AUTONOMOUS

SYLLABUS

V & VI Semesters

B.E in Mechatronics

2023

MITE

Invent Solutions

MANGALORE INSTITUTE OF TECHNOLOGY & ENGINEERING

Institute Vision

*"To attain perfection in providing **Globally Competitive Quality Education** to all our Students and also benefit the global community by using our strength in **Research and Development**"*

Institute Mission

*"To establish world class educational institutions in their respective domains, which shall be C**enters of Excellence** in their stated and implied sense. To achieve this objective we dedicate ourselves to meet the challenges of becoming **Visionary and Realistic**, **Sensitive and Demanding**, **Innovative and Practical,** Theoretical **and Pragmatic;** ALL at the same time"*

Department Vision

"To accomplish excellence in imparting Quality Education in Mechatronics and tocontribute to community through Research and Development"

Department Mission

- *To divulge knowledge in the fields of Mechanical, Electricals & Electronics, and Computer Engineering, related areas with an emphasis on evolving the essential proficiencies and virtues anticipated of Mechatronics Engineer.*
- *To establish best in class laboratories to endorse applied knowledge of Mechatronics to meet the needs of the society.*
- *To instill better interpersonal abilities, promote leadership, ethics and entrepreneurship among students through efficient training and development.*
- *To prepare robust and responsible graduate to pursue higher studies and research to meet the global requirements.*

Program Educational Objectives (PEOs)

After successful completion of the program, the graduates will be

PEO-1: Be able to solve engineering problems and develop sustainable products by integrating multi-disciplinary knowledge in Mechanical, Electronics, Computer andControl engineering to meet societal needs.

PEO-2: Be able to work and manage teams in cross cultural, multinational and multilingual environment with competent interpersonal and communication skills alongwith high professional, social and ethical morale.

PEO-3: Have research aptitude and engage in continual learning with inclination towards entrepreneurship.

Program Specific Outcomes (PSOs)

Graduates of the Mechatronics will be able to

PSO1: Exhibit multi-disciplinary knowledge in robotics and automation, mechanical, electronics, and computer engineering to excel in professional career.

PSO2: Manage and lead teams with ethics, have research aptitude, adapt to currenttrends in technologies and contribute to society with a passion towards life-long learning.

LIST OF COURSES

V / VI Semester Courses			
Sl. No.	**Course Code**	**Course Title**	**Sem**
HUMANITIES & SOCIAL SCIENCE COURSES			
1	23HMCC301	Entrepreneurship, Management & Finance	V
PROFESSIONAL CORE COURSES			
2	23MTPC302	Industrial Automation	V
3	23MTPC303	Computer Aided Machine Drawing	V
4	23MTPC304	Systems Engineering	V
5	23MTPC305	Structural and Electromechanical Analysis Lab	V
6	23MTPC306	Fundamentals of HDL	VI
7	23MTPC307	Control Engineering	VI
8	23MTPC308	Virtual Instrumentation Lab	VI
SKILL ENHANCEMENT COURSE			
9	23MTSE309	Project Phase-I	VI
PROFESSIONAL ELECTIVE COURSES			
10	23MTPE311	Industry 4.0 and IOT	V
11	23MTPE312	Mechanisms and Design of Machine Elements	V
12	23MTPE313	Power Electronics	V
13	23MTPE321	Micro Robotics	VI
14	23MTPE322	Electric and Hybrid Vehicles	VI
15	23MTPE323	Micro and Smart System Technology	VI
OPEN ELECTIVE COURSES			
16	23MTOE311	Mechatronics System Design	V
17	23MTOE312	Virtual Instrumentation	V
18	23MTOE313	Introduction to Industry 4.0- Manufacturing	V
19	23MTOE321	Robotics and Automation	VI
20	23MTOE322	PLC and SCADA Technology	VI
21	23MTOE323	Autonomous Mobile Robots	VI
NON-CREDIT MANDATORY COURSES			
22	23NMCC321	Yoga – III	V
23	23NMCC322	Physical Education – III	V
24	23NMCC323	National Service Scheme – III	V
25	23NMCC324	Arts – III	V
26	23NMCC325	Yoga – IV	VI
27	23NMCC326	Physical Education – IV	VI
28	23NMCC327	National Service Scheme – IV	VI
29	23NMCC328	Arts – IV	VI

V SEMESTER (2023 Scheme): Mechatronics

Sl. No.	Course Code	Course Title	Category	Teaching Dept.	Teaching Hours /Week			Examination (Marks)			Duration of Exam (SEE) in Hrs.	Credits
					L	T	P	CIE	SEE	Total		
1	23HMCC301	Entrepreneurship, Management & Finance	Humanities & Social Sciences	MBA/Any Department	3	0	0	50	50	100	3	3
2	23MTPC302	Industrial Automation	Professional Core Course	MT	3	0	2	50	50	100	3	4
3	23MTPC303	Computer Aided Machine Drawing	Professional Core Course	MT	2	0	2	50	50	100	3	3
4	23MTPC304	Systems Engineering	Professional Core Course	MT	2	0	2	50	50	100	3	3
5	23MTPC305	Structural and Electromechanical Analysis Lab	Professional Core Course	MT	0	1	3	50	50	100	2.5	2
6	23MTPE31X	Professional Elective–I*	Discipline Specific Elective	MT	3	0	0	50	50	100	3	3
7.	23MTOE31X	Open Elective-I**	Open Electives	MT	3	0	0	50	50	100	3	3
8.	23NMCC32X	Yoga/Physical Education/NSS/Arts***	Non-Credit Mandatory Course	Yoga Teacher/ PED/NSS Coordinator/ Cultural Coordinator	0	0	1	100	-	100	-	-
										Total Credits		**21**

Note: MOOC Courses

MOOC Requirement:

- Students are required to register and successfully complete one MOOC (Massive Open Online Course) of 8 or 12 weeks duration, offered through the NPTEL/SWAYAM platforms, between the 6th and 7th semesters.
- The list of eligible courses shall be approved and notified by the Board of Studies (BoS) of the respective discipline at least 15 days before

the start of the semester.

- The successfully completed MOOC will be considered equivalent to a Professional Elective carrying 2 credits, which will be accounted for in the 8th semester.
- Students must submit the course completion certificate and the official scorecard issued by NPTEL as proof of completion.
- **Failure Policy:** Students who are unable to clear the MOOC in two consecutive attempts during the 6th and 7th semesters will be allowed to register for a Professional Elective course offered by the department in online mode during the 8th semester to earn the required 2 credits. SEE will be conducted by the department in the offline mode.

***Professional Elective Course-I**

Sl. No.	Course Code	Course Title
1	23MTPE311	Industry 4.0 and IOT
2	23MTPE312	Mechanisms and Design of Machine Elements
3	23MTPE313	Power Electronics

****Open Elective Course -I**

Sl. No.	Course Code	Course Title
1	23MTOE311	Mechatronics System Design
2	23MTOE312	Virtual Instrumentation
3	23MTOE313	Introduction to Industry 4.0- Manufacturing

*****Yoga/Physical Education/NSS/Arts:**

Sl. No.	Course Code	Course Title
1	23NMCC321	Yoga-III
2	23NMCC322	Physical Education-III
3	23NMCC323	National Service Scheme -III
4	23NMCC324	Arts-III

VI SEMESTER (2023 Scheme): Mechatronics

Sl. No.	Course Code	Course Title	Category	Teaching Dept.	Teaching Hours /Week			Examination Marks			Duration of Exam (SEE) in Hrs.	Credits
					L	T	P	CIE	SEE	Total		
1.	23MTPC306	Fundamentals of HDL	Professional Core Course	MT	3	0	2	50	50	100	3	4
2.	23MTPC307	Control Engineering	Professional Core Course	MT	3	0	0	50	50	100	3	3
3.	23MTPC308	Virtual Instrumentation Lab	Professional Core Course	MT	0	1	3	50	50	100	2.5	2
4.	23MTSE309	Project Phase-I	Project	MT	0	0	6	100	-	100	3	3
5.	23MTPE32X	Professional Elective–II*	Discipline Specific Electives	MT	3	0	0	50	50	100	3	3
6.	23MTOE32X	Open Elective-II**	Open Electives	MT	3	0	0	50	50	100	3	3
7.	23NMCC32X	Yoga/Physical Education/NSS/Arts***	Non-Credit Mandatory Course	Yoga Teacher/ PED/ NSS Coordinator/ Cultural Coordinator	0	0	1	100	-	100	-	-
										Total Credits		**18**

*** Professional Elective Course-II**

Sl. No.	Course Code	Course Title
1	23MTPE321	Micro Robotics
2	23MTPE322	Electric and Hybrid Vehicles
3	23MTPE323	Micro and Smart System Technology

****Open Elective Course -II**

Sl. No.	Course Code	Course Title
1	23MTOE321	Robotics and Automation
2	23MTOE322	PLC and SCADA Technology
3	23MTOE323	Autonomous Mobile Robots

*****Yoga/Physical Education/NSS/Arts:**

Sl. No.	Course Code	Course Title
1	23NMCC325	Yoga-IV
2	23NMCC326	Physical Education-IV
3	23NMCC327	National Service Scheme -IV
4	23NMCC328	Arts-IV

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V Semester

Sl No.	Course Code	Course title	Page No.
1	23HMCC301	Entrepreneurship, Management & Finance	1
2	23MTPC302	Industrial Automation	3
3	23MTPC303	Computer Aided Machine Drawing	6
4	23MTPC304	Systems Engineering	8
5	23MTPC305	Structural and Electromechanical Analysis Lab	11
6	23MTPE31X	Professional Elective–I	13-18
7	23MTOE31X	Open Elective-I	19-24
8	23NMCC32X	Yoga/Physical Education/NSS/Arts	25-32

