ANNA UNIVERSITY, CHENNAI
NON-AUTONOMOUS AFFILIATED COLLEGES
REGULATIONS 2021
CHOICE BASED CREDIT SYSTEM

B. E. ROBOTICS AND AUTOMATION

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

I. The program aims to develop a proficient engineer in Robotics and Automation field to serve the various technological needs of Industry and Society.

II. To develop the engineers to practice the multidisciplinary engineering knowledge in particularly in mechanical, electrical, electronic, control, manufacturing and software for Robotics and Automation systems development.

III. The program shall create engineers continuously to uplift the knowledge, skill, attitude, self-learning, teamwork, value of ethics and able to protect environmental eco-systems.

PROGRAM OUTCOMES (POs)

PO	Graduate Attribute
1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

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

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

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

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

PROGRAM SPECIFIC OUTCOMES (PSOs)

(1) Multi-disciplinary Engineering in Robotics: Analyse the real world needs and design the robot and Automation solutions using the competency in multi domain engineering elements and integrated software tools.

(2) Enhancement and upgradation: Analyse conventional functions and process of various engineering elements and propose robots and automation solution for enhanced performance of conventional systems.

(3) Robotic system integration and automated Solution and connectivity: Recommend the sensing, interfacing, controlling, actuating, communicating technologies and analysing the data through various subsystems and build the robots.

PEO's – PO's & PSO's MAPPING:

PEO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
I.	3	2	3	2	3	1	1	1	3	1	1	1	2	3	2
II.	3	2	3	2	2	2	2	1	2	1	2	2	3	2	3
III.	3	3	2	2	1	2	3	3	3	2	3	1	2	2	3

ANNA UNIVERSITY, CHENNAI
NON-AUTONOMOUS COLLEGES AFFILIATED TO ANNA UNIVERSITY
B. E. ROBOTICS AND AUTOMATION
REGULATIONS 2021
CHOICE BASED CREDIT SYSTEM
CURRICULUM FOR SEMESTERS I TO VIII AND SYLLABI FOR SEMESTERS III AND IV

SEMESTER I

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	IP3151	Induction Programme	-	-	-	-	-	0
THEORY								
2.	HS3151	Professional English - I	HSMC	3	0	0	3	3
3.	MA3151	Matrices and Calculus	BSC	3	1	0	4	4
4.	PH3151	Engineering Physics	BSC	3	0	0	3	3
5.	CY3151	Engineering Chemistry	BSC	3	0	0	3	3
6.	GE3151	Problem Solving and Python Programming	ESC	3	0	0	3	3
7.	GE3152	அறிவியல் தமிழ் / Scientific Thoughts in Tamil	HSMC	1	0	0	1	1
PRACTICAL								
7	GE3171	Problem Solving and Python Programming Laboratory	ESC	0	0	4	4	2
8	BS3171	Physics and Chemistry Laboratory	BSC	0	0	4	4	2
9	GE3172	English Laboratory[$]	EEC	0	0	2	2	1
			TOTAL	**16**	**1**	**10**	**27**	**22**

$ Skill Based Course

SEMESTER II

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	HS3251	Professional English - II	HSMC	2	0	0	2	2
2.	MA3251	Statistics and Numerical Methods	BSC	3	1	0	4	4
3.	PH3259	Applied Materials Science	BSC	3	0	0	3	3
4.	BE3253	Basic Electrical, Electronics Engineering and Measurements	ESC	3	0	0	3	3
5.	GE3251	Engineering Graphics	ESC	2	0	4	6	4
6.	GE3252	தமிழர் மரபு /Heritage of Tamils	HSMC	1	0	0	1	1
7.		NCC Credit Course Level	-	2	0	0	2	2[#]
PRACTICAL								
8.	GE3271	Engineering Practices Laboratory	ESC	0	0	4	4	2
9.	BE3273	Basic Electrical, Electronics Engineering and Measurements Laboratory	ESC	0	0	4	4	2
10.	GE3272	Communication Laboratory / Foreign Language [$]	EEC	0	0	4	4	2
			TOTAL	**14**	**1**	**16**	**31**	**23**

[#] NCC Credit Course level 1 is 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.

[$] Skill Based Course

SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA3351	Transforms and Partial Differential Equations	BSC	3	1	0	4	4
2.	ME3351	Engineering Mechanics	ESC	3	0	0	3	3
3.	MR3351	Fluid Mechanics and Thermal Systems	ESC	4	0	0	4	4
4.	MR3391	Digital Electronics and Microprocessor	PCC	3	0	0	3	3
5.	MR3392	Electrical Drives and Actuators	PCC	3	0	0	3	3
6.	RA3301	Robot Kinematics	PCC	3	0	0	3	3
PRACTICALS								
7.	MR3361	Electrical Drives and Actuators Laboratory	PCC	0	0	4	4	2
8.	RA3311	Robot Modelling and Simulation Laboratory	PCC	0	0	4	4	2
9.	GE3361	Professional Development [$]	EEC	0	0	2	2	1
			TOTAL	**19**	**1**	**10**	**30**	**25**

[$] Skill Based Course

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	ME3493	Manufacturing Technology	PCC	3	0	0	3	3
2.	RA3401	Design of Robot Elements	PCC	3	0	0	3	3
3.	MR3491	Sensors and Instrumentation	PCC	3	0	0	3	3
4.	MR3452	Control Systems Engineering	PCC	3	0	2	5	4
5.	MR3591	Fluid Power Systems and Industrial Automation	PCC	3	0	0	3	3
6.	GE3451	Environmental Sciences and Sustainability	BSC	2	0	0	2	2
7.		NCC Credit Course Level 2[#]		3	0	0	3	3[#]
PRACTICALS								
8.	ME3382	Manufacturing Technology Laboratory	PCC	0	0	4	4	2
9.	MR3461	Sensors and Instrumentation Laboratory	PCC	0	0	4	4	2
			TOTAL	**17**	**0**	**10**	**27**	**22**

[#] NCC Credit Course level 2 is 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

SEMESTER V

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MR3492	Embedded Systems and Programming	PCC	2	0	2	4	3
2.	RA3501	Robot Path Planning and Programming	PCC	3	0	0	3	3
3.		Professional Elective I	PEC	-	-	-	-	3
4.		Professional Elective II	PEC	-	-	-	-	3
5.		Professional Elective III	PEC	-	-	-	-	3
6.		Professional Elective IV	PEC	-	-	-	-	3
7.		Mandatory Course-I[&]	MC	3	0	0	3	0
PRACTICALS								
8.	MR3561	Industrial Automation Laboratory	PCC	0	0	4	2	2
			TOTAL	-	-	-	-	**20**

[&] Mandatory Course-I is a Non-credit Course (Student shall select one course from the list given under MC- I)

SEMESTER VI

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	RA3601	Robot Dynamics and Control	PCC	3	0	0	3	3
2.		Open Elective – I*	OEC	3	0	0	3	3
3.		Professional Elective V	PEC	-	-	-	-	3
4.		Professional Elective VI	PEC	-	-	-	-	3
5.		Professional Elective VII	PEC	-	-	-	-	3
6.		Professional Elective VIII	PEC	-	-	-	-	3
7.		Mandatory Course-II[&]	MC	3	0	0	3	0
8.		NCC Credit Course Level 3[#]		3	0	0	3	3[#]
PRACTICALS								
9.	RA3611	Robot Kinematics and Dynamics Laboratory	PCC	0	0	4	4	2
9.	RA3612	Mini Project	EEC	0	0	2	2	1
			TOTAL	-	-	-	-	**21**

***Open Elective – I shall be chosen from the emerging technologies.**

[&] Mandatory Course-II is a Non-credit Course (Student shall select one course from the list given under MC- II)

[#] NCC Credit Course level 3 is 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

SEMESTER VII / VIII*

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	RA3701	Robotic Vision and Intelligence	PCC	3	0	0	3	3
2.	RA3702	Mobile Robotics	PCC	3	0	0	3	3
3.		Human Values and Ethics	HSMC	2	0	0	2	2
4.		Elective – Management #	HSMC	3	0	0	3	3
5.		Open Elective – II**	OEC	3	0	0	3	3
6.		Open Elective – III***	OEC	3	0	0	3	3
7.		Open Elective – IV***	OEC	3	0	0	3	3
PRACTICALS								
8.	RA3711	Robotic Vision and Intelligence Laboratory	PCC	0	0	2	2	2
			TOTAL	**20**	**0**	**2**	**22**	**22**

***If students undergo internship in Semester VII, then the courses offered during semester VII will be offered during semester VIII**

****Open Elective – II shall be chosen from the emerging technologies**

*****Open Elective III and IV (Shall be chosen from the list of open electives offered by other Programmes)**

#Elective – management shall be chosen from the Elective – Management Courses

SEMESTER VIII/VII*

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	RA3811	Project Work/ Internship	EEC	0	0	20	20	10
			TOTAL	**0**	**0**	**20**	**20**	**10**

***If students undergo internship in Semester VII, then the courses offered during semester VII will be offered during semester VIII**

TOTAL CREDITS: 165

ELECTIVE – MANAGEMENT COURSES

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PERWEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	GE3751	Principles of Management	HSMC	3	0	0	3	3
2.	GE3752	Total Quality Management	HSMC	3	0	0	3	3
3.	GE3753	Engineering Economics and Financial Accounting	HSMC	3	0	0	3	3
4.	GE3754	Human Resource Management	HSMC	3	0	0	3	3
5.	GE3755	Knowledge Management	HSMC	3	0	0	3	3
6.	GE3792	Industrial Management	HSMC	3	0	0	3	3

MANDATORY COURSES I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MX3081	Introduction to Women and Gender Studies	MC	3	0	0	3	0
2.	MX3082	Elements of Literature	MC	3	0	0	3	0
3.	MX3083	Film Appreciation	MC	3	0	0	3	0
4.	MX3084	Disaster Management	MC	3	0	0	3	0

