in security and privacy aspects (Understand)
CO5: Design the mechatronics system with integration of CPS for different applications tools (Apply)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	-	-	-	-	-	-	-	1		
CO2	3	2	2	1	-	-	-	-	-	-	-	1		
CO3	3	2	2	1	-	-	-	-	-	-	-	1		
CO4	3	2	2	1	-	-	-	-	-	-	-	1		
CO5	3	2	-	-	-	-	-	-	-	-	-	1		
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I INTRODUCTION 9

Cyber-Physical Systems (CPS) in the real world, Basic principles of design and validation of CPS, CPS HW platforms: Processors, Sensors, Actuators, CPS network, CPS SW stack RTOS, Scheduling real time control tasks.

UNIT II DESIGN OF EMBEDDED SYSTEMS 9

Types of Processors - Parallelism. Memory architectures - Memory technologies - Memory hierarchy - Memory models. Input and Output - I/O Hardware - Sequential software in a concurrent world - Analog/Digital interface.

UNIT III MULTITASKING AND SCHEDULING 9

Imperative Programs - Threads - Processes and message passing. Scheduling with fixed timing parameters - Memory effects, Multiprocessor/ Multicore scheduling - Accommodating variability and uncertainty- Managing other resources - Rhythmic tasks scheduling.

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UNIT IV SECURITY OF CYBER-PHYSICAL SYSTEMS 9

Cyber security requirements - Defining security and privacy - Attack model - Counter measures - System theoretic approaches - Examples of security and privacy in action - Approaches to secure cyber-physical systems - Ongoing security and privacy challenges for CPSs- Ethical hacking.

UNIT V DESIGN OF MECHATRONICS SYSTEM AND CPS 9

V Model and its variants - System boundary definition - Multi-view and multi-level modelling - Topological modelling - Semantic interoperability modelling - Multi-agent modelling - Collaboration modelling - internal block diagrams - multi-agent development platform - Software tools - Java, Modelica. Case Study: Suspension control, Healthcare: Artificial Pancreas/Infusion Pump/Pacemaker, Green buildings: Automated lighting, AC control, Digital twin system.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Edward A. Lee and Sanjit A. Seshia, "Introduction to Embedded Systems: A Cyber-Physical Systems Approach", 2nd Edition, MIT press, United Kingdom, 2017.
2. Song H., Rawat D. B., Jeschke S. and Brecher C., "Cyber-physical systems: foundations, principles and applications", Morgan Kaufmann, United States, 2016.

REFERENCES:

1. Rajeev Alu, "Principles of Cyber-Physical Systems", MIT Press, United Kingdom, 2016.
2. Rodrigues, Joel Jose PC, Ivan Stojmenovic, and Danda B. Rawat, "Cyber-physical systems: from theory to practice", CRC Press, Florida, 2015.

EVALUATION PATTERN:

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SEMESTER VII

U21MIX09	INTRODUCTION TO INDUSTRY 4.0	Category: OEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To recognize need and trends of Industry 4.0.
- To understand concepts and technologies supporting Industry 4.0
- To explore challenges and industrial applications of Industry 4.0

COURSE OBJECTIVES:

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

CO1: Understand the basic concepts of Industry 4.0 and the other related fields (Understand)
CO2: Identify the smart devices required for Industry 4.0 (Apply)
CO3: Analyze the different smart platforms adopted for Industry 4.0 (Apply)
CO4: Recognize the data management principles and cloud computing for Industry 4.0 (Understand)
CO5: Implement the Industry 4.0 to solve engineering problems (Apply)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
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Correlation levels:		1: Slight (Low)		2: Moderate (Medium)				3: Substantial (High)						

SYLLABUS:

UNIT I INTRODUCTION 9

Various Industrial Revolutions, Digitalization and the Networked Economy, Digital twin - Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation, Lean Production Systems. Additive manufacturing, Robotization and automation, Current situation of Industry 4.0.

UNIT II SMART DEVICES IN INDUSTRY 4.0 9

Sensing & actuation, Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services, Smart Manufacturing, Smart Devices and Products, Smart Logistics, Predictive Analytics

UNIT III SMART PLATFORMS IN INDUSTRY 4.0 9

Cyberphysical Systems, Robotic Automation and Collaborative Robots, Support System for Industry 4.0, Cyber Security, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Artificial Intelligence, Big Data and Advanced Analysis

UNIT IV DATA MANAGEMENT AND CLOUD COMPUTING 9

Resource - based view of a firm, Data as a new resource for organizations, Harnessing and sharing knowledge in organizations, Cloud Computing Basics, Cloud Computing and Industry 4.0

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UNIT V CHALLENGES AND INDUSTRIAL APPLICATIONS 9

Industry 4.0 laboratories, IIoT case studies, Application Domains, Business Issues, Opportunities and Challenges, Strategies for competing in an Industry 4.0 world. Introduction to Industry 4.0 to Industry 5.0 Advances.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXTBOOKS:

1. Gilchrist, A, "Industry 4.0: the industrial internet of things", 1st Edition, Apress Publishers, New York, 2016.
2. Schwab, K, "The fourth industrial revolution", 1st Edition, Portfolio Penguin Publishers, United Kingdom, 2017.

REFERENCES:

1. Garbie, I, "Sustainability in manufacturing enterprises: Concepts, analyses and assessments for industry 4.0", 1st Edition, Springer International Publishing, Switzerland, 2016.
2. Sudip Misra , Chandana Roy and Anandarup Mukherjee, "Introduction to Industrial Internet of Things and Industry 4.0", 1st Edition, CRC Press, New Delhi, India, 2020.

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Learn Beyond

(Autonomous, NAAC "A")

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