VI Semester

Sl No.	Course Code	Course title	Page No.
1	23MTPC306	Fundamentals of HDL	33
2	23MTPC307	Control Engineering	35
3	23MTPC308	Virtual Instrumentation Lab	37
4	23MTSE309	Project Phase-I	39
5	23MTPE32X	Professional Elective–II	41-46
6	23MTOE32X	Open Elective-II	47-52
7	23NMCC32X	Yoga/Physical Education/NSS/Arts	53-60

Entrepreneurship, Management & Finance			
Semester	**V**	CIE Marks	**50**
Course Code	**23HMCC301**	SEE Marks	**50**
Teaching Hours/Week (L: T: P)	**3:0:0**	Exam Hrs	**3**
Total Hours	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Impart key competencies, qualities, and skills of entrepreneurship
2. Provide insights into the pathways to new venture creation and concepts of management in organizations
3. Familiarize the functions of management and financial aspects of an organization

Module 1: Entrepreneur and Entrepreneurship	**No. of Hrs: 8**

Entrepreneur: Definition, Entrepreneurial competencies, Characteristics of Entrepreneurs, Qualities of an entrepreneur, Entrepreneurial skills. Developing Entrepreneurial competencies, Classification of Entrepreneurs, Entrepreneur vs Professional Managers
Entrepreneurship: Concept, Phases of Entrepreneurship Development, Fostering Entrepreneurship, Barriers to Entrepreneurship, Factors influencing Entrepreneurship

Textbook 1: Chapter 2, 3 and 10

Module 2: Opportunities and pathways to Entrepreneurship	**No. of Hrs: 8**

Opportunity identification, Sources of Innovative ideas, Entrepreneurial imagination, and creativity: Concept of Creativity, Rules, Components, Process or phases of creativity, the critical thinking process
Pathways to new ventures: Creating New ventures, Acquiring an established venture, Franchising

Textbook 2: Chapter 5 and 6

Module 3: Introduction to Management	**No. of Hrs: 8**

Management: Nature, Objectives, Importance. Difference between administration and management. Levels of management, Types of managers, Managerial skills, Managerial Competencies, Scope or Functional areas of management.

Textbook 3: Chapter 1

Module 4: Management Functions	**No. of Hrs: 9**

Functions of Management: Planning, Organizing, Staffing, Directing and Controlling.
Planning: Meaning, Features, Importance, Types, and steps. Organizing: Meaning, Need, Principles, and Process. Staffing: Meaning, Nature, and Process. Directing: Meaning, Need, Elements and Techniques. Controlling: Meaning, Need, Characteristics, Steps, and Types.

Textbook 3: Chapter 3, 4, 5 and 6

Module 5: Business Organizations and Finance	**No. of Hrs: 9**

Forms of Business Organization: Sole proprietorship, Partnership, Cooperative Society, and Company. Financial decisions in a firm, Goal of Financial Management, Fundamental principle of finance, building blocks of modern finance, Risk-return tradeoff, Emerging role of financial manager in India, Cost profit volume analysis; Profit volume ratio, Break Even Analysis and Margin of safety

Textbook 4: Chapter 1- Section 1.1, 1.2,1.3, 1.4, 1.5, 1.6 and 1.11
Chapter 13 – Section 13.4

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

1. Outline the entrepreneurial skills & qualities required for business development
2. Describe the processes of opportunity identification, creativity, and pathways to establishing new ventures
3. Explain the fundamental concepts of management
4. Apply the functions of management in decision-making
5. Apply financial management principles to assess financial decisions, and determine cost-profit-volume relationship

Textbooks:

1. Vasanth Desai, "The Dynamics of Entrepreneurial Development and Management", 6th Edition, Himalaya Publishing House, 2018
2. Donald F. Kuratko and T.V. Rao, "Entrepreneurship: A South Asian Perspective", 1st Edition, Cengage Learning, 2017
3. Chandrani Singh and Aditi Khatri, "Principles and Practices of Management and Organisational Behaviour", 5th Edition, Sage Texts, 2021
4. Prasanna Chandra, "Financial Management- Theory and Practice",10th Edition, Mc Graw Hill, 2022

Reference Books:

1. Deependra Sharma, "Entrepreneurship in India",1st Edition, Routledge India, 2023
2. Robert D. Hisrich, Michael P. Peters, Dean A. Shepherd, and Sabyasachi Sinha, "Entrepreneurship", 11th Edition, McGraw Hill, 2022
3. Charanthimath Poornima M, "Entrepreneurship Development and Small Business Enterprises", 3rd Edition, Pearson, 2018

Web links:

1. Introduction to Entrepreneur: https://www.youtube.com/watch?v=rbmz5VEW90A
2. Pathways to new creations: https://www.youtube.com/watch?v=zkgbss81QKE
3. Concepts of Management: https://www.youtube.com/watch?v=GZ2dmbDmB5I
4. Functions of Management: https://www.youtube.com/watch?v=Vq8GChMK5Zg
5. Types of Business Organizations: https://www.youtube.com/watch?v=UGSlED1Jx1Y

Industrial Automation			
Semester	**V**	CIE Marks	**50**
Course Code	**23MTPC302**	SEE Marks	**50**
Teaching Hrs/Week (L: T: P)	**3:0:2**	Exam Hrs	**3**
Total Hrs	**64**	Credits	**4**

Course Learning Objectives: This course is designed to

1. Provide foundational knowledge of industrial automation
2. Enable understanding of PLC systems and its architecture
3. Provide skills to create PLC programs
4. Impart knowledge of SCADA systems and communication protocols
5. Enhance practical problem-solving skills using PLC programming

Module 1: Introduction to Industrial Automation | **No. of Hrs: 8 + 6**

Overview of industrial automation, Necessity of automation, Architecture of Industrial Automation Network, Types of industrial automation, Levels of automation
Industrial Control Systems: Process industries vs discrete manufacturing industries; Continuous vs. Discrete Control; Continuous Control Systems; Discrete Control Systems; Computer Process Control: Capabilities, Forms – DDC, CNC, PLC, SCADA

Textbook 1: Chapter 1 – Section 1.1 – 1.6
Textbook 2: Chapter 4 – Section 4.3
Chapter 5

Laboratory Components:

1. Implement PLC ladder diagram for basic gate operation
2. Interfacing of Lamp & button with PLC for ON&OFF Operation. Verify all logic gates
3. A selection committee comprises four members including president. In order for selection, the candidate should have support of at least two members. However, the president can push through any candidate. If each member is provided with a switch, design a logic that will ring a bell when the candidate is selected

Module 2: Introduction to PLC | **No. of Hrs: 8 + 6**

Technical definition of PLC, Classification, Features and advantages, I/O devices of PLC, PLC programming devices, PLC selection criteria, Architecture of PLC, Block diagram, Central Control Unit, Memory types, Human Machine Interfaces (HMI), Functional Modes of PLC, PLC Program structure and Execution, Selection of I/O modules, Programming languages

Textbook 1: Chapter 2 – Section 2.1 – 2.3
Textbook 3: Chapter 1

Laboratory Components:

1. Implement ladder diagram for 4:1 MUX and 1:4 DEMUX
2. Develop a ladder diagram to implement the following: When the start switch is ON, the motor is ON, When the stop switch is ON, the motor is OFF. When the motor is ON, the green light is ON, when the motor is OFF, the red light is ON
3. Consider a bi-directional movable arm. Develop a ladder diagram to control it as per the conditions mentioned: Both start and stop switches are push buttons. When the system is ON, the motor should rotate continuously. It should change direction when limit switch is pressed

Module 3: PLC Programming	**No. of Hrs: 8 + 4**

Ladder logic, symbols – contacts, coils, plc ladder, branching, start/stop circuit, plc scanning, Logic operations, AND gate, OR gate, XOR Gate, NOT Gate, NOR gate, NAND gate, Variables and Data Types, Register, Bit-level logic, branch instructions, internal relay, contactors

Textbook 3: Chapter 2

Laboratory Components:

1. Implement a ladder logic diagram for a three-motor system having the following conditions: Motor 2 can start 5 seconds after Motor 1. Only when Motor 2 is running, Motor 3 can be started. When M2 is turned off, M3 is off. When M1 is turned off, both M2 and M3 stop
2. Design and Implement PLC ladder diagram to control a stepper motor so that it moves 10 steps forward, waits for 20 seconds, and then moves 10 steps in reverse direction

Module 4: Advanced Programming Concepts	**No. of Hrs: 8 + 4**

Timers and counters, Delays, ON delay, OFF delay, retentive and non-retentive timers, cascading timers, count-up counters, count-down counters, cascading counters, special timing instructions, pulse generation, one-shot operations, Math operations, Comparison instructions, Data manipulation instructions, Closed-loop control, Sequencer and Shift register instructions

Textbook 3: Chapter 3

Laboratory Components:

1. Design PLC logic for an agitator-motor system having the following conditions: The pump can be started after 5 seconds of starting the agitator. When the pump is switched OFF, the agitator also stops. Once the agitator goes off, it cannot be started for 3 seconds
2. Design a PLC ladder diagram to simulate a parking lot. IN counter counts the number of vehicles going in. OUT counter counts the number of vehicles going out. When the number of vehicles in the parking lot reached 10, red light glows