MANDATORY COURSES II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MX3085	Well Being with Traditional Practices (Yoga, Ayurveda and Siddha)	MC	3	0	0	3	0
2.	MX3086	History of Science and Technology in India	MC	3	0	0	3	0
3.	MX3087	Political and Economic Thought for a Humane Society	MC	3	0	0	3	0
4.	MX3088	State, Nation Building and Politics in India	MC	3	0	0	3	0
5.	MX3089	Industrial Safety	MC	3	0	0	3	0

PROFESSIONAL ELECTIVE COURSES: VERTICALS

VERTICAL 1	VERTICAL 2	VERTICAL 3	VERTICAL 4	VERTICAL 5	VERTICAL 6	VERTICAL 7
APPLIED ROBOTICS	**DESIGN AND MANUFACTURING**	**SMART MOBILITY SYSTEMS**	**INTELLIGENCE SYSTEMS**	**INTELLIGENCE SYSTEMS**	**AVIONICS AND DRONE TECHNOLOGY**	**DIVERSIFIED COURSES GROUP 1**
Robots and Systems in Smart Manufacturing	Robot and Machine Elements Design	Automobile Engineering	Applied Signal Processing	Object Oriented Programming in C++	Avionics	Linear Integrated Circuits
Drone Technologies	Design for X	Electric and Hybrid Vehicles	Applied Image Processing	Power Electronics	Control Engineering	Single Board Computers
Mircrorobotics	CNC Machine Tools and Programming	Automotive Mechatronics	Machine Learning for Intelligent Systems	Computer Architecture and Organisation	Guidance and Control	Reliability and Maintenance Engineering
Agricultural Robotics and Automation	Computer Integrated Manufacturing	Automotive System Modelling and Simulation	Condition Monitoring and Fault Diagnostics	Virtual Instrumentation	Navigation and Communication System	Integrated Product Development
Collaborative Robotics	Advanced Manufacturing Systems	Vehicle Dynamics and Controls	Systems Modelling and Simulation Methods	Industrial Network Protocols	Design of UAV systems	Medical Mechatronics
Robot Operating Systems	Additive Manufacturing	Aircraft Mechatronics	Optimization Techniques	Motion Control System	Aerodynamics of Drones	Micro Electro Mechanical Systems
Medical Robotics	Electronics Manufacturing Technology	Smart mobility and Intelligent Vehicles	Immersive Technologies and Haptic	Total integrated Automation	-	Process Planning and Cost Estimation
Humanoid Robotics	Computer Aided Inspection and Testing	Advanced Driver Assistance Systems	Computer Vision and Deep Learning	Digital Twin and Industry 5.0	-	VLSI and FPGA

Registration of Professional Elective Courses from Verticals:

Professional Elective Courses will be registered in Semesters V and VI. These courses are listed in groups called verticals that represent a particular area of specialisation / diversified group. Students are permitted to choose all the Professional Electives from a particular vertical or from different verticals. Further, only one Professional Elective course shall be chosen in a semester horizontally (row-wise). However, two courses are permitted from the same row, provided one course is enrolled in Semester V and another in semester VI.

The registration of courses for B.E./B.Tech (Honours) or Minor degree shall be done from Semester V to VIII. The procedure for registration of courses explained above shall be followed for the courses of B.E/B.Tech (Honours) or Minor degree also. For more details on B.E./B.Tech (Honours) or Minor degree refer to the Regulations 2021, Clause 4.10.

PROFESSIONAL ELECTIVE COURSES : VERTICALS

VERTICAL 1: APPLIED ROBOTICS

SL. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CRA331	Robots and Systems in Smart Manufacturing	PEC	3	0	0	3	3
2.	CRA332	Drone Technologies	PEC	3	0	0	3	3
3.	CRA333	Micro robotics	PEC	3	0	0	3	3
4.	CRA334	Agricultural Robotics and Automation	PEC	3	0	0	3	3
5.	CRA335	Collaborative Robotics	PEC	3	0	0	3	3
6.	CRA336	Robot Operating Systems	PEC	1	0	4	5	3
7.	CRA337	Medical Robotics	PEC	3	0	0	3	3
8.	CRA338	Humanoid Robotics	PEC	3	0	0	3	3

VERTICAL 2: DESIGN AND MANUFACTURING

SL. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CRA339	Robot and Machine Elements Design	PEC	3	0	0	3	3
2.	CME341	Design for X	PEC	3	0	0	3	3
3.	CMR331	CNC Machine Tools and Programming	PEC	3	0	0	3	3
4.	ME3792	Computer Integrated Manufacturing	PEC	3	0	0	3	3
5.	CMR332	Advanced Manufacturing Systems	PEC	3	0	0	3	3
6.	CME339	Additive Manufacturing	PEC	2	0	2	4	3
7.	CMR350	Electronics Manufacturing Technology	PEC	3	0	0	3	3
8.	CMR333	Computer Aided Inspection and Testing	PEC	3	0	0	3	3

VERTICAL 3: SMART MOBILITY SYSTEMS

SL. NO.	COURSE CODE	COURSE TITLE	CATEG ORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CME380	Automobile Engineering	PEC	3	0	0	3	3
2.	AU3791	Electric and Hybrid Vehicles	PEC	3	0	0	3	3
3.	CMR334	Automotive Mechatronics	PEC	3	0	0	3	3
4.	CMR335	Automotive System Modelling and Simulation	PEC	3	0	0	3	3
5.	CMR336	Vehicle Dynamics and Controls	PEC	3	0	0	3	3
6.	CMR337	Aircraft Mechatronics	PEC	3	0	0	3	3
7.	CMR338	Smart Mobility and Intelligent Vehicles	PEC	3	0	0	3	3
8.	CMR339	Advanced Driver Assistance Systems	PEC	3	0	0	3	3

VERTICAL 4: INTELLIGENCE SYSTEMS

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CRA340	Applied Signal Processing	PEC	3	0	0	3	3
2.	CRA341	Applied Image Processing	PEC	3	0	0	3	3
3.	CRA342	Machine Learning for Intelligent Systems	PEC	3	0	0	3	3
4.	CMR340	Condition Monitoring and Fault Diagnostics	PEC	3	0	0	3	3
5.	CMR341	Systems Modelling and Simulation Methods	PEC	3	0	0	3	3
6.	CMR342	Optimization Techniques	PEC	3	0	0	3	3
7.	CMR343	Immersive Technologies and Haptic	PEC	3	0	0	3	3
8.	CMR344	Computer Vision and Deep Learning	PEC	3	0	0	3	3

VERTICAL 5: AUTOMATION

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CMR345	Object Oriented Programming in C++	PEC	3	0	0	3	3
2.	EE3591	Power Electronics	PEC	3	0	0	3	3
3.	CCS376	Computer Architecture and Organisation	PEC	3	0	0	3	3
4.	CBM372	Virtual Instrumentation	PEC	3	0	0	3	3
5.	CMR346	Industrial Network Protocols	PEC	3	0	0	3	3
6.	CMR347	Motion Control System	PEC	3	0	0	3	3
7.	CMR348	Total integrated Automation	PEC	3	0	0	3	3
8.	CMR349	Digital Twin and Industry 5.0	PEC	3	0	0	3	3

VERTICAL 6: AVIONICS AND DRONE TECHNOLOGY

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CAE337	Avionics	PEC	3	0	0	3	3
2.	CAE338	Control Engineering	PEC	3	0	0	3	3
3.	CAE339	Guidance and Control	PEC	3	0	0	3	3
4.	CAE340	Navigation and Communication System	PEC	3	0	0	3	3
5.	CAE341	Design of UAV systems	PEC	3	0	0	3	3
6.	CAE342	Aerodynamics of Drones	PEC	3	0	0	3	3

VERTICAL 7: DIVERSIFIED COURSES GROUP 1

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CMR381	Linear Integrated Circuits	PEC	3	0	0	3	3
2.	CMR382	Single Board Computers	PEC	3	0	0	3	3
3.	CMR383	Reliability and Maintenance Engineering	PEC	3	0	0	3	3
4.	CMR387	Integrated Product Development	PEC	3	0	0	3	3
5.	CMR384	Medical Mechatronics	PEC	3	0	0	3	3
6.	CMR385	Micro Electro Mechanical Systems	PEC	3	0	0	3	3
7.	CME396	Process Planning and Cost Estimation	PEC	3	0	0	3	3
8.	CMR386	VLSI and FPGA	PEC	3	0	0	3	3

OPEN ELECTIVES

(Students shall choose the open elective courses, such that the course contents are not similar to any other course contents/title under other course categories).

OPEN ELECTIVE I AND II

(EMERGING TECHNOLOGIES)

To be offered other than Faculty of Information and Communication Engineering

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	OCS351	Artificial Intelligence and Machine Learning Fundamentals	OEC	2	0	2	4	3
2.	OCS352	IoT Concepts and Applications	OEC	2	0	2	4	3
3.	OCS353	Data Science Fundamentals	OEC	2	0	2	4	3
4.	OCS354	Augmented and Virtual Reality	OEC	2	0	2	4	3

OPEN ELECTIVES – III

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	OHS351	English for Competitive Examinations	OEC	3	0	0	3	3
2.	OCE353	Lean Concepts, Tools And Practices	OEC	3	0	0	3	3
3.	OMG352	NGOs and Sustainable Development	OEC	3	0	0	3	3
4.	OMG353	Democracy and Good Governance	OEC	3	0	0	3	3
5.	OME353	Renewable Energy Technologies	OEC	3	0	0	3	3
6.	OME354	Applied Design Thinking	OEC	2	0	2	4	3
7.	OMF351	Reverse Engineering	OEC	3	0	0	3	3
8.	OMF353	Sustainable Manufacturing	OEC	3	0	0	3	3
9.	OAS352	Space Engineering	OEC	3	0	0	3	3
10.	OIM351	Industrial Management	OEC	3	0	0	3	3
11.	OIE354	Quality Engineering	OEC	3	0	0	3	3
12.	OSF351	Fire Safety Engineering	OEC	3	0	0	3	3
13.	OML351	Introduction to Non-destructive testing	OEC	3	0	0	3	3
14.	OAE352	Fundamentals of Aeronautical engineering	OEC	3	0	0	3	3
15.	OGI351	Remote Sensing Concepts	OEC	3	0	0	3	3
16.	OAI351	Urban Agriculture	OEC	3	0	0	3	3
17.	OEN351	Drinking Water Supply and Treatment	OEC	3	0	0	3	3
18.	OEE352	Electric Vehicle technology	OEC	3	0	0	3	3
19.	OEI353	Introduction to PLC Programming	OEC	3	0	0	3	3
20.	OCH351	Nano Technology	OEC	3	0	0	3	3
21.	OCH352	Functional Materials	OEC	3	0	0	3	3
22.	OBT352	Biomedical Instrumentation	OEC	3	0	0	3	3
23.	OFD352	Traditional Indian Foods	OEC	3	0	0	3	3
24.	OFD353	Introduction to food processing	OEC	3	0	0	3	3
25.	OPY352	IPR for Pharma Industry	OEC	3	0	0	3	3
26.	OTT351	Basics of Textile Finishing	OEC	3	0	0	3	3
27.	OTT352	Industrial Engineering for Garment Industry	OEC	3	0	0	3	3