Module 5: SCADA	**No. of Hrs: 8 + 4**

Introduction, SCADA system block diagram, functions of SCADA, applications, SCADA hardware overview, SCADA software, SCADA architecture, Remote Terminal Units (RTU), Control processor, Analog input modules, Analog outputs, Digital inputs, Digital output module, Communication interface, communication architectures, power supply module, SCADA protocols, HDLC protocol, CSMA/CD protocol, Distributed Network Protocol

Textbook 1: Chapter 4 – Section 4.1 – 4.8

Laboratory Components:

1. Design PLC based temperature sensing using RTD
2. Design temperature sensing using SCADA

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

1. Understand the principles of industrial automation
2. Describe the architecture and components of PLC systems
3. Implement PLC ladder logic programs for a variety of automation tasks
4. Apply advanced programming concepts such as counters and timers for automation
5. Explain SCADA systems and communication protocols

Textbooks:

1. Chanchal Dey and Sunit Kumar Sen, "Industrial Automation Technologies", 1st Edition, CRC Press, 2020
2. Mikkel P. Groover, "Automation, Production Systems, and Computer-Integrated Manufacturing", 4th Edition, Pearson, 2015
3. Madhuchhanda Mitra and Samarjit Sen Gupta, "Programmable Logic Controllers and Industrial Automation", 4th Edition, Penram International, 2012

Reference Book:

1. Frank D. Petruzella, "Programmable Logic Controllers", 6th Edition, McGraw Hill, 2023

Web Links:

1. What is Industrial Automation: https://www.youtube.com/watch?v=tw-79FiRYKA&pp=ygUVaW5kdXN0cmlhbCBhdXRvbWF0aW9u
2. Difference between PLC and SCADA: https://www.youtube.com/watch?v=gC4MEhx3NnM&pp=ygUNcGxjIGFuZCBzY2FkYQ%3D%3D
3. PLV vs SCADA vs DCS: https://www.youtube.com/watch?v=uhZnVwkWgFw&pp=ygUNcGxjIGFuZCBzY2FkYQ%3D%3D

Computer Aided Machine Drawing			
Semester	**V**	CIE Marks	**50**
Course Code	**23MTPC303**	SEE Marks	**50**
Teaching Hours/Week (L: T: P)	**2:0:2**	Exam Hrs	**03**
Total Hours	**50**	Credits	**03**

Course Learning Objectives: This course is designed to

1. Deliver the knowledge of limits, tolerance, and fits and indicate them on machine drawings
2. Familiarize with drawings using orthographic projections and sectional views
3. Impart the knowledge of thread forms & fasteners
4. Familiarize with joints & couplings
5. Provide knowledge of drawing machine components using CAD packages leading to the preparation of assembly drawings

Module 1: Geometrical Dimensioning and Tolerances	**No. of Hrs: 04+02**

Review of basic concepts of Engineering Visualization
Geometrical Dimensioning and Tolerances (GD&T): Introduction, Fundamental Tolerances, Geometrical Tolerances on drawings. Deviations, Methods of placing limit dimensions, Machining Symbols, Types of Fits with symbols and Applications, and Standards followed in industry

Textbook 1: Chapter 20

Module 2: Section of Solids	**No. of Hrs: 06+06**

Sections of Pyramids, Cones, Prisms, Cylinders and resting only on their bases (No problems on axis inclinations, spheres and hollow solids). True shape of sections

Textbook 2: Chapter 5

Module 3: Threads and Fasteners	**No. of Hrs: 05+04**

Thread Forms: Thread terminology, sectional views of threads. ISO Metric (Internal & External), BSW (Internal & External) square and Acme. Seller's thread
Fasteners: Specification, Representation, Right and Left-hand Threads, Single and Multi-start threads, Hexagonal headed bolt and nut with washer (assembly), Square headed bolt and nut with washer (assembly)

Textbook 2: Chapter 7 and 8

Module 4: Joints and Couplings	**No of Hrs: 05+04**

Joints: Cotter joint (socket and spigot) and Knuckle joint (pin joint)
Couplings: Flange coupling, Flexible Coupling, Oldham's coupling and Universal coupling

Textbook 2: Chapter 9 and 14

Module 5: Assembly Drawings	**No of Hrs: 06+08**

(Part drawings should be given)

1. Screw Jack (Bottle type)
2. Plummer Block (Pedestal Bearing)
3. Machine Vice
4. Connecting Rod of an IC Engine
5. Stepper Motor
6. Robotic Arm

Textbook 2: Chapter 20

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

1. Acquire the knowledge of limits, tolerance and fits in machine drawing
2. Incorporate the understanding of the theory of orthographic projection and develop the sectional views of solids using orthographic projections
3. Develop drawings of different threads and fasteners using 3D CAD packages
4. Develop drawings of different mechanical joints and couplings using 3D CAD packages
5. Model machine components and develop machine drawings in 2D &3D to produce assembly drawings using part drawings

Textbooks:

1. N Sidheswar, P Kannaiah & V V S Sastry, "Machine Drawing", 1st Edition, Tata McGraw-Hill Publishing Company Limited, 2008
2. N. D. Bhat, V. M. Panchal & Pramod R Ingle, "Machine Drawing", 51st Edition, Charotar Publishing House Pvt Ltd, 2022

Reference Books:

1. K.R. Gopalakrishna, "Machine Drawing", 23rd Edition, Subhas Publication, 2017
2. S. Trymbaka Murthy, "A Text Book of Computer Aided Machine Drawing using SOLID EDGE", 2nd Edition, CBS Publishers, 2008
3. "A Primer on Computer Aided Machine Drawing", 1st Edition, Published by VTU, Belagavi, 2007

Web Links:

1. Basics of GD & T - https://www.youtube.com/@Gdandtbasics/videos
2. Introduction to Machine Drawing - https://www.youtube.com/watch?v=ptJfomL1I7o&list=PLLvBXFAV-DeIsmVkmcNv2RzwCuT1XvhTV
3. 3D modelling in Solid Edge - https://www.youtube.com/watch?v=XXAcgtF5sBE&list=PLAELa0kqRz65ctxT4eDmlF6kz4BENZbDS

Systems Engineering			
Semester	**V**	CIE Marks	**50**
Course Code	**23MEPC304**	SEE Marks	**50**
Teaching Hrs/Week (L: T: P)	**2:0:2**	Exam Hrs	**3**
Total Hrs	**50**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Impart fundamental Systems Engineering principles and their application to real-world engineering problems
2. Familiarize system life cycle approach and functional & feasibility analysis
3. Teach simulation tools and techniques to explore, validate, and optimize system performance requirements
4. Familiarize with verification and validation strategies to ensure system reliability, effectiveness, and successful deployment

Module 1: Foundations of Systems Engineering (SE)	**No. of Hrs:6 +4**

Introduction, systems engineering & traditional engineering, functions, examples, challenges, perspectives, systems domains, fields, approaches, activities and products

Textbook 1: Chapter 1

Practice sessions:
Case Study on breaking down a complex mechanical system (e.g., car engine) and map its components to Systems Engineering concepts
Role-playing exercises with assigned roles (e.g., systems engineer, project manager) and discuss solutions to common challenges

Module 2: System Development Process	**No. of Hrs:6+4**

Systems engineering life cycle, concept development stage, engineering development stage, post-development stage, and systems engineering methods, Systems Engineering Standards : ISO15288, IEC61508, ISO26262

Textbook 1: Chapter 4 - Sections 4.1, 4.2 and 4.4

Practice sessions:

1. Life cycle Model Creation using software tools (Systems Modeling Language -SysML) to visually represent a system's life cycle (e.g., HVAC system).
2. System Lifecycle Analysis of a given system (e.g., industrial robot) and identify necessary engineering tasks at each lifecycle phase

Module 3: Concept Development	**No. of Hrs: 4+6**

Needs analysis, originating a new system, operations analysis, functional analysis, feasibility definition, needs validation, system operational requirements

Textbook 1: Chapter 6 - Section 6.1, 6.2, 6.3, 6.4, 6.5 and 6.6

Practice sessions:

1. Conduct a need analysis (by interviewing potential users, analyzing market trends, and considering technical feasibility) for a new mechanical product (e.g., an energy-efficient vehicle) and present their findings.
2. Develop a functional flow block diagram by breaking down a system based on functionality

Module 4: Simulation & Model-Based System Engineering	**No. of Hrs: 6+4**

Developing the system requirements, operational requirements analysis, performance requirements formulation, implementation of concept exploration, and performance requirements validation

Operational Simulation, System Effectiveness Simulation, Mission, Types of Simulation - Physical, Hardware - in - the - Loop, Engineering, Environmental & Virtual Reality; Simulation Verification and Validation

Quality of great models, stitching the models, model-based attribute tradeoffs & decision making

Textbook 1: Chapter 7 - Section 7.1, 7.2, 7.3, 7.4 and 7.5
Chapter 9 - Section 9.4

Practice sessions:

1. Use simulation software to develop a simple model of a system component (e.g., a mechanical subsystem) and experiment with different parameters and analyze the system's behavior under various conditions
2. Develop performance requirements for a new system (e.g., wind turbine) and use simulation results to validate the requirements

Module 5: Integrating, Testing, and Evaluating the Total System	**No. of Hrs: 4+6**

Integration and evaluation phase in a system life cycle, Systems Engineering Method in Integration and Evaluation, System Integration - Physical Test Configuration, Subsystem Integration, Total System Integration, Operational Test and Evaluation

Textbook 1: Chapter 13

Practice sessions:

1. Verification & Validation of a Project by developing and executing test plans for a mechanical system (e.g., a mechanical arm) and performing unit, integration, and system testing
2. Deployment strategies for a system (e.g., a factory automation line), including testing, installation, and validation phases

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

1. Explain fundamental Systems Engineering principles and their relevance to engineering challenges
2. Apply the system life cycle approach to design and evaluate engineering systems
3. Identify system needs and perform feasibility analysis to define operational requirements
4. Demonstrate the application of simulation tools to validate and optimize system performance
5. Develop verification and validation strategies for testing and deploying engineering systems

Textbook:

1. Kossiakoff, A., Sweet, W. N., Seymour, S. J., & Biemer, S. M., "Systems engineering principles and practice", 2nd Edition, Wiley, 2011

Reference Books:

1. Dennis M. Buede, "The Engineering Design of Systems: Models and Methods", 20th Edition, Wiley-Interscience, 2011
2. Reinhard Haberfellner, Olivier de Weck, Ernst Fricke, Siegfried V, "Systems Engineering: Fundamentals and Applications", Springer Nature link, 2019
3. Wasson C. S.,"System engineering: Analysis, design, and development", 2nd Edition, Wiley, 2015

Web links:

1. Module 1: https://ocw.mit.edu/courses/16-842-fundamentals-of-systems-engineering-fall-2015/pages/lecture-notes/
2. Module 2: https://www.youtube.com/watch?v=-gmDkEHl004
3. Module 3: https://www.youtube.com/watch?v=H2WQ2qH2G3M
4. Module 4: https://www.youtube.com/watch?v=pmUkmawKrMA
5. Module 5: https://www.youtube.com/watch?v=avMnK9FpZd0
6. Design Architectures and Activity Diagram for Mobile Robot : https://in.mathworks.com/help/systemcomposer/ug/design-architectural-models.html
7. Modeling System Architecture of Keyless Entry System: https://in.mathworks.com/help/systemcomposer/ug/modeling-system-architecture-of-keyless-entry-system.html

Structural and Electromechanical Analysis Lab			
Semester	**V**	CIE Marks	**50**
Course Code	**23MTPC305**	SEE Marks	**50**
Teaching Hrs/Week (L: T:P)	**0:1:3**	Exam Hrs	**2.5**
Total Hrs	**36**	Credits	**02**

Course Learning Objectives: This course is designed to

1. Impart knowledge on modeling 2D components such as bars & trusses in the FEA tool
2. Familiarize linear static analysis of bar and truss
3. Provide knowledge of piezoelectric components
4. Enable students to perform electro-mechanical analysis using the FEA tool

Introduction to Finite Element Analysis	**No. of Hrs: 12**

Definition of FEM, Steps Involved in FEM, Introduction to FEA Tool – Physical Model, Descritization, Boundary Conditions, Physical Properties, Types of analysis – Structural, Thermal, Fluid Flow & Coupled field, Introduction to Smart Materials – Piezoelectric Actuators, Properties and Applications

Sl. No.	**Experiments**
1	Determine maximum stress and displacement for a given bar & stepper bar component
2	Determine maximum stress and displacement for a given bar component of different cross section
3	Estimate the maximum stress and displacement for a specified truss component
4	Calculate the maximum stress, strain, and displacement for a specified 2D plate component.
5	Determine maximum stress, strain, and displacement for a given 2D plate component with 10mm diameter hole
6	Determine the maximum stress and displacement of a 3D component
7	Execute static analysis (coupled field) on piezoelectric 3D components of various cross- sections to determine deflection when applied with an electric voltage
8	Perform static analysis (coupled field) on piezoelectric 3D components of various cross sections to determine the electric voltage to be applied for a resulting displacement of 20µm
9	Carry out static analysis (coupled field) on piezoelectric 3D components of various cross sections to determine the electric voltage to be applied for a resulting displacement of 70µm
10	Perform static analysis (coupled field) for an applied voltage of 50V and determine the beam tip deflection for the piezoelectric beam
11	Conduct static analysis (coupled field) for an applied beam tip deflection of 15 mm and determine the electrode voltage for the piezoelectric beam
12	Perform static analysis (coupled field) for an applied voltage of 100V and determine the center deflection for a piezoelectric wafer

Course outcomes: At the end of the course, the student will be able to

1. Create 2D models of different components in FEA software
2. Analyze various structures for stress and strain
3. Apply coupled field analysis methods for electromechanical analysis of smart materials
4. Analyze piezoelectric structures for different applications

Textbooks:

1. Singiresu S Rao, "The Finite Element Method in Engineering", 4th Edition, Butterworth Heinemann, Elsevier, 2011
2. Tirupathi R Chandrupatla, Ashok D Belegundu, "Introduction to Finite Elements in Engineering", 3rd Edition, PHI, 2009

Reference Books:

1. C S Krishnamoorthy, "Finite Element Analysis – Theory and Programming", 2nd Edition, Tata McGraw Hill Publishing Company, 2019
2. J N Reddy, "An Introduction to the Finite Element Method", 3rd Edition, Tata McGraw Hill Edition, 2013

Web Links:

1. Finite Element Method: https://archive.nptel.ac.in/courses/112/105/112105308/
2. Analysis of Micro-ElectroMechanical System (MEMS): https://www.youtube.com/watch?v=fbLnyFmCHuA

Industry 4.0 and IoT			
Semester	**V**	CIE Marks	**50**
Course Code	**23MTPE311**	SEE Marks	**50**
Teaching Hrs/Week (L: T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Impart knowledge of Industry 4.0 fundamentals
2. Provide an understanding of Industrial IoT
3. Equip with knowledge of key industry 4.0 technologies
4. Impart knowledge of sensors, actuators, and data handling
5. Familiarize the concepts of machine learning and data science for Industry 4.0

Module 1: Fundamentals of Industry 4.0	**No. of Hrs: 8**

Industrial revolutions and evolution of Industry 4.0, Comparison between industry 4.0 and traditional automation, Applications of Industry 4.0, Design requirements of Industry 4.0, Drivers of Industry 4.0, Megatrends, Lean production, Smart Sensors, Sustainability Assessment, Smart Business Model, Impact of Industry 4.0

Textbook 1: Chapter 2 and 3

Module 2: Industrial IoT	**No. of Hrs: 8**

Introduction, IIoT and Industry 4.0, Prerequisites of IIoT, Basics of Cyber Physical Systems, Design of industrial Internet systems, Impact of Industrial Internet, Benefits of Industrial Internet, Industrial sensing, Smart sensing, Industrial processes, Applications of IIoT, Business models of IoT and IIoT, Reference architecture of IoT and IIoT, Categorization of reference architecture

Textbook 1: Chapter 4 and 5

Module 3: Key Technologies of Industry 4.0 and IoT	**No. of Hrs: 8**

Off-site key technologies – Cloud computing, Industrial cloud platforms, Fog computing and its applications On-site key technologies – Augmented reality; Virtual reality; Big Data and Advanced Analytics: Categories, characteristics, sources, necessity of data analytics Smart factories: characteristics, technologies used; Lean manufacturing system

Textbook 1: Chapter 6 and 7

Module 4: Sensors, Actuators, and Data Handling	**No. of Hrs: 9**

Sensor characteristics, Sensor categories, Actuators – thermal, hydraulic, pneumatic, electromechanical

Industrial Data transmission: Foundation Fieldbus, Profibus, HART protocol, Controller Area Network (CAN), Device Net, LoRA, IEEE 802.11AH

Industrial Data Acquisition: Distributed Control System (DCS), PLC, SCADA
IIoT Analytics: Necessity of analytics, Categorization of analytics, Challenges, Deployment of analytics

Textbook 1: Chapter 8, 9 and 10

Module 5: Machine Learning and Data Science in Industries	**No. of Hrs: 9**

Introduction, Machine Learning: Categorization – Supervised learning, unsupervised learning, reinforcement learning; Applications of ML in industries; Data science in industries Deep learning, Applications of deep learning in industries

Case Studies: IIoT in Healthcare, IIoT in inventory management and Quality control, Plant safety and security
Textbook 1: Chapter 13-17

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

1. Explain the concept of Industry 4.0 and allied technologies
2. Describe the foundational concepts of Industrial IoT
3. Explain Industry 4.0 technologies, such as cloud computing, augmented reality, and big data analytics
4. Describe the functions of sensors, actuators, and data handling systems
5. Illustrate how Machine learning and Data Science are applied across various industries

Textbooks:

1. Sudip Misra, Chandana Roy and Anandarup Mukherjee, "Introduction to Industrial Internet of Things and Industry 4.0", 1st Edition, CRC Press, 2021
2. Ravi Kant and Hema Gurung, "Industry 4.0: Concepts, Processes and Systems", 1st Edition, CRC Press, 2023

Reference Books:

1. Alasdair Gilchrist "Industry 4.0 – The Industrial Internet of Things", 1st Edition, Apress. 2016
2. Klaus Schwab, "The Fourth Industrial Revolution", 1st Edition, World Economic Forum, 2016

Web Links:

1. What is Industry 4.0: https://www.youtube.com/watch?v=b9mJrzdlfR8&pp=ygUMaW5kdXN0cnkgNC4w
2. Industry 4.0 https://youtu.be/yKPrJJSv94M
3. Lectures on Industry 4.0 and IIoT: https://www.youtube.com/watch?v=hv-aBonZMRQ&list=PLdYcKdE5uRf1lvXANoaOaYQTe4DrINPZO