28.	OTT353	Basics of Textile Manufacture	OEC	3	0	0	3	3
29.	OPE351	Introduction to Petroleum Refining and Petrochemicals	OEC	3	0	0	3	3
30.	OPE352	Energy Conservation and Management	OEC	3	0	0	3	3
31.	OPT351	Basics of Plastics Processing	OEC	3	0	0	3	3
32.	OEC351	Signals and Systems	OEC	3	0	0	3	3
33.	OEC352	Fundamentals of Electronic Devices and Circuits	OEC	3	0	0	3	3
34.	OBM351	Foundation Skills in integrated product Development	OEC	3	0	0	3	3
35.	OBM352	Assistive Technology	OEC	3	0	0	3	3
36.	OMA352	Operations Research	OEC	3	0	0	3	3
37.	OMA353	Algebra and Number Theory	OEC	3	0	0	3	3
38.	OMA354	Linear Algebra	OEC	3	0	0	3	3

OPEN ELECTIVES – IV

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	OHS352	Project Report Writing	OEC	3	0	0	3	3
2.	OCE354	Basics of Integrated Water Resources Management	OEC	3	0	0	3	3
3.	OMA355	Advanced Numerical Methods	OEC	3	0	0	3	3
4.	OMA356	Random Processes	OEC	3	0	0	3	3
5.	OMA357	Queuing and Reliability Modelling	OEC	3	0	0	3	3
6.	OMG354	Production and Operations Management for Entrepreneurs	OEC	3	0	0	3	3
7.	OMG355	Multivariate Data Analysis	OEC	3	0	0	3	3
8.	OME352	Additive Manufacturing	OEC	3	0	0	3	3
9.	OME353	New Product Development	OEC	3	0	0	3	3
10.	OME355	Industrial Design & Rapid Prototyping Techniques	OEC	2	0	2	4	3
11.	OMF352	Micro and Precision Engineering	OEC	3	0	0	3	3
12.	OMF354	Cost Management of Engineering Projects	OEC	3	0	0	3	3

13.	OAS353	Space Vehicles	OEC	3	0	0	3	3
14.	OIM352	Management Science	OEC	3	0	0	3	3
15.	OIM353	Production Planning and Control	OEC	3	0	0	3	3
16.	OIE353	Operations Management	OEC	3	0	0	3	3
17.	OSF352	Industrial Hygiene	OEC	3	0	0	3	3
18.	OSF353	Chemical Process Safety	OEC	3	0	0	3	3
19.	OML352	Electrical, Electronic and Magnetic materials	OEC	3	0	0	3	3
20.	OML353	Nanomaterials and applications	OEC	3	0	0	3	3
21.	OMV351	Marine Propulsion	OEC	3	0	0	3	3
22.	OMV352	Marine Merchant Vehicles	OEC	3	0	0	3	3
23.	OMV353	Elements of Marine Engineering	OEC	3	0	0	3	3
24.	OAE353	Drone Technologies	OEC	3	0	0	3	3
25.	OGI352	Geographical Information System	OEC	3	0	0	3	3
26.	OAI352	Agriculture Entrepreneurship Development	OEC	3	0	0	3	3
27.	OEN352	Biodiversity Conservation	OEC	3	0	0	3	3
28.	OEE353	Introduction to control systems	OEC	3	0	0	3	3
29.	OEI354	Introduction to Industrial Automation Systems	OEC	3	0	0	3	3
30.	OCH353	Energy Technology	OEC	3	0	0	3	3
31.	OCH354	Surface Science	OEC	3	0	0	3	3
32.	OBT353	Environment and Agriculture	OEC	3	0	0	3	3
33.	OFD354	Fundamentals of Food Engineering	OEC	3	0	0	3	3
34.	OFD355	Food safety and Quality Regulations	OEC	3	0	0	3	3
35.	OPY353	Nutraceuticals	OEC	3	0	0	3	3
36.	OTT354	Basics of Dyeing and Printing	OEC	3	0	0	3	3
37.	OTT355	Fibre Science	OEC	3	0	0	3	3
38.	OTT356	Garment Manufacturing Technology	OEC	3	0	0	3	3
39.	OPE353	Industrial safety	OEC	3	0	0	3	3
40.	OPE354	Unit Operations in Petro Chemical Industries	OEC	3	0	0	3	3
41.	OPT352	Plastic Materials for Engineers	OEC	3	0	0	3	3

42.	OPT353	Properties and Testing of Plastics	OEC	3	0	0	3	3
43.	OEC353	VLSI Design	OEC	3	0	0	3	3
44.	OEC354	Industrial IoT and Industry 4.0	OEC	2	0	2	4	3
45.	OBM353	Wearable devices	OEC	3	0	0	3	3
46.	OBM354	Medical Informatics	OEC	3	0	0	3	3

SUMMARY

B.E. ROBOTICS AND AUTOMATION										
S. No	**Subject Area**	**Credits per Semester**								
		I	**II**	**III**	**IV**	**V**	**VI**	**VII/VIII**	**VIII/VII**	
1	**HSMC**	**4**	**3**					**5**		**12**
2	**BSC**	**12**	**7**	**4**	**2**					**25**
3	**ESC**	**5**	**11**	**7**	**-**					**23**
4	**PCC**			**13**	**20**	**8**	**5**	**8**		**54**
5	**PEC**					**12**	**12**			**24**
6	**OEC**						**3**	**9**		**12**
7	**EEC**	**1**	**2**	**1**			**1**		**10**	**15**
8	**Non-Credit /(Mandatory)**					√	√			
Total		**22**	**23**	**25**	**22**	**20**	**21**	**22**	**10**	**165**

ENROLLMENT FOR B.E. / B. TECH. (HONOURS) / MINOR DEGREE (OPTIONAL)

A student can also optionally register for additional courses (18 credits) and become eligible for the award of B.E. / B. Tech. (Honours) or Minor Degree.

For B.E. / B. Tech. (Honours), a student shall register for the additional courses (18 credits) from semester V onwards. These courses shall be from the same vertical or a combination of different verticals of the same programme of study only.

For minor degree, a student shall register for the additional courses (18 credits) from semester V onwards. All these courses have to be in a particular vertical from any one of the other programmes, Moreover, for minor degree the student can register for courses from any one of the following verticals also.

Complete details are available in clause 4.10 of Regulations 2021.

VERTICALS FOR MINOR DEGREE
(In addition to all the verticals of other programmes)

Vertical I	Vertical II	Vertical III	Vertical IV	Vertical V
Fintech and Block Chain	**Entrepreneurship**	**Public Administration**	**Business Data Analytics**	**Environment and Sustainability**
Financial Management	Foundations of Entrepreneruship	Principles of Public Administration	Statistics for Management	Sustainable infrastructure Development
Fundamentals of Investment	Team Building and Leadership Management for Business	Constitution of India	Datamining for Business Intelligence	Sustainable Agriculture and Environmental Management
Banking, Financial Services and Insurance	Creativity and Innovation in Entrepreneurship	Public Personnel Administration	Human Resource Analytics	Sustainable Bio Materials
Introduction to Blockchain and its Applications	Principles of Marketing Management for Business	Administrative Theories	Marketing and Social Media Web Analytics	Materials for Energy Sustainability
Fintech Personal Finance and Payments	Human Resource Management for Entrepreneurs	Indian Administrative System	Operation and Supply Chain Analytics	Green Technology
Introduction to Fintech	Financing New Business Ventures	Public Policy Administration	Financial Analytics	Environmental Quality Monitoring and Analysis
-	-	-	-	Integrated Energy Planning for Sustainable Development
-	-	-	-	Energy Efficiency for Sustainable Development

(Choice of courses for Minor degree is to be made from any one vertical of other programmes or from anyone of the following verticals)

VERTICAL 1: FINTECH AND BLOCK CHAIN

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CMG331	Financial Management	PEC	3	0	0	3	3
2.	CMG332	Fundamentals of Investment	PEC	3	0	0	3	3
3.	CMG333	Banking, Financial Services and Insurance	PEC	3	0	0	3	3
4.	CMG334	Introduction to Blockchain and its Applications	PEC	3	0	0	3	3
5.	CMG335	Fintech Personal Finance and Payments	PEC	3	0	0	3	3
6.	CMG336	Introduction to Fintech	PEC	3	0	0	3	3

VERTICAL 2: ENTREPRENERUSHIP

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CMG337	Foundations of Entrepreneruship	PEC	3	0	0	3	3
2.	CMG338	Team Building and Leadership Management for Business	PEC	3	0	0	3	3
3.	CMG339	Creativity and Innovation in Entrepreneurship	PEC	3	0	0	3	3
4.	CMG340	Principles of Marketing Management for Business	PEC	3	0	0	3	3
5.	CMG341	Human Resource Management for Entrepreneurs	PEC	3	0	0	3	3
6.	CMG342	Financing New Business Ventures	PEC	3	0	0	3	3

VERTICAL 3: PUBLIC ADMINISTRATION

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CMG343	Principles of Public Administration	PEC	3	0	0	3	3
2.	CMG344	Constitution of India	PEC	3	0	0	3	3
3.	CMG345	Public Personnel Administration	PEC	3	0	0	3	3
4.	CMG346	Administrative Theories	PEC	3	0	0	3	3
5.	CMG347	Indian Administrative System	PEC	3	0	0	3	3
6.	CMG348	Public Policy Administration	PEC	3	0	0	3	3

VERTICAL 4: BUSINESS DATA ANALYTICS

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CMG349	Statistics for Management	PEC	3	0	0	3	3
2.	CMG350	Datamining for Business Intelligence	PEC	3	0	0	3	3
3.	CMG351	Human Resource Analytics	PEC	3	0	0	3	3
4.	CMG352	Marketing and Social Media Web Analytics	PEC	3	0	0	3	3
5.	CMG353	Operation and Supply Chain Analytics	PEC	3	0	0	3	3
6.	CMG354	Financial Analytics	PEC	3	0	0	3	3

VERTICAL 5: ENVIRONMENT AND SUSTAINABILITY

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CES331	Sustainable infrastructure Development	PEC	3	0	0	3	3
2.	CES332	Sustainable Agriculture and Environmental Management	PEC	3	0	0	3	3
3.	CES333	Sustainable Bio Materials	PEC	3	0	0	3	3
4.	CES334	Materials for Energy Sustainability	PEC	3	0	0	3	3
5.	CES335	Green Technology	PEC	3	0	0	3	3
6.	CES336	Environmental Quality Monitoring and Analysis	PEC	3	0	0	3	3
7.	CES337	Integrated Energy Planning for Sustainable Development	PEC	3	0	0	3	3
8.	CES338	Energy Efficiency for Sustainable Development	PEC	3	0	0	3	3

MA3351 TRANSFORMS AND PARTIAL DIFFERENTIAL EQUATIONS L T P C
3 1 0 4

OBJECTIVES:

- To introduce the basic concepts of PDE for solving standard partial differential equations.
- To introduce Fourier series analysis which is central to many applications in engineering apart from its use in solving boundary value problems.
- To acquaint the student with Fourier series techniques in solving heat flow problems used in various situations.
- To acquaint the student with Fourier transform techniques used in wide variety of situations.
- To introduce the effective mathematical tools for the solutions of partial differential equations that model several physical processes and to develop Z transform techniques for discrete time systems.

UNIT I PARTIAL DIFFERENTIAL EQUATIONS 9+3

Formation of partial differential equations –Solutions of standard types of first order partial differential equations - First order partial differential equations reducible to standard types- Lagrange's linear equation - Linear partial differential equations of second and higher order with constant coefficients of both homogeneous and non-homogeneous types.

UNIT II FOURIER SERIES 9+3

Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series and cosine series – Root mean square value – Parseval's identity – Harmonic analysis.

UNIT III APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS 9+3

Classification of PDE – Method of separation of variables - Fourier series solutions of one dimensional wave equation – One dimensional equation of heat conduction – Steady state solution of two dimensional equation of heat conduction (Cartesian coordinates only).

UNIT IV FOURIER TRANSFORMS 9+3

Statement of Fourier integral theorem– Fourier transform pair – Fourier sine and cosine transforms – Properties – Transforms of simple functions – Convolution theorem – Parseval's identity.

UNIT V Z - TRANSFORMS AND DIFFERENCE EQUATIONS 9+3

Z-transforms - Elementary properties – Convergence of Z-transforms - – Initial and final value theorems - Inverse Z-transform using partial fraction and convolution theorem - Formation of difference equations – Solution of difference equations using Z - transforms.

TOTAL: 60 PERIODS

OUTCOMES:

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

- Understand how to solve the given standard partial differential equations.
- Solve differential equations using Fourier series analysis which plays a vital role in engineering applications.
- Appreciate the physical significance of Fourier series techniques in solving one and two dimensional heat flow problems and one dimensional wave equations.
- Understand the mathematical principles on transforms and partial differential equations would provide them the ability to formulate and solve some of the physical problems of engineering.
- Use the effective mathematical tools for the solutions of partial differential equations by using Z transform techniques for discrete time systems.

TEXT BOOKS:

1. Grewal B.S., "Higher Engineering Mathematics", 44th Edition, Khanna Publishers, New Delhi, 2018.
2. Kreyszig E, "Advanced Engineering Mathematics ", 10th Edition, John Wiley, New Delhi, India, 2016.

REFERENCES:

1. Andrews. L.C and Shivamoggi. B, "Integral Transforms for Engineers" SPIE Press, 1999.
2. Bali. N.P and Manish Goyal, "A Textbook of Engineering Mathematics", 10th Edition, Laxmi Publications Pvt. Ltd, 2015.
3. James. G., "Advanced Modern Engineering Mathematics", 4th Edition, Pearson Education, New Delhi, 2016.
4. Narayanan. S., Manicavachagom Pillay.T.K and Ramanaiah.G "Advanced Mathematics for Engineering Students", Vol. II & III, S.Viswanathan Publishers Pvt. Ltd, Chennai, 1998.
5. Ramana. B.V., "Higher Engineering Mathematics", McGraw Hill Education Pvt. Ltd, New Delhi, 2018.
6. Wylie. R.C. and Barrett . L.C., "Advanced Engineering Mathematics "Tata McGraw Hill Education Pvt. Ltd, 6th Edition, New Delhi, 2012.

ME3351	ENGINEERING MECHANICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1 To Learn the use scalar and vector analytical techniques for analysing forces in statically determinate structures

2 To introduce the equilibrium of rigid bodies, vector methods and free body diagram

3 To study and understand the distributed forces, surface, loading on beam and intensity.

4 To learn the principles of friction, forces and to determine the apply the concepts of frictional forces at the contact surfaces of various engineering systems.

5 To develop basic dynamics concepts – force, momentum, work and energy;

UNIT I STATICS OF PARTICLES 9

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

UNIT II EQUILIBRIUM OF RIGID BODIES 9

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

UNIT III DISTRIBUTED FORCES 9

Centroids of lines and areas – symmetrical and unsymmetrical shapes, Determination of Centroids by Integration, Theorems of Pappus-Guldinus, Distributed Loads on Beams, Centre of Gravity of a Three-

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

UNIT IV FRICTION 9

The Laws of Dry Friction, Coefficients of Friction, Angles of Friction, Wedge friction, Wheel Friction, Rolling Resistance, Ladder friction.

UNIT V DYNAMICS OF PARTICLES 9

Kinematics - Rectilinear Motion and Curvilinear Motion of Particles. Kinetics- Newton's Second Law of Motion -Equations of Motions, Dynamic Equilibrium, Energy and Momentum Methods - Work of a Force, Kinetic Energy of a Particle, Principle of Work and Energy, Principle of Impulse and Momentum, Impact of bodies.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course the students would be able to

1. Illustrate the vector and scalar representation of forces and moments
2. Analyse the rigid body in equilibrium
3. Evaluate the properties of distributed forces
4. Determine the friction and the effects by the laws of friction
5. Calculate dynamic forces exerted in rigid body

TEXTBOOKS:

1. Beer Ferdinand P, Russel Johnston Jr., David F Mazurek, Philip J Cornwell, Sanjeev Sanghi, Vector Mechanics for Engineers: Statics and Dynamics, McGraw Higher Education., 12thEdition, 2019.
2. Vela Murali, "Engineering Mechanics-Statics and Dynamics", Oxford University Press, 2018.

REFERENCES:

1. Boresi P and Schmidt J, Engineering Mechanics: Statics and Dynamics, 1/e, Cengage learning, 2008.
2. Hibbeller, R.C., Engineering Mechanics: Statics, and Engineering Mechanics: Dynamics, 13th edition, Prentice Hall, 2013.
3. Irving H. Shames, Krishna Mohana Rao G, Engineering Mechanics – Statics and Dynamics, 4thEdition, Pearson Education Asia Pvt. Ltd., 2005.
4. Meriam J L and Kraige L G, Engineering Mechanics: Statics and Engineering Mechanics: Dynamics, 7th edition, Wiley student edition, 2013.
5. Timoshenko S, Young D H, Rao J V and SukumarPati, Engineering Mechanics, 5thEdition, McGraw Hill Higher Education, 2013.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	2	1	2							2	3	1	1
2	3	2	2	1	2							2	3	1	1
3	3	2	3	1	2							2	3	1	2
4	3	2	3	1	2							2	3	1	2
5	3	2	3	1	2							2	3	1	2
Low (1); Medium (2); High (3)															

MR3351 FLUID MECHANICS AND THERMAL SYSTEMS L T P C
4 0 0 4

COURSE OBJECTIVES:

1. To knowledge in Fluid Properties and Statics
2. To understand the concept of fluid kinematics and Dynamics.
3. To learn about the flows in fluid, Viscous flows and flow through pipes
4. To understand the basics laws of thermodynamics
5. To understand the second law of thermodynamics and entropy

UNIT I FLUID PROPERTIES AND FLUID STATICS 12

Fluid Definition and Classification – Properties of fluids: Density, Specific Weight, Specific Volume, Specific Gravity, Viscosity, Compressibility, Bulk Modulus, Capillary and Surface Tension – Fluid statics: Concept of fluid static pressure – Pascal's law –Absolute and Gauge pressures – Manometers: Types and Pressure measurement – Concept of Buoyancy and Floatation.

UNIT II FLUID KINEMATICS AND FLUID DYNAMICS 12

Fluid Kinematics: Types of fluid flow – Continuity equation in two and three dimensions – Velocity and Acceleration of fluid particle – Velocity potential function and Stream function. Fluid dynamics: Euler's equation along a streamline –Bernoulli's equation and applications – Venturi meter, Orifice meter and Pitot tube.

UNIT III VISCOUS FLOW, FLOW THROUGH PIPES AND DIMENSIONAL ANALYSIS 12

Viscous flow: Shear stress, pressure gradient relationship – Flow of viscous fluid through circular pipe – Flow through pipes: Loss of head due to friction – Minor head losses – Hydraulic gradient and Total energy lines – Flow through pipes in series and in parallel – Power transmission through pipes. Dimensional analysis: Buckingham's theorem.

UNIT IV BASICS OF THERMODYNAMICS AND FIRST LAW OF THERMODYNAMICS 12

Thermodynamics – Microscopic and macroscopic point of view – Systems, properties, process, path, cycle. Thermodynamic equilibrium – Zeroth law of Thermodynamics – internal energy, enthalpy, specific heat capacities CV and CP, Relationship between CV and CP. First law of Thermodynamics – Application to closed and open systems – Steady Flow Energy Equation (SFEE) – Simple problems.

UNIT V SECOND LAW OF THERMODYNAMICS AND ENTROPY 12

Second Law of thermodynamics – Kelvin Planck and Clausius Statements – Equivalents of Kelvin Planck and Clausius statements. Reversibility – Irreversibility, reversible cycle – Heat engine, heat pump and refrigerator. Carnot cycle and Clausius theorem, the property of entropy, the inequality of Clausius – Entropy principle – General expression for entropy – Simple problems in entropy.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1: Recognize the fluid properties, fluid statics and laws of thermodynamics

CO2: Interpret the problems related to kinematics and dynamics of fluids and thermal systems

CO3: Review the energy losses in flow through pipes and steady flow equation in thermal systems.
CO4: Analyse the fluid flow and thermal process
CO5: Solve the problems related to fluid and thermal systems.

Mapping of COs with POs and PSOs															
COs/POs&PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	2		1						1	1	2	2	1
CO2	3	3	2		1						1	1	2	2	1
CO3	2	2	3	2	2	3					1	1	3	3	1
CO4	2	2	3	2	1	2					1	1	3	3	1
CO5	3	3	2	2	2	2					1	1	2	2	1
CO/PO & PSO Average	2.6	2.6	2.4	2	1.4	2.3					1	1	2.4	2.4	1
1 – Slight, 2 – Moderate, 3 – Substantial															

TEXT BOOK:

1. Bansal R.K., ―Fluid Mechanics and Hydraulic Machines‖, 9th Edition, Laxmi Publications, New Delhi, 2015.

REFERENCES:

1. Nag P.K., ―Engineering Thermodynamics‖, 5th Edition, Tata McGraw Hill Publishing Company, New Delhi, 2013.
2. Cengel Yunus A. and Boles Michael A., ―Thermodynamics: An Engineering Approach‖, 7th Edition, McGraw-Hill, New York, 2011.
3. Frank M. White., ―Fluid Mechanics‖, 7th Edition, Tata McGraw Hill Publishing Company, New Delhi, 2009.

MR3391 DIGITAL ELECTRONICS AND MICROPROCESSOR L T P C
3 0 0 3

COURSE OBJECTIVES:

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

UNIT I DIGITAL FUNDAMENTALS 9

Number Systems – Decimal, Binary, Octal, Hexadecimal, 1‘s and 2‘s complements, Codes – Binary, BCD, Excess 3, Gray, Alphanumeric codes, Boolean theorems, Logic gates, Universal gates, Sum of products and product of sums, Minterms and Maxterms, Karnaugh map Minimization and Quine-McCluskey method of minimization.

UNIT II COMBINATIONAL & SYNCHRONOUS SEQUENTIAL CIRCUITS 9

Design of Half and Full Adders, Half and Full Subtractors, Binary Parallel Adder -Multiplexer, Demultiplexer, Decoder, Priority Encoder. Flip flops – SR, JK, T, D, design of clocked sequential circuits – Design of Counters- Shift registers, Universal Shift Register

UNIT III ASYNCHRONOUS SEQUENTIAL CIRCUITS AND MEMORY DEVICES 9

Stable and Unstable states, output specifications, cycles and races, state reduction, race free assignments, Hazards, Essential Hazards, Pulse mode sequential circuits, Design of Hazard free circuits. Basic memory structure – ROM -PROM – EPROM – EEPROM –EAPROM, RAM – Static and dynamic RAM - Programmable Logic Devices – Programmable Logic Array (PLA) - Programmable Array Logic (PAL) – Field Programmable Gate Arrays (FPGA).

UNIT IV 8085 PROCESSOR 9

Hardware Architecture, pin diagram – Functional Building Blocks of Processor – Memory organization – I/O ports and data transfer concepts– Timing Diagram – Interrupts.

UNIT V PROGRAMMING PROCESSOR 9

Instruction - format and addressing modes – Assembly language format – Data transfer, data manipulation& control instructions – Programming: Loop structure with counting & Indexing – Look up table - Subroutine instructions – stack -8255 architecture and operating modes

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1: State the fundamental operating concepts behind digital logic circuits and microprocessors.

CO 2: Recognize the use of various digital logic circuits and sub units in microprocessors.

CO 3: Interpret the information flow in digital logic circuits and the architectures of microprocessors.

CO 4: Design the DLC and Microprocessor for the standard applications.

CO 5: Create the circuits using DLC and Microprocessor for given applications

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

TEXT BOOKS:

1. M. Morris Mano and Michael D. Ciletti, “Digital Design”, 5th Edition, Pearson, 2014.
2. Krishna Kant, “Microprocessor and Microcontrollers”, Eastern Company Edition, Prentice Hall of India, New Delhi, 2007.

REFERENCES:

1. Charles H.Roth. “Fundamentals of Logic Design”, 6th Edition, Thomson Learning, 2013.
2. Thomas L. Floyd, “Digital Fundamentals”, 10th Edition, Pearson Education Inc, 2011
3. Muhammad Ali Mazidi & Janice Gilli Mazidi, R.D.Kinely ‘The 8051 Micro Controller and Embedded Systems’, PHI Pearson Education, 5th Indian reprint, 2003.
4. R.S. Gaonkar, ‘Microprocessor Architecture Programming and Application’, with 8085, Wiley Eastern Ltd., New Delhi, 2013

MR3392 ELECTRICAL DRIVES AND ACTUATORS L T P C
3 0 0 3

COURSE OBJECTIVES:

1. To familiarize a relay and power semiconductor devices
2. To get a knowledge on drive characteristics
3. To obtain the knowledge on DC motors and drives.
4. To obtain the knowledge on AC motors and drives.
5. To obtain the knowledge on Stepper and Servo motor.

UNIT I RELAY AND POWER SEMI-CONDUCTOR DEVICES 9

Study of Switching Devices – Relay and Types, Switching characteristics -BJT, SCR, TRIAC, GTO, MOSFET, IGBT and IGCT-: SCR, MOSFET and IGBT - Triggering and commutation circuit - Introduction to Driver and snubber circuits

UNIT II DRIVE CHARACTERISTICS 9

Electric drive – Equations governing motor load dynamics – steady state stability – multi quadrant Dynamics: acceleration, deceleration, torque, and Direction starting & stopping – Selection of motor.

UNIT III DC MOTORS AND DRIVES 9

DC Servomotor - Types of PMDC & BLDC motors - principle of operation- emf and torque equations - characteristics and control – Drives- H bridge - Single and Three Phases – 4 quadrant operation – Applications

UNIT IV AC MOTORS AND DRIVES 9

Introduction – Induction motor drives – Speed control of 3-phase induction motor – Stator voltage control – Stator frequency control – Stator voltage and frequency control – Stator current control – Static rotor resistance control – Slip power recovery control.

UNIT V STEPPER AND SERVO MOTOR 9

Stepper Motor: Classifications- Construction and Principle of Operation – Modes of Excitation-Drive System-Logic Sequencer - Applications. Servo Mechanism – DC Servo motor-AC Servo motor – Applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

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

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

TEXT BOOKS:

1. Bimbhra B.S., "Power Electronics", 5th Edition, Kanna Publishers, New Delhi, 2012.
2. Mehta V.K. & Rohit Mehta, "Principles of Electrical Machines", 2nd Edition, S.Chand& Co. Ltd., New Delhi, 2016.

REFERENCES:

1. Gobal K. Dubey, "Fundamentals of Electrical Drives", 2nd Edition, Narosal Publishing House, New Delhi, 2001.
2. Theraja B.L. &Theraja A.K., "A Text Book of Electrical Technology", 2nd Edition, S.Chand& Co. Ltd., New Delhi, 2012.
3. Singh M.D. &Kanchandhani K.B., "Power Electronics", McGraw Hill, New Delhi, 2007

RA3301 ROBOT KINEMATICS L T P C

3 0 0 3

COURSE OBJECTIVES

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

UNIT I OVERVIEW OF ROBOTICS 9

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

UNIT II FORWARD KINEMATICS - GEOMETRICAL AND ALGEBRAIC APPROACH 9

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

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

Unit Circle Trigonometry - Translation Matrix - Rotation matrix, Euler Angles - Quaternion Fundamental - Dot and Cross Products - Frames and Joint Coordinates - Homogeneous Transformation - D-H and Modified D-H Convention and Procedures – Forward kinematics Solution using D-H Convention: 3 DOF wrist , RR Planar, 3 DOF RRP, Cartesian, Cylindrical, Spherical , SCARA and Articulated 3 DOF robots - 3 DOF robot with wrist.

UNIT IV INVERSE KINEMATICSMODELING 9

Introduction to inverse kinematics -Issues in inverse kinematics - Inverse kinematics of 2 DOF Planar robot - 2 and 3DOF planar and Spatial robot - Tool configuration - Inverse kinematics of 3 axis robot and 6 axis Robot - Inverse kinematics Computation- Closed loop solution

UNIT V KINEMATIC MODELING OF DIFFERENTIAL DRIVE ROBOT 9

Degree of Mobility, Steerability and Maneuverability- Mobile Robot kinematics - Kinematic model and constraints, Mobile robot workspace – Representation of robot position – Kinematic models of differential wheel drive - Fixed wheel and steered wheel - Mobile manipulators and its applications – swarm robots.

TOTAL : 45 PERIODS

COURSE OUTCOMES

At the end of the course students able to

CO1: Explain the history, classifications, and basic terminologies of robotics and various configuration of robots.

CO 2: Evaluate forward kinematic model for planar and spatial robot manipulator.

CO 3: Evaluate forward kinematic model for multi-DOF robot manipulators.

CO 4: Evaluate inverse kinematic model for multi-DOF robot manipulators.

CO 5: Evaluate forward kinematic model for differential drive mobile robot.

TEXT BOOKS:

1. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2012.
2. John J. Craig, “Introduction to Robotics”, 3rd Edition, Addison Wesley, ISE 2008.
3. Lynch, Kevin M., and Frank C. Park. Modern Robotics: Mechanics, Planning, and Control 1st ed. Cambridge University Press, 2017.

REFERENCES:

1. S K Saha, Introduction to Robotics, Tata McGraw-Hill, Second Edition, 2017
2. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2017
3. Arthor Critchlow, “Introduction to Robotics”, 1st edition, Macmillan, 2009.
4. Mohsen Shahinpoor, “A Robot Engineering Text Book”, 1st edition, Harper and Row, 2004.
5. Deb S.R., “Robotics Technology and Flexible Automation”, 2nd edition, Tata McGraw - Hill Publis Robotics: Control and Programming.
6. J. Srinivas, R. V. Dukkipati, K., “Robotics: Control and Programming”, Narosa Publishing House, 2009.
7. Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd., 2001
8. Bijay K. Ghosh, Ning Xi, T.J. Tarn, Control in Robotics and Automation Sensor - Based integration, Academic Press, 1999.

Mapping of COs with POs and PSOs															
COs/Pos &PSOs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	1	1								1	1	1	3
CO2	3	2	1	1								1	1	1	3
CO3	3	2	1	1								1	1	1	3
CO4	3	3	1	2								1	1	1	3
CO5	3	1	1	2								1	1	1	3
CO/PO & PSO Average	3.0	2.0	1.0	1.4								1.0	1.0	1.0	3.0
1 – Slight, 2 – Moderate, 3 – Substantial															

MR3361 ELECTRICAL DRIVES AND ACTUATORS LABORATORY L T P C
0 0 4 2

COURSE OBJECTIVES:

1. To impart knowledge on Performance of the fundamental control practices associated with AC and DC machines (starting, reversing, braking, plugging, etc.) using power electronics To impart industry oriented learning
2. To evaluate the use of computer-based analysis tools to review the major classes of machines and their physical basis for operation

LIST OF EXPERIMENTS:

(i) Load test on DC Motor
(ii) Load test on 3 Phase Induction Motor
(iii) Load test on 3 Phase Synchronous Motor.
(iv) Rheostat based Speed control of motors (AC and DC)
(v) Switching circuits of MOSFET, IGBT, SCR and TRAIC.
(vi) Gate pulsation generation using PWM signals.
(vii) Speed control of DC motor using Power Electronic Drive.
(viii) Position and direction control DC servomotor using Power Electronic Drive.
(ix) Position, direction and speed control of BLDC and PMDC motors using Power Electronic Drive.
(x) Position, Direction and speed control of stepper Motor.
(xi) Four quadrant operation of three-phase Induction Motor using Power Electronic Drive.
(xii) VFD control of single phase and three-phase induction motor using Power Electronic Drive.
(xiii) AC servomotor position, direction and speed control using Power Electronic Drive.

(Any 10 experiments)

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1: Practice the basic working of AC, DC motor, stepper motor, servo motor and synchronous motor using power electronic drive

CO2: Demonstrate the control of AC, DC motor, stepper motor, servo motor and synchronous motor using power electronic drive

CO 3:Analyze the performance of AC, DC motor, stepper motor, servo motor and synchronous motor using power electronic drive

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

List of Equipment's:

1. DC Motor with load – 1. N.o.
2. 3 Phase Induction Motor with load – 1. N.o.
3. 3 Phase Synchronous Motor with load – 1. N.o.
4. Rheostat based Speed control of motors (AC and DC) with load – 1. N.o.
5. MOSFET, IGBT, SCR and TRAIC – 1. N.o.
6. DC motor with speed control Drive. – 1. N.o.
7. DC servomotor with Power Electronic Drive (Position, Direction and speed). – 1. N.o.
8. BLDC and PMDC motors with Power Electronic Drive (Position, Direction and speed). – 1. N.o.
9. Stepper Motor with Power Electronic Drive (Position, Direction and speed). – 1. N.o.
10. Three-phase Induction Motor with Power Electronic Drive. – 1. N.o.
11. VFD with single phase and three-phase induction motor. – 1. N.o.
12. AC servomotor with Power Electronic Drive (Position, Direction and speed). – 1. N.o.

RA3311	**ROBOT MODELLING AND SIMULATION LABORATORY**	**L**	**T**	**P**	**C**
		0	**0**	**4**	**2**

COURSE OBJECTIVES

1. Make the students knowledgeable in modeling the basic components of a robot
2. Make the students knowledgeable in modeling some common joints, links and transmission assembly for a robot.
3. Make the students knowledgeable in modeling a robot and its end effector.

LIST OF EXPERIMENTS

1. 2D Sketch of a Gear.
2. 2D Sketch and 3D modelling of Sheet Metal Components
3. 3D Modelling Mounting clamp for motor.
4. 3D Modeling of GT2 pulley and belt drive system
5. 3D Modelling Ball Screw and Nut assembly.
6. 3D Modelling and motion simulation of Rotational Joint assembly.
7. 3D Modelling and motion simulation of Prismatic Joint assembly.
8. 3D modelling and simulation of Cartesian Robot
9. 3D modelling and simulation of Articulated / Spherical / Cylindrical Robot.
10. 3D modelling and motion simulation of 2 fingered gripper assembly.

11. 3D modelling of 2 Wheeled skid steering Mobile Robot.
12. 3D modelling of 4 Wheeled 2 steering Mobile Robot.
13. 3D modelling of 4 Wheeled 4 steering Mobile Robot.
14. Study on Harmonic Gear drive.

(ANY 10 EXPERIMENTS)

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

1. Identify components and physical features of various parts for a robot system and sub systems.
2. Model components and physical features of various parts for a robot system and sub systems.
3. Create a CAD and simulation model for a robot system and sub systems.

EQUIPMENT

1. Computers – 30no's
2. CAD modelling packages – open source/ licensed – 30 users

CO-PO MAPPING:

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

ME3493 MANUFACTURING TECHNOLOGY L T P C
3 0 0 3

COURSE OBJECTIVES:

1. To study the concepts and basic mechanics of metal cutting and the factors affecting machinability
2. To learn working of basic and advanced turning machines.
3. To teach the basics of machine tools with reciprocating and rotating motions and abrasive finishing processes.
4. To study the basic concepts of CNC of machine tools and constructional features of CNC.
5. To learn the basics of CNC programming concepts to develop the part programme for Machine centre and turning centre

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: semi-automatic – single spindle: Swiss type, automatic screw type – multi spindle

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 centres – Work holding methods in Turning and machining centres, 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.

TOTAL : 45 PERIODS

OUTCOMES:

At the end of the course the students would be able to

1. Apply the mechanism of metal removal process and to identify the factors involved in improving machinability.
2. Describe the constructional and operational features of centre lathe and other special purpose lathes.
3. Describe the constructional and operational features of reciprocating machine tools.
4. Apply the constructional features and working principles of CNC machine tools.
5. Demonstrate the Program CNC machine tools through planning, writing codes and setting up CNC machine tools to manufacture a given component.

TEXT BOOKS:

1. Kalpakjian. S, “Manufacturing Engineering and Technology”, Pearson Education India Edition, 2009.
2. Michael Fitzpatrick, Machining and CNC Technology, McGraw-Hill Education; 3rd edition, 2013.

REFERENCES:

1. Roy. A. Lindberg, Processes and materials of manufacture, PHI / Pearson education, 2006.
2. GeofreyBoothroyd, “Fundamentals of Metal Machining and Machine Tools”, McGraw Hill, 1984. Rao. P.N “Manufacturing Technology,” Metal Cutting and Machine Tools, Tata McGraw- Hill, New Delhi, 2003.
3. A. B. Chattopadhyay, Machining and Machine Tools, Wiley, 2nd edition, 2017.
4. Peter Smid, CNC Programming Handbook, Industrial Press Inc.,; Third edition, 2007

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

RA3401 DESIGN OF ROBOT ELEMENTS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

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

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

UNIT I FUNDAMENTALS OF MECHANICAL DESIGN **9**

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

UNIT II DESIGN OF LINKS AND JOINTS **9**

Loads and Forces on Links and Joints - Design of solid and hollow shafts - Rigid and flexible couplings -Threaded fasteners - rolling contact bearings-– Links Design: Path and Motion Synthesis – Cognate Linkages – Design of Spherical Joints.

UNIT III FUNDAMENTALS OF COMPUTER GRAPHICS **9**

Product cycle- Design process - Computer Aided Design – Computer graphics – co-ordinate systems- 2D and 3D transformations- homogeneous coordinates - graphic primitives (point, line, circle drawing algorithms) - Clipping- viewing transformation.

UNIT IV CURVES AND MODELLING **9**

Representation of curves - Hermite cubic spline curve, Bezier curve, B-spline curves, Fundamentals of solid modeling, Different solid representation schemes, Half -spaces, Boundary representation (B-rep), Constructive solid geometry (CSG), Sweep representation, Analytic solid modeling, Perspective, Parallel projection, Hidden line removal algorithms.

UNIT V DESIGN OF GRIPPERS **9**

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. State the design parameters for designing the components of a robot.
2. Apply the CAD modelling techniques in designing a Robot
3. Analyse the design parameters for designing the components of a robot.
4. Formulate the methods for designing the entire robot assembly
5. Create a Robot CAD Model.

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

TEXT BOOKS:

1. Joseph Edward Shigley, Charles R. Mischke “Mechanical Engineering Design”, McGraw Hill, International Edition, 1992
2. Sharma. C.S. and Kamlesh Purohit, “Design of Machine Elements”, Prentice Hall of India Private Limited, 2003
3. Ibrahim Zeid, “CAD/CAM theory and Practice”, Tata McGraw Hill, 2nd edition, 2008
4. Ashby. M.F., “Materials Selection in Mechanical Design”, Third edition, Butterworth-Heineman, New York, 16th edition, 2012

REFERENCES:

1. Bhandari. V.B., “Design of Machine Elements”, Tata McGraw-Hill Publishing Company Limited, 2003.
2. Robert L. Norton, “Machine Design – An Integrated Approach”, Prentice Hall International Edition, 2000.
3. Charles. J. A. and Crane. F. A. A, “Selection and Use of Engineering Materials”, second edition, Butterworth-Heinemann Ltd., 3rd edition 2005.
4. Kevin Otto, Kristin Wood, “Product Design”, Pearson Education, 7th Reprint, 2011.
5. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2012.
6. Dragomir N. Nenchev, Atsushi Konno, Teppei Tsujita, “Humanoid Robots: Modelling and Control”, Butterworth-Heinemann, 2018
7. Zeid, I., CAD/CAM, McGraw Hil , 2008.

MR3491 SENSORS AND INSTRUMENTATION L T P C

3 0 0 3

COURSE OBJECTIVES:

1. To understand the concepts of measurement technology.
2. To learn the various sensors used to measure various physical parameters.
3. To learn the fundamentals of signal conditioning, data acquisition and communication systems used in mechatronics system development
4. To learn about the optical, pressure and temperature sensor
5. To understand the signal conditioning and DAQ systems

UNIT I INTRODUCTION 9

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

UNIT II MOTION, PROXIMITY AND RANGING SENSORS 9

Motion Sensors – Potentiometers, Resolver, Encoders – Optical, Magnetic, Inductive, Capacitive, LVDT – RVDT – Synchro – Microsyn, Accelerometer – GPS, Bluetooth, Range Sensors – RF beacons, Ultrasonic Ranging, Reflective beacons, Laser Range Sensor (LIDAR).

UNIT III FORCE, MAGNETIC AND HEADING SENSORS 8

Strain Gage, Load Cell, Magnetic Sensors –types, principle, requirement and advantages: Magneto resistive – Hall Effect – Current sensor Heading Sensors – Compass, Gyroscope, Inclinometers.

UNIT IV OPTICAL, PRESSURE AND TEMPERATURE SENSORS 10

Photo conductive cell, photo voltaic, Photo resistive, LDR – Fiber optic sensors – Pressure – Diaphragm, Bellows, Piezoelectric – Tactile sensors, Temperature – IC, Thermistor, RTD, Thermocouple. Acoustic Sensors – flow and level measurement, Radiation Sensors - Smart Sensors - Film sensor, MEMS & Nano Sensors, LASER sensors.

UNIT V SIGNAL CONDITIONING AND DAQ SYSTEMS 9

Amplification – Filtering – Sample and Hold circuits – Data Acquisition: Single channel and multi-channel data acquisition – Data logging - applications - Automobile, Aerospace, Home appliances, Manufacturing, Environmental monitoring.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1: Recognize with various calibration techniques and signal types for sensors.

CO2: Describe the working principle and characteristics of force, magnetic, heading, pressure and temperature, smart and other sensors and transducers.

CO3: Apply the various sensors and transducers in various applications

CO4: Select the appropriate sensor for different applications.

CO5: Acquire the signals from different sensors using Data acquisition systems.

TEXT BOOKS:

1. Ernest O Doebelin, “Measurement Systems – Applications and Design”, Tata McGraw-Hill, 2009.
2. Sawney A K and Puneet Sawney, “A Course in Mechanical Measurements and Instrumentation and Control”, Dhanpat Rai & Co, 12th edition New Delhi, 2013.

REFERENCES

1. C. Sujatha ... Dyer, S.A., Survey of Instrumentation and Measurement, John Wiley & Sons, Canada, 2001.

2. Hans Kurt Tönshoff (Editor), Ichiro, “Sensors in Manufacturing” Volume 1, Wiley-VCH April 2001.
3. John Turner and Martyn Hill, “Instrumentation for Engineers and Scientists”, Oxford Science Publications, 1999.
4. Patranabis D, “Sensors and Transducers”, 2nd Edition, PHI, New Delhi, 2011.
5. Richard Zurawski, “Industrial Communication Technology Handbook” 2nd edition, CRC Press, 2015.

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

MR3452 CONTROL SYSTEMS ENGINEERING L T P C
3 0 2 4

COURSE OBJECTIVES:

1. To introduce the components and their representation of control systems
2. To learn various methods for analyzing the time response, frequency response and stability of the systems.
3. To learn the various approach for the system frequency analysis
4. To understand the concept of stability analysis
5. To know about the state variable methods of control system analysis

UNIT I SYSTEMS COMPONENTS AND THEIR REPRESENTATION 9

Control System: Terminology and Basic Structure-Feed forward and Feedback control theory-Electrical and Mechanical Transfer Function Models-Block diagram Models-Signal flow graphs

UNIT II TIME RESPONSE ANALYSIS 9

Transient response-steady state response-Measures of performance of the standard first order and second order system-effect on an additional zero and an additional pole-steady error constant and system- type number-PID control-Analytical design for PD, PI,PID control systems

UNIT III FREQUENCY RESPONSE AND SYSTEM ANALYSIS 9

Closed loop frequency response-Performance specification in frequency domain-Frequency response of standard second order system- Bode Plot - Polar Plot-Design of compensators using Bode plots- Cascade lead, lag and lag-lead compensation.

UNIT IV CONCEPTS OF STABILITY ANALYSIS 9

Concept of stability-Bounded - Input Bounded - Output stability-Routh stability criterion-Relative stability-Root locus concept-Guidelines for sketching root locus-Nyquist stability criterion.

UNIT V CONTROL SYSTEM ANALYSIS USING STATE VARIABLE METHODS 9

State variable representation-Conversion of state variable models to transfer functions-Conversion of transfer functions to state variable models-Solution of state equations-Concepts of Controllability and Observability

TOTAL: 45 PERIODS

CONTROL SYSTEMS LABORATORY

Experiments

1. Mathematical Modelling and Simulation of a Physical Systems and Simulation and Reduction of Cascade and Parallel, and Closed Loop Sub-System.
2. Simulation and Analysis of First and Second Order System Equations in Time and Frequency Domain.
3. Simulation and Analysis of System using Root-Locus and Bode Plot.
4. Simulation and Implementation of PID Combination for First Order Systems.
5. Simulation and Implementation of PID Combination Second Order Systems.
6. Auto tuning of PID parameters and analysis of PID Control.

TOTAL : 30 PERIODS

COURSE OUTCOMES

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

CO1: State the various control terminologies and concepts.

CO2: Know the procedures in developing the transfer function, state space models and time and frequency domain analysis methods.

CO3: Apply the procedures on developing the systems in transfer function and state space approach and apply to evaluate the performance of system in time and frequency domain techniques.

CO4: Illustrate the time and frequency response characteristics of system response.

CO5: Analyze the performance of system using various time and frequency domain techniques.

TEXT BOOKS:

1. M.Gopal,"Control System – Principles and Design", Tata McGraw Hill, 4th Edition, 2012.
2. K.Ogata, "Modern Control Engineering", PHI, 5 th Edition, 2012.

REFERENCES:

1. J.Nagrath and M.Gopal, "Control System Engineering", New Age International Publishers, 5th Edition, 2007.
2. S.K.Bhattacharya, "Control System Engineering", Pearson, 3 rd Edition, 2013.
3. Benjamin.C.Kuo, "Automatic Control Systems", Prentice Hall of India, 7th Edition,1995.
4. Nagoor Kani, "Conrol Systems", RBA Publications, 2017.
5. Norman. S. Nise, "Control Systems Engineering", Wiley India edition, 2018.

TOTAL : 45(L) + 30(P) = 75 PERIODS

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

MR3591 FLUID POWER SYSTEMS AND INDUSTRIAL AUTOMATION L T P C
3 0 0 3

COURSE OBJECTIVES:

1. To recognize the standard symbols and to understand the functions of basic fluid power generation and actuation elements.
2. To realize the functions of fluid regulation and control elements and its typical uses in fluid power circuit and to acquire the practice on assembling the various types of pneumatic circuits.
3. To familiar and exercise the design procedure of various types of pneumatic and hydraulic fluid power circuits and to provide a training to create the various types of hydraulic circuits.
4. To learn about the fundamentals of Programmable Logic Controller.
5. To familiarize the Data Communication and Supervisory Control Systems.

UNIT I FLUID POWER SYSTEM GENERATION AND ACTUATORS 9

Need For Automation, Classification of Drives - Hydraulic, Pneumatic and Electric – Comparison – ISO Symbols for their Elements, Selection Criteria. Generating Elements- Hydraulic Pumps and Motor Gears, Vane, Piston Pumps – Motors - Selection and Specification - Drive Characteristics – Utilizing Elements - Linear Actuator – Types, Mounting Details, Cushioning – Power Packs – Accumulators.

UNIT II CONTROL AND REGULATIING ELEMENTS 9

Control and Regulating Elements — Direction, Flow and Pressure Control Valves -Methods of Actuation, Types, Sizing of Ports. Spool Valves - Operating Characteristics -Electro Hydraulic Servo Valves - Types - Characteristics and Performance.

UNIT III CIRCUIT DESIGN FOR HYDRAULIC AND PNEUMATICS 9

Typical Design Methods – Sequencing Circuits Design - Combinational Logic Circuit Design - Cascade Method – KV Mapping - Electrical Control of Pneumatic and Hydraulic Circuits - Use of Relays, Timers, Counters and PLC in pneumatics and hydraulics

UNIT IV PROGRAMMABLE LOGIC CONTROLLER 9

Industrial Automation - Programmable Logic Controller - Functions of PLCs - Features of PLC - Selection of PLC - Architecture – IEC61131-3 programming standard and types - Basics of PLC Programming – Ladder Logic Diagrams – Communication in PLC – Programming Timers and Counters – Data Handling - PLC modules – Advanced motion controlled Multi Axis PLC

UNIT V DATA COMMUNICATION AND SUPERVISORY CONTROL SYSTEMS 9

Industrial Data Communications -– Modbus – HART – DeviceNet – Profibus – Fieldbus – RS232- RS485- Modbus/ Modbus TCP/IP - mechatrolink – CAN – Ether CAT - Introduction to Supervisory Control Systems – SCADA - Distributed Control System (DCS) – Safety Systems – human machine interfaces - Total Integrated Automation (TIA) – Industry 4.0.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO 1: Recognize the various concepts of fluid power and PLC systems.

CO 2: Comprehend functions of fluid power and PLC systems.

CO 3:Explain the various standard fluid power circuits, functions, communication and IO details of PLC.

CO 4: Demonstrate the standard fluid power circuits and PLC based interfaces.

CO 5: Construct the fluid power circuits and PLC based automation system.

TEXT BOOKS:

1. Antony Esposito, “Fluid Power Systems and Control”, Prentice-Hall, 2006.
2. Peter Rohner, “Fluid Power Logic Circuit Design”, the Macmillan Press Ltd., London, 1979.
3. Frank D, Petruzella, “Programmable Logic Controller” McGraw – Hill Publications, Fourth Edition, 2016.

REFERENCE BOOKS:

1. Lucas, M.P., “Distributed Control System”, Van Nastrand Reinhold Company, New York, 1986.
2. Mackay S., Wrijut E., Reynders D. and Park J., “Practical Industrial Data Networks Design, Installation and Troubleshooting”, Newnes Publication, Elsevier, First Edition, 2004.
3. Patranabis. D, “Principles of Industrial Instrumentation”, Tata McGraw-Hill Publishing Ltd., New Delhi, 1999.

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

GE3451 ENVIRONMENTAL SCIENCE AND SUSTAINABILITY L T P C
2 0 0 2

COURSE OBJECTIVES:

1. To study the nature and its impacts on human life.
2. To study the environmental pollution, its types, control methods and protection acts
3. To provide the knowledge of about the energy management and energy resources
4. To study the concepts of Sustainability, global warming and Management
5. To study the Sustainability Practices and socio economical changes

UNIT I ENVIRONMENT AND BIODIVERSITY 9

Definition, scope and importance of environment – need for public awareness. Eco-system and Energy flow– ecological succession. Types of biodiversity: genetic, species and ecosystem diversity– values of biodiversity, India as a mega-diversity nation – hot-spots of biodiversity – threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts – endangered and endemic species of India – conservation of biodiversity: In-situ and ex-situ.

UNIT II ENVIRONMENTAL POLLUTION 9

Causes, Effects and Preventive measures of Water, Soil, Air and Noise Pollutions. Solid, Hazardous and E-Waste management. Case studies on Occupational Health and Safety Management system (OHASMS). Environmental protection, Environmental protection acts.

UNIT III RENEWABLE SOURCES OF ENERGY 9

Energy management and conservation, New Energy Sources: Need of new sources. Different types new energy sources. Applications of- Hydrogen energy, Ocean energy resources, Tidal energy conversion. Concept, origin and power plants of geothermal energy.

UNIT IV SUSTAINABILITY AND MANAGEMENT 9

Development , GDP ,Sustainability- concept, needs and challenges-economic, social and aspects of sustainability-from unsustainability to sustainability-millennium development goals, and protocols-Sustainable Development Goals-targets, indicators and intervention areas Climate change- Global, Regional and local environmental issues and possible solutions-case studies. Concept of Carbon Credit, Carbon Footprint. Environmental management in industry-A case study.

UNIT V SUSTAINABILITY PRACTICES 9

Zero waste and R concept, Circular economy, ISO 14000 Series, Material Life cycle assessment, Environmental Impact Assessment. Sustainable habitat: Green buildings, Green materials, Energy efficiency, Sustainable transports. Sustainable energy: Non-conventional Sources, Energy Cycles-carbon cycle, emission and sequestration, Green Engineering: Sustainable urbanization- Socio-economical and technological change.

TOTAL: 30 PERIODS

OUTCOMES:

At the end of the course the students would be able to

1.Understand the nature and its impacts on human life.
2.The students have the knowledge and awareness of Environmental Pollution.
3.Understanding of the energy sources and scientific concepts/principles behind them
4.Understand the concepts of the Sustainability and Management
5. Understand the Sustainability Practices and socio economic changes

TEXT BOOKS:

1. Anubha Kaushik and C. P. Kaushik's "Perspectives in Environmental Studies", 6th Edition, New Age International Publishers ,2018.
2. Benny Joseph, 'Environmental Science and Engineering', Tata McGraw-Hill, New Delhi, 2016.

REFERENCES:

1. R.K. Trivedi, 'Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards', Vol. I and II, Enviro Media. 38, 2008.
2. Cunningham, W.P. Cooper, T.H. Gorhani, 'Environmental Encyclopedia', Jaico Publ., House, Mumbai, 2001.
3. Dharmendra S. Sengar, 'Environmental law', Prentice hall of India PVT. LTD, New Delhi, 2007.
4. Rajagopalan, R, 'Environmental Studies-From Crisis to Cure', Oxford University Press, 2005.
5. Erach Bharucha "Textbook of Environmental Studies for Undergraduate Courses" Orient Blackswan Pvt. Ltd. 2013.

ME3382	MANUFACTURING TECHNOLOGY LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

1 To Selecting appropriate tools, equipment's and machines to complete a given job.

2 To Performing various welding process using GMAW and fabricating gears using gear making machines.

3 To Performing various machining process such as rolling, drawing, turning, shaping, drilling, milling and analyzing the defects in the cast and machined components.

LIST OF EXPERIMENTS

1. Fabricating simple structural shapes using Gas Metal Arc Welding machine.

2. Preparing green sand moulds with cast patterns.

3. Taper Turning and Eccentric Turning on circular parts using lathe machine.

4. Knurling, external and internal thread cutting on circular parts using lathe machine.

5. Shaping – Square and Hexagonal Heads on circular parts using shaper machine.

6. Drilling and Reaming using vertical drilling machine.

7. Milling contours on plates using vertical milling machine.

8. Cutting spur and helical gear using milling machine.

9. Generating gears using gear hobbing machine.

10. Generating gears using gear shaping machine.

11. Grinding components using cylindrical and centerless grinding machine.

12. Grinding components using surface grinding machine.

13. Cutting force calculation using dynamometer in milling machine

14. Cutting force calculation using dynamometer in lathe machine

LIST OF EQUIPMENT FOR BATCH OF 30 STUDENTS

S.No.	NAME OF THE EQUIPMENT	Qty.
1.	Centre Lathes	7 Nos.
2.	Shaper	1 No.
3.	Horizontal Milling Machine	1 No.
4.	Vertical Milling Machine	1 No.
5.	Surface Grinding Machine	1 No.
6.	Cylindrical Grinding Machine	1 No.
7.	Radial Drilling Machine	1 No.
8.	Lathe Tool Dynamometer	1 No.
9.	Milling Tool Dynamometer	1 No.
10.	Gear Hobbing Machine	1 No.
11.	Gear Shaping Machine	1 No.
12.	Arc welding transformer with cables and holders	2 Nos.
13.	Oxygen and Acetylene gas cylinders, blow pipe and other welding outfit	1 No.
14.	Moulding table, Moulding equipments	2 Nos.

TOTAL:60 PERIODS

OUTCOMES: At the end of the course the students would be able to

1. Demonstrate the safety precautions exercised in the mechanical workshop and join two metals using GMAW.
2. The students able to make the work piece as per given shape and size using machining process such as rolling, drawing, turning, shaping, drilling and milling.
3. The students become make the gears using gear making machines and analyze the defects in the cast and machined components

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3						1		2			1	1	2	2
2	3						1		2			1	1	2	2
3	3						1		2			1	1	2	2
Low (1) ; Medium (2) ; High (3)															

MR3461 SENSORS AND INSTRUMENTATION LABORATORY L T P C
0 0 4 2

COURSE OBJECTIVES

1. To learn about various force, pressure and vibration measuring sensors.
2. To learn about various Temperature, light and magnetic field measuring sensors
3. To learn about various displacement and speed measuring sensors.

LIST OF EXPERIMENTS:

SENSORS AND INSTRUMENTATION

1. Determination of Load, Torque and Force using Strain Gauge.
2. Determination of the characteristics of Pressure Sensor and Piezoelectric Force Sensor
3. Determination of Displacement using LVDT.
4. Determine the Characteristics of Various Temperature Sensors.
5. Determine the Characteristics of Various Light Detectors (Optical Sensors).
6. Distance Measurement using Ultrasonic and Laser Sensor.
7. Determine angular velocity of gyroscope,
8. Vibration measurement using Accelerometer.
9. Direction measurement using Magnetometer.
10. Speed, Position and Direction Measurement Using Encoders.
11. Force measurement using 3 axis force sensor.
12. Force Measurement using tactile sensors.
13. Data acquisition, visualization and analysis of signals.

TOTAL: 60 PERIODS

COURSE OUTCOMES:
Upon the completion of this course, the students will be able to;
CO1: Demonstrate the various contact and non-contact sensors.
CO2: Analyze and Identify appropriate sensors for given applications.
CO3: Create a sensor system for given requirements.

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

Equipment List

1. Load, Torque and Force using Strain Gauge – 3 Nos
2. Pressure Sensor and Piezoelectric Force Sensor- 1 No's
3. LVDT setup – 1 No.
4. Temperature Sensors measurement setup with RTD, Thermocouple and Thermistor -1 No.
5. Measurement setup Optical Sensors LDR, Photo transistor, photo diode – 1 each
6. Measurement setup -Ultrasonic and Laser Sensor- 1 No.
7. Gyroscope measurement setup - 1 No.
8. Accelerometer measurement setup - 1 No.

9. Magnetometer measurement setup -1 No.
10. Absolute Encoders and Incremental encoder with DSO/ single board computer- 1 no
11. DAQ with sensor or transducer -1 set
12. 3 axis force sensor – 1 No.
13. Tactile Sensor – 1No.