Mechanisms and Design of Machine Elements			
Semester	**V**	CIE Marks	**50**
Course Code	**23MTPE312**	SEE Marks	**50**
Teaching Hours/Week (L: T:P)	**3:0:0**	Exam Hrs	**03**
Total Hours	**42**	Credits	**03**

Course Learning Objectives: This course is designed to

1. Impart fundamental knowledge of mechanisms, types of mechanisms, and their inversions
2. Familiarize belt drives for power transmission and cam profiles
3. Present theories of failure and explain design of machine elements against static and fluctuating loads
4. Familiarize with gear terminology & design spur and helical gears for power transmission

Module 1: Introduction to Mechanisms — **No. of Hrs: 08**

Mechanisms: Link, types of links, joint, types of joints kinematic pairs, Constrained motion, kinematic chain, mechanism and types, degrees of freedom of planar mechanisms, Grashoff's criteria and types of four-bar mechanisms, inversions of four bar chain, slider crank chain, Doubler slider crank chain and its inversions

Mechanisms: Quick return motion mechanisms Drag link mechanism, Whitworth mechanism and Crank and slotted lever Mechanism. Straight line motion mechanisms

Intermittent Motion mechanisms: Geneva wheel mechanism, Ratchet and Pawl mechanism, condition for correct steering, Ackerman steering gear mechanism

Textbook 1: Chapter 1

Module 2: Power Transmission Elements — **No. of Hrs: 09**

Flat Belt Drives, Ratio of Belt Tensions, Centrifugal Tension, Power Transmitted and simple numerical, Types of Cams, Types of followers & Displacement, Velocity and, Acceleration time curve for cam profiles, Disc Cam with Reciprocating Follower having Knife-Edge, Roller Follower, Follower Motions including SHM, Uniform Acceleration and Retardation

Textbook 1: Chapter 6

Module 3: Theories of Failure and Design for Static Loads — **No. of Hrs: 08**

Theories of Failure: Maximum Normal Stress Theory, Maximum Shear Stress Theory & Distortion Energy Theory Design Considerations, Tri-axial stresses, Stress Tensor, Codes and Standards, Factor of Safety, Design Procedure for Simple and Combined Stresses

Textbook 3: Chapter 1

Module 4: Design of Fatigue Loads — **No of Hrs: 09**

Introduction to Stress Concentration, Stress concentration Factor and its effects
Endurance limit, S-N Diagram, Low cycle fatigue, High cycle fatigue, Modifying Factors: Size Effect, Surface Effect. Stress Concentration Effects, Notch Sensitivity, Fluctuating Stresses, Goodman and Soderberg Relationship, Stresses due to Combined Loading & Cumulative Fatigue Damage

Textbook 3: Chapter 2 & 4

Module 5: Design of Spur and Helical Gears — **No of Hrs: 08**

Beam Strength of Spur Gear, Stresses in Gear Teeth (Lewis's Equation), Dynamic Tooth Load & Design for Wear, Beam Strength of Helical Gear, Stresses in Gear Teeth (Lewis's Equation), Dynamic Tooth Load & Design for Wear

Textbook 1: Chapter 14

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

1. Explain the kinematics associated with machines and their inversions
2. Select belt drives & construct cam profiles for different applications
3. Apply theories of failure for designing machine elements to sustain static loads
4. Design of machine elements against fluctuating loads
5. Design spur and helical gears for dynamic and wear loads

Textbooks:

1. Sadhu Singh, "Theory of Machines – Kinematics and Dynamics", 3rd Edition, Pearson Education, 2012
2. S S Rattan, "Theory of Machines", 3rd Edition, Tata McGraw Hill Education Private Limited, 2009
3. J.B.K. Das and Dr. P L Srinivasa Murthy, "Design of Machine Elements – I", 10th Edition, Sapna Book House (P) Ltd., 2015

Reference Books:

1. V B Bhandari. "Design of Machine Elements", 3rd Edition, Tata McGraw Hill Education Private Limited, 2010
2. David H Myszka, "Machines & Mechanisms – Applied Kinematic Analysis", 4th Edition, Pearson Education, Inc., 2012

Design Data Hand Book:

1. K Mahadevan and K Balaveera Reddy, "Design Data Hand Book for Mechanical Engineering in SI and Metric Units", 4th Edition, CBS Publishers and Distributors Pvt. Ltd., 2018

Web Links:

1. Theory of Mechanisms: https://nptel.ac.in/courses/112106270
2. Design of Gear: https://www.youtube.com/watch?v=qtqr9sj9w78&list=PLg9TnucUbzBXIqK0PhaE40cphW_ QGcq9F
3. Machine Design: https://nptel.ac.in/courses/112106137

Power Electronics			
Semester	**V**	CIE Marks	**50**
Course Code	**23MTPE313**	SEE Marks	**50**
Teaching Hrs/Week (L: T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Familiarize the working principles of Power semiconductor devices and its switching characteristics
2. Impart knowledge of thyristor characteristics to analyze their operation in power electronic circuits
3. Familiarize principle of operation of AC voltage controllers and Controlled rectifiers and their significance in power control applications
4. Emphasize the design aspects of choppers using power devices
5. Provide insights into design inverter circuits with different Pulse width modulation techniques

Module 1: Power semiconductor Device and its characteristics	**No. of Hrs: 8**

Applications of Power Electronics, Control Characteristics, Types of power electronics circuits, Peripheral effects

Power MOSFETs: switching characteristics, Gate drive, di/dt and dv/dt limitations, Isolation of gate and base drives

Textbook 1: Chapter 1 – Section 1.1, 1.3, 1.6 and 1.9
Chapter 4 – Section 4.3, 4.11, 4.14 and 4.17

Module 2: Thyristors	**No. of Hrs: 8**

Characteristics, Two Transistor Model, Turn-on and turn-off, di/dt and dv/dt protection, Thyristor types, Thyristor firing circuits, Simple design of firing circuits using UJT. Communication Techniques: Natural Communication

Forced commutation: Self-commutation, Impulse commutation, Resonant pulse commutation and Complementary commutations

Textbook 1: Chapter 9 – Section 9.2, 9.3, 9.4, 9.5, 9.6, 9.9, 9.10 and 9.13

Module 3: AC Voltage Controllers and Controlled Rectifiers	**No. of Hrs: 8**

AC Voltage Controllers: Principle of ON-OFF and phase control. Single-phase bidirectional controllers with resistive and inductive loads

Controlled Rectifiers: Single phase full converters, single phase dual converters, three-phase full converters

Textbook 1: Chapter 10 – Section 10.2, 10.3 and 10.4
Chapter 11 – Section 11.1, 11.2, 11.3 and 11.4

Module 4: DC Choppers	**No. of Hrs: 9**

Performance parameters of DC to DC converters, principle of step-down operation, step-down converter with RL - Load, principle of step-up operation, step-up converter with a resistive load, chopper classification

Textbook 1: Chapter 5 – Section 5.2, 5.3, 5.4, 5.5 and 5.6
Textbook 3: Chapter 8 – Section 8.2

Module 5: Inverters	**No. of Hrs: 9**
Principle of operation. Performance parameters. Single-phase bridge inverters. Three phase inverters. Voltage control of single-phase Inverters using Single pulse width, Multiple pulse width, and Sinusoidal Pulse width modulation Textbook 1: Chapter 6 – Section 6.2, 6.4, 6.5 and 6.6	

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

1. Explain control, switching characteristics and drive circuits for power semiconductor devices
2. Apply suitable commutation techniques in thyristor-based power electronic circuits.
3. Determine performance parameters of power converter circuits
4. Design step-down and step-up choppers for various load conditions
5. Develop inverter circuits with different modulation schemes

Textbooks:

1. Mohammad H Rashid. "Power Electronics: Circuits Devices and Applications", 4th Edition, Masood Books UP, 2017
2. M Morris Mano. "Power Electronics" 2nd Edition, McGraw Hill Education (India) Private Limited, 2017
3. M.D Singh, "Power Electronics", 2nd Edition, McGraw Hill Education (India) Private Limited, 2017

Reference Books:

1. Ned Mohan, "Power Electronics: Converters, Applications and Design", 3rd Edition, Wiley, 2014
2. Daniel W Hart. "Power Electronics", 1st Edition, McGraw Hill, 2011
3. P S. Bimbhra, "Power Electronics", 7th Edition, Khanna Publishers, 2022

Web Links:

1. Power Electronics: https://www.youtube.com/watch?v=1Auay7ja2oY
2. Introduction to Power Electronics: https://www.youtube.com/watch?v=djbJm-xWo2w&list=PLgwJf8NK-2e5Hnu82T1CYLZ8kbZs4Jx8x
3. Power Electronics: https://www.youtube.com/watch?v=g1bm6FP_oBQ

Mechatronics System Design			
Semester	**V**	CIE Marks	**50**
Course Code	**23MTOE311**	SEE Marks	**50**
Teaching Hrs/Week (L: T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Impart knowledge of basics of Mechatronics system design
2. Impart knowledge of modelling and simulation of physical elements
3. Provide the working of actuating devices and signals and systems
4. Familiarize signal conditioning methods and convert the data in real time interfacing
5. Familiarize real time mechatronic system design through case study

Module 1: Introduction to Mechatronics System Design	**No. of Hrs: 8**

Mechatronics Definition, integrated design issues in Mechatronics, the Mechatronics design process, the key elements, Application in Mechatronics-Condition Monitoring, Monitoring On- Line, Model-Based Manufacturing, Supervisory Control Structure, Embedded Sensors and Actuators, Rapid Prototyping of a Mechatronic Product, Opto-Mechatronics, E-Manufacturing

Textbook 1: Chapter 1

Module 2: Modeling of Physical Systems	**No. of Hrs: 8**

Operator notation and transfer functions, Block diagrams manipulations, block diagram modeling- Direct method and analogy approach, Electrical systems, Mechanical systems and Electromechanical Systems

Textbook 1: Chapter 2
Textbook 2: Chapter 9 – Section 9.3

Module 3: Actuating Devices, Signals and Systems	**No. of Hrs: 9**

Direct Current Motors, Permanent magnet stepper motor, Piezoelectric Actuators, Introduction to signals, systems and Controls,

Types of signals: continuous & discrete, even & odd, periodic & non-periodic, energy & power and deterministic & random signals Elementary Functions: step, impulse, ramp, exponential and sinusoidal functions

Basic Operations on signals: amplitude scaling, addition, multiplication, time scaling, time shifting and time reversal

Textbook 1: Chapter 4 – Section 4.1,4.2 and 4.5
Textbook 3: Chapter 1 – Section 1.1, 1.2, 1.3, 1.4, 1.5 and 1.6

Module 4: Signal Conditioning and Real time Interfacing	**No. of Hrs: 9**

Introduction, elements of Data Acquisition and Control System, Transducers and Signal Conditioning, Devices for data conversion, Data conversion process

Textbook 1: Chapter 7 – Section 7.1, 7.2, 7.3, 7.4 and 7.5

Module 5: Case Studies of Mechatronic System	**No. of Hrs: 8**

A pick-and-place robot, Car park barriers, Automotive control systems- ECU, Antilock braking system (ABS) control, Hard disk drive, Automatic washing machine

Textbook 2: Chapter 22

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

1. Explain the key elements and integrated components in mechatronics system
2. Develop mathematical modelling for physical systems
3. Describe the actuating devices, functions and operation of signals
4. Explain the use of signal conditioning techniques to process and convert data for real-time system interfacing
5. Discuss the different applications of mechatronics

Text Books:

1. Devdas Shetty and Richard A Kolk, "Mechatronics System Design", 2nd Edition, Cengage Learning, 2010
2. W. Bolton, "Mechatronics", 6th Edition, Pearson Education, 2015
3. Simon Haykin and Barry Van Veen, "Signals and Systems", 2nd Edition., Wiley India, 2021

Reference Books:

1. B. Mihura, "LabVIEW for Data Acquisition", Prentice Hall of India, 2013
2. K. Ogata, "Modern Control Engineering", 5th Edition, Pearson Education Asia/PHI, 2015

Web Links:

1. Mechatronics design approach: **https://youtu.be/pn0d1gjL7Vs?si=47oaD7dbIiafti7N**
2. Mechatronics: **https://onlinecourses.nptel.ac.in/noc21_me27/preview**

Virtual Instrumentation			
Semester	**V**	CIE Marks	**50**
Course Code	**23MTOE312**	SEE Marks	**50**
Teaching Hrs/Week (L: T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Familiarize the importance of Virtual Instrumentation (VI) and its architecture
2. Provide various operations of DAQ devices used in VI and LabVIEW
3. Provide the basic programming concepts in LabVIEW
4. Familiarize types of I/O module, Data Acquisition System, and Communication Networks (Bus Systems) using the Standard Protocol
5. Impart the knowledge on applications of VI

Module 1: Concept of Virtual Instrumentation	**No. of Hrs: 8**

Introduction of Instrumentation and Measurements Historical perspective, Need of VI, Advantages of VI, Define VI, Block diagram & Architecture of VI, Data flow techniques, Comparison with conventional programming and Graphical programming, PC based data acquisition – Typical on board DAQ card

Text book 1: Chapter 1
Text book 2: Chapter 1 – Section 1.2, 1.3 and 1.11

Module 2: Data Acquisition in Virtual Instrumentation	**No. of Hrs: 9**

Introduction to data acquisition on PC, Sampling fundamentals, Input/Output techniques and buses. ADC, DAC, Digital I/O, counters and timers, Direct Memory Access, Software and hardware installation, Calibration, Resolution Data acquisition interface requirements

Text book 1: Chapter 10
Text book 2: Chapter 11

Module 3: Graphical Programming	**No. of Hrs: 8**

VIs and sub VI, Loops (While Loop and For Loop), Charts, Structures (Case, Formula node, and sequence structures) Arrays, Array Functions, Clusters and Graphs, Strings, String Functions and file I/O

Text book 1: Chapter 3, 4, 5, 6 and 8

Module 4: Communication Protocols	**No. of Hrs: 8**

RS232, RS 422, RS 485 and USB standards – IEEE 488 standard – ISO OSI model for serial bus – Introduction to bus protocols of MOD bus and CAN bus

Text book 1: Chapter 13

Module 5: Application of Virtual Instrumentation	**No. of Hrs: 9**

Fourier transform, Power spectrum, Correlation, Windowing and filtering tools, Simple temperature indicator, ON/OFF controller, P-I-D controller, CRO emulation, Simulation of a simple second order system, Generation of HTML page

Text book 1: Chapter 14

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

1. Explain the concepts of Virtual Instrumentation and its applications over conventional programming techniques
2. Explain the fundamentals of Data Acquisition and its essential software and hardware requirements
3. Apply structured programming concepts using mathematical and logical for Virtual Instrumentation applications
4. Apply industry-standard protocols for efficient data transfer and communication
5. Apply inbuilt application tools to develop and analyze application-oriented Virtual Instruments

Text Books:

1. Sanjay Gupta and Joseph John, "Virtual Instrumentation using LabVIEW", 2nd Edition, Tata McGraw-Hill Publishing Company Limited, 2017
2. Jovitha Jerome, "Virtual Instrumentation using LabVIEW", 2nd Edition, PHI publication, 2010

Reference Books:

1. Jeffrey Travis and Jim Kring, "LabVIEW for Everyone: Graphical Programming Made Easy and Fun", 3rd Edition, Prentice Hall, 2007
2. Robert H. Bishop, "Learning with LabVIEW", 1st Edition, Pearson Publishing, 2014
3. Bruce Mihura, "LabVIEW for Data Acquisition", 1st Edition, Prentice Hall of India, 2013

Web Links:

1. Virtual Instrumentation Introduction: **https://youtu.be/EmmpdzBzY74?si=bD3geKQliMk2NOHP**
2. LabVIEW Software: **https://youtu.be/Sd0RhN7CigY?si=qla2XFp9zm3IZMZp**
3. Dataflow Programming: **https://youtu.be/ygTlvtPTD5w?si=0PPpsCjnFKa4LE_7**

Introduction to Industry 4.0			
Semester	**V**	CIE Marks	**50**
Course Code	**23MTOE313**	SEE Marks	**50**
Teaching Hrs/Week (L: T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Familiarize with concepts of Automation, Industry 4.0 (I 4.0), and Manufacturing systems and their functional components
2. Impart the knowledge of production parameters in the Industry 4.0 manufacturing system
3. Familiarize with concepts of different Manufacturing Systems in Industry 4.0

Module 1: Introduction to Automation and I 4.0	**No. of Hrs: 8**

Introduction to Automation in Production System: Principles and Strategies of Automation, Basic Elements of an Automated System and Levels of Automation

Industry 4.0: Introduction to I 4.0, Phase of I 4.0, Revolution of I 4.0, Application of I 4.0, Design Requirements of I 4.0, Introduction to IIoT, Prerequisites of IIoT, Applications of IIoT

Textbook 1: Chapter 1- Section 1.2, 1.4, 4.1 and 4.3
Textbook 2: Chapter 2- Section 2.2-2.2.1, 2.2.5, 2.3-2.3.1, 2.3.4 and 3.2

Module 2: Manufacturing Cells and Functional Components of I 4.0	**No. of Hrs: 9**

Single-Station Manufacturing Cells: Automated Cells, Applications and Analysis of Single-Station Cells

Sensors and Actuators: Introduction to Sensors, Sensor Categories: Thermal, Mechanical, Electrical, Chemical, Optical, Acoustic, Introduction to Actuators, Actuator Categories: Thermal, Hydraulic, Pneumatic, Electromechanical

Textbook 1: Chapter 14- Section 14.2-14.2.2, 14.3 and 14.4
Textbook 2: Chapter 8- Section 8.1 and 8.3
Chapter 9- Section 9.1-9.5

Module 3: Manufacturing System of I 4.0	**No. of Hrs: 9**

Automated Production Lines: Fundamentals & Applications of Automated Production Lines, Analysis of Transfer Lines

Automated Assembly Systems: Fundamentals & Analysis of Single and Multi-Station Automated Assembly Systems

Textbook 1: Chapter 16- Section 16.1-16.1.1, 16.2, 16.2.1 and 16.3
Chapter 17- Section -17.1, 17.2.2, 17.2.3 and 17.3

Module 4: Mass Production Key Technologies of I 4.0	**No. of Hrs: 8**

Lean Production: Introduction to lean production system, structure, comparison of mass and Lean production

Just-In-Time Production: Introduction to Just-In-Time Production Systems, pull and push system, reduced setup time

Textbook 1: Chapter 26- Section 26.1-26.2.2

Module 5: Batch Production Key Technologies of I 4.0	**No. of Hrs: 8**

Group Technology and Cellular Manufacturing: Introduction, Part Families and Composite Part Concept, Applications of Group Technology

Flexible Manufacturing Cells and Systems: Introduction, Types of FMS, FMS Components, FMS Application Considerations

Textbook 1: Chapter 18- Section 18.1-18.1.1, 18.2-18.2.1 and 18.3
Chapter 19- Section 19.1 and 19.3.2

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

1. Explain the principles and elements of Automation and Industry 4.0
2. Apply the fundamentals of the automated single-station cell to determine the required workload, workstations and time
3. Apply the fundamentals of automated production and assembly systems to enhance manufacturing efficiency
4. Explain the concepts of Lean and Just-In-Time production in mass production
5. Explain the concepts of Group Technology, Cellular Manufacturing and Flexible Manufacturing Systems in batch production

Textbooks:

1. Mikkel P. Groover, "Automation, Production Systems, and Computer-Integrated Manufacturing", 4th Edition, Pearson, 2015
2. Misra, Sudip, Chandana Roy, and Anandarup Mukherjee, "Introduction to Industrial Internet of Things and Industry 4.0", 1st Edition, CRC Press, 2021

Reference Book:

1. A. Gilchrist, "Industry 4.0: The Industrial Internet of Things", 1st Edition, Apress, 2016

Web Links:

1. Fundamentals of Industry 4.0: https://www.youtube.com/watch?v=U7UGkk0oKyM&t=35s
2. Single station manufacturing cells: https://www.youtube.com/watch?v=dh6FSc-qySg
3. Sensing and Actuation: https://www.youtube.com/watch?v=hv-aBonZMRQ&list=PLWbMIWDTOauBvP0ZxvoIshg55WPMF37UI
4. Modular Manufacturing System: https://www.youtube.com/watch?v=1UyNGwI0X3Q
5. Group Technology: https://archive.nptel.ac.in/courses/110/105/110105155/
6. IoT Based Home Automation System: ttps://www.youtube.com/watch?v=rlWVYBR-W54

Yoga-III			
Semester	**V**	CIE Marks	**100**
Course Code	**23NMCC321**	SEE Marks	**-**
Teaching Hours/Week (L: T: P)	**0:0:1**	Exam Hrs	**-**
Total Hours	**13**	Credits	**-**

Course Learning Objectives: This course is designed to

1. Empower students to achieve and maintain good health.
2. Promote the practice of mental hygiene.
3. Facilitate students in attaining emotional stability.
4. Impart moral values and higher level of consciousness.

Contents **No. of Hrs: 13**

- Ashtanga Yoga
  1. Asana
  2. Pranayama
  3. Pratyahara
- Suryanamaskar13 count- 3 rounds of practice
- Asana its meaning by name, technique, precautionary measures and benefits of each asana
- Different types of Asanas

a) Sitting
   1. Ardha Ushtrasana
   2. Vakrasana
   3. Yogamudra in Padmasana

b) Standing
   1. UrdhvaHastothanasana
   2. Hastapadasana
   3. ParivrittaTrikonasana
   4. Utkatasana

c) Prone line
   1. Padangushtha Dhanurasana
   2. Poorna Bhujangasana

d) Supine line
   1. Sarvangasana
   2. Chakraasana
   3. Navasana/Noukasana
   4. Pavanamuktasana

- Revision of Kapalabhati practice 30 strokes/min 3 rounds
- Meaning by name, technique, precautionary measures and benefits of each Pranayama
  1. Ujjayi
  2. Sheetali
  3. Sheektari

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

1. Describe the meaning, aim and objectives of Yoga
2. Perform Suryanamaskar and able to analyze its benefits
3. Exhibit the different Asanas by name, its importance, methods and benefits
4. Perform Kapalabhati.
5. Perform the different types of Pranayama by its name, precautions, procedure and uses

Textbooks:

1. Ajitkumar, " Y o g a Pravesha in Kannada" 1st Edition, Raashtroththaana Saahithya,2017, ISBN-13: 978-8175310124
2. BKS Iyengar, "Light on Yoga", 1st Edition, Thorsons, 2017, ISBN-13: 978-0008267919
3. Dr. M L Gharote & Dr. S K Ganguly, "Teaching Methods for Yogic practices", 1st Edition, Kaivalyadhama, 2001, ISBN-13: 978-8189485252

Reference Book:

1. Yamini Muthanna, "Yoga for Children step by step", 1st Edition, Om Books International, 2022, ISBN-13: 978-9394547018

Web links:

1. My Life My Yoga , https://youtu.be/KB-TYlgd1wE
2. Adiyoga, https://youtu.be/aa-TG0Wg1Ls

Scheme and Assessment:		
Sl. No.	Activity	Marks
1	Quiz	20
2	Practical demonstration	50
3	Final Report	30

Physical Education-III			
Semester	**V**	CIE Marks	**100**
Course Code	**23NMCC322**	SEE Marks	**-**
Teaching Hours/Week (L: T: P)	**0:0:1**	Exam Hrs	**-**
Total Hours	**13**	Credits	**-**

Course Learning Objectives: This course is designed to

1. Impart the fundamental concepts and skills of Physical Education, Health, Nutrition and Fitness
2. Familiarization of health-related Exercises, Sports for overall growth and development
3. Build a strong foundation for the professionals in Physical Education and Sports

Contents	**No. of Hrs: 13**

- Ethics in Sports & Moral Values in Sports and Games
- Sports Training Methods and its Impacts: Continuous Training, Interval Training, Circuit Training, Weight Training.
- FITT Implementing FITT principles to design personalized fitness programs. (Lectures & Practical Sessions)
- Specific Games (Students continue prior semester's game by practicing Intermediate Skills)

Basket	Crossover dribble - Between-the-legs dribble - Bounce pass and no-look pass
Ball	Shooting with form from mid-range - Defensive stance and footwork
Cricket	Advanced batting shots (cover drive, square drive, pull shot) - and seam bowling variations - Fielding positions and strategies - Game sense and awareness
Football	Shielding the ball - Crossing the ball - Long passing and through balls - Tackling techniques (sliding & standing) - Shooting with power and accuracy - Playing different positions
Hockey	Stickhandling in tight spaces - Slapshot and sweep shot techniques - Passing with speed and accuracy - Dodging defenders - Defensive positioning and checking
Kabaddi	Advanced raiding techniques (frog jump, jump over) - Diverse raiding holds (frog kick, thigh hold) - Anticipation and countering defense - Effective raiding strategies - Advanced team defense formations
Karate	Kihon (repetition of basic techniques) - Kata (forms to practice technique and flow) - Combinations of punches and kicks - Footwork and movement - Basic kumite (sparring) techniques
Table	Looping technique (forehand and backhand) - Topspin and backspin serves -
Tennis	Footwork for attacking and defense - Blocking and countering techniques - Match strategy and tactics
Throwball	Long throws and bounce passes - Fake passes and deception moves - Dodging techniques to create space - Defensive positioning and guarding techniques - Team offense and set plays
Volleyball	Attack, Block, Service, Upper Hand Pass and Lower hand Pass

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

1. Develop strategies to promote ethical conduct and a positive sporting culture.
2. Understand the importance of ethics and moral values in sports and games.
3. Perform in the selected sports or athletic events

Textbooks:

1. Muller, J. P., "Health, Exercise and Fitness", 1st Edition, Sports Publication, 2018.
2. Uppal, A.K., "Physical Fitness", Friends Publication New Delhi, 1992.
3. Russell R.P., "Health & Fitness through Physical Education: Human Kinematics", Human Kinetics Publishers, 1994

Reference Books:

1. Anaika, "Play Field Manual", Friends Publication New Delhi, 2005.
2. IAAF Manual
3. Pinto John & Roshan Kumar Shetty, "Introduction to Physical Education"

Web links:

1. https://www.youtube.com/watch?v=wvlztaJYKYI
2. https://www.youtube.com/playlist?list=PLHCNPOIaj2Wc8P5xAWq9g2DUrrbixoTOK
3. https://www.youtube.com/watch?v=K9X_wB1Yu84
4. https://www.youtube.com/watch?v=HEHggOOds1w&list=PLgVaM7Baa_8myp4njEDc oYyZkBq-542S5

Scheme & Assessment of students for auditing the course & Grades		
Sl. No.	Activity	Marks
1	Participation of students	20
2	Quizzes-2, each of 15 marks	30
3	Final presentation/Exhibition/Participation in Competitions (Certificate of participation in National/International)	50
	Total	**100**

National Service Scheme-III			
Semester	**V**	CIE Marks	**100**
Course Code	**23NMCC323**	SEE Marks	
Teaching Hours/Week (L: T: P)	**0:0:1**	Exam Hrs	
Total Hours	**13**	Credits	**-**

Course Learning Objectives: This course is designed to

1. Develop discipline, character, brotherhood, the spirit of adventure and ideals of selfless service amongst young citizens
2. Develop youth leadership in the students.
3. Induce social consciousness among students through various societal activities.
4. Impart knowledge in finding practical solutions to individual and community problems

NSS -Contents	**No. of Hrs: 13**

Introduction:

- Promoting a healthy lifestyle among youth
- Nutrition education, stress management and mental health activities

Activities:

- Village awareness programs on women hygiene, various superstitious beliefs, avoiding self-medication, etc.
- Helping local schools to achieve good results and enhance their enrolment in Higher/technical/ vocational education

Note:

- Students in individual or in a group should select any one activity in the beginning of each semester till end of that respective semester for successful completion as per the instructions of NSS officer with the consent of HOD of the department.
- At the end of every semester, activity report should be submitted for evaluation.

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

1. Understand the importance of nation building and individual contribution to the betterment of the society
2. Discover grassroots challenges of community and solve them by technological intervention
3. Create societal impact by upholding the value of one for all and all for one
4. Maintain discipline and team spirit

Textbooks:

1. Ministry of Youth Affairs & Sports, Government of India (2022) "National Service Scheme Manual"
2. Rajiv Gandhi National Institute of Youth Development, Ministry of Youth Affairs & Sports, Government of India, (2017) "Introduction Training Module for National Service Scheme (NSS) Program officers",
3. Gurmeet Hans (1996), "Case material as Training Aid for field workers" TISS

Reference Books:

1. Dr. G R Bannerjee, (2012), Social service opportunities in Hospitals, TISS
2. Ram Ahuja (Third Edition) 2014, Social Problems in India, Rawat Publications

Web links:

1. History of NSS https://thebetterindia.com/140/national-service-scheme-nss/
2. NSS – an introduction https://www.youtube.com/@nationalserviceschemeoffic4034/videos

Assessment details (CIE): Students will be assessed with the	
Weightage	CIE
Participation of students	30 Marks
Individual contribution to success of the program	40 marks
Report preparation	30 Marks
Total marks	100 Marks

Arts-III			
Semester	**V**	CIE Marks	**100**
Course Code	**23NMCC324**	SEE Marks	**-**
Teaching Hours/Week (L: T: P)	**0:0:1**	Exam Hrs	**-**
Total Hours	**13**	Credits	**-**

Course Learning Objectives: This course is designed to

1. To impart an understanding of the creative process from initial concept to final execution.
2. Create and demonstrate proficiency in a chosen arts discipline through practical application.
3. Analyze and appreciate diverse art forms and styles
4. To participate in art competitions at regional, state, national, and international levels, as well as in cultural events

Contents	**No. of Hrs: 13**

Note: Student will continue the arts form selected in previous semester.

Performing Arts (Dance)	Orientation, Cinema Acting Basics, Facial Expression Exercises, Body Language, Camera Angles, Characterization demo and Practice, Individual Presentations, Evaluation.
Music	Orientation, Film Songs, Karaoke Singing, Rhythm Fusion and voice, Individual Presentation, song styles demo and practical, Evaluation.
Arts & Crafts	Orientation, Craft Forms, Paper Craft, Mask Making, Model Making, Thermocol Art, Finger Puppet Making, Group Presentation, Evaluation.
Theatre	Orientation, Introduction to Theatre Sets and properties, Practical use of properties, Set Designing, Costume Design, Headgears and Masks, Theatre Makeup, Evaluation.

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

1. To be capable of creating choreography and delivering live performances for an audience.
2. Employ a range of acting techniques and use them to create a performance.
3. Evolve into creative, effective, independent, and reflective individuals capable of making informed decisions in both process and performance.
4. Acquire knowledge and comprehension of the roles and processes used in current theatre arts practice.

Textbooks:

1. Music in Theory and Practice by Bruce Benward and Marilyn Sake, McGraw-Hill Education,2014
2. Art Fundamentals: Theory and Practice by Otto G. Ocvirk, Robert E. Stinson, Philip R. Wigg, Robert Bone, and David L. Cayton, McGraw-Hill Education, 2012
3. The Viewpoints Book: A Practical Guide to Viewpoints and Composition by Anne Bogart and Tina Landau, Theatre Communications Group, 2004

Reference Books:

1. Dance Composition: A practical guide to creative success in dance making, Jacqueline M. Smith
2. The Artist's handbook of method and materials by Ralph Mayer
3. Glimpses of Indian music and dance by Dr. Arun Bangre.

Web links:

1. https://ccrtindia.gov.in/audio-visual-catalogue/

Scheme & Assessment of students for auditing the course & Grades		
Sl. No.	Activity	Marks
1	Students Participation	20
2	Quizzes-2 (each of 15 marks)	30
3	Final presentation/Exhibition/Participation in Competitions	50
	Total	**100**

Fundamentals of HDL			
Semester	**VI**	CIE Marks	**50**
Course Code	**23MTPC306**	SEE Marks	**50**
Teaching Hrs/Week (L: T: P)	**3:0:2**	Exam Hrs	**3**
Total Hrs	**64**	Credits	**4**

Course Learning Objectives: This course is designed to

1. Build a foundation in HDL, focusing on its structure and its applications in digital system design
2. Impart proficiency in modeling combinational and sequential circuits using data flow and behavioral techniques in HDL
3. Impart skills in creating modular digital designs through structural modeling and parameterized components
4. Familiarize with procedures, tasks, and functions in HDL, emphasizing modularity and code reusability

Module 1: Introduction to HDL — **No. of Hrs: 8+4**

Hardware Description Language and evolution, Structure of HDL Module, Operators, Data types, Types of Descriptions, Simulation and Synthesis, Brief Comparison of VHDL and Verilog

Textbook 1: Chapter 1

Laboratory Components:

1. Introduction to HDL code and to realize all logic gates and verify the results using testbench
2. Given a logic expression, simplify it using k-map and implement the simplified expression using HDL

Module 2: Data Flow Modeling — **No. of Hrs: 8+4**

Highlights of Data-Flow Description, Data flow discerption of full adder, Subtractor, Signal Declaration and Assignment Statement, multiplexer with assignment statement, Data Type: Vector, Delay Latch, Common Programming Errors

Textbook 1: Chapter 2

Laboratory Components:

1. HDL code to describe the functions of a Full Adder using three modeling styles
2. Design an HDL program for the following combinational circuits:
   a) Multiplexers
   b) Demultiplexers

Module 3: Behavioral Modeling — **No. of Hrs: 8+6**

Behavioral Description highlights, structure of HDL behavioral Description, The VHDL Variable-Assignment Statement, Sequential Statements, If statement, Signal and Variable assignment Case Statement and Loop statement, Common Programming errors

Textbook 1: Chapter 3

Laboratory Components:

1. Design an HDL program for the following combinational circuits:
   a) Decoders
   b) Encoders
2. HDL Code to develop Magnitude comparator
3. HDL program to design 4 bits Binary to Gray converter

Module 4: Structural Modeling	**No. of Hrs: 8+6**

Importance of structural Description, Organization of the structural Descriptions, Binding, state Machines, Generate, Generic, and Parameter statements

Textbook 1: Chapter 4

Laboratory Components:

1. HDL program to implement the up counter and the down counter
2. HDL program to implement synchronous counter (Ring counter and Johnston's counter)
3. Develop the HDL code for the following flipflops: T, D, SR, JK

Module 5: Procedures, Tasks and Functions	**No. of Hrs: 8+6**

Importance of Procedures, tasks, and Functions, N bit ripple carry adder and binary vector to integer conversion using Procedures and tasks, Functions, Implementation of IEEE 754 Floating-Point Representation using function

Textbook 2: Chapter 6

Laboratory Components:

1. HDL code to implement an N-bit ripple carry adder using a function or procedure
2. HDL function to convert a 32-bit IEEE 754 floating-point number into its decimal equivalent

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

1. Explain the basics of HDL, focusing on its structure, data types, and simulation.
2. Apply data flow modeling concepts to efficiently design HDL modules
3. Implement behavioral modeling techniques for effective sequential and conditional HDL programming
4. Design digital systems using structural modeling, including state machines and advanced constructs
5. Implement reusable procedures, tasks, and functions in HDL with practical applications

Textbooks:

1. Nazeih M. Botros, "HDL with Digital Design: VHDL and Verilog", 7th Edition, Mercury Learning and Information 2015
2. Nazeih M. Botros, "HDL Programming VHDL and Verilog", 3rd Edition, John-Wiley India Pvt. Ltd, 2015

Reference Books:

1. M Morris Mano and Michael D Ciletti, "Digital Design with Introduction to the Verilog HDL", 5th Edition, Pearson Education, 2015
2. Douglas Perry, "VHDL: Programming by Example", 4th Edition, Tata McGraw-Hill Publication, 2004

Web Links:

1. Introduction to HDL https://youtu.be/IZDgIg6cllw?si=oZHM2p3Wfgu7opro
2. Behavioral modelling & Data flow modelling https://youtu.be/DoqQdddSO3M?si=KFq2ykSL_8I4ELHK
3. HDL Code for Adder Design https://mddl-iitb.vlabs.ac.in/adder/index.html

Control Engineering			
Semester	**VI**	CIE Marks	**50**
Course Code	**23MTPC307**	SEE Marks	**50**
Teaching Hrs/Week (L: T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Provide fundamental knowledge of control systems, mathematical modelling of physical system
2. Impart knowledge of Time Domain Analysis and Stability of Control Systems
3. Provide fundamental knowledge of Root Locus and Frequency Response Analysis in Control Systems
4. Impart fundamental knowledge of Compensation Techniques & State Space Analysis
5. Familiarize with the application specific to control engineering

Module 1: Modelling of Systems and Block Diagram — **No. of Hrs: 8**

Introduction to control systems, types of control systems, mathematical modelling of physical systems- mechanical systems and analogous systems

Block Diagram: Introduction to block diagram algebra and Block reduction techniques, Obtaining Transfer functions using block reduction

Textbook 1: Chapter 13 – Section 13.5
Textbook 2: Chapter 1

Module 2: Time Domain Analysis — **No. of Hrs: 9**

Standard test signals, Unit step response of first and second order systems, Time response specifications of second order systems, Steady state errors and error constants, Effect of P, PI, PD and PID controller, Effect of adding a pole and zero to a system

Textbook 1: Chapter 4 and 7

Module 3: Stability Analysis in Time — **No. of Hrs: 9**

Stability Concepts: Concepts of stability, Necessary conditions for stability, Routh stability criterion, Relative stability analysis

Root-Locus Technique: Introduction to Root-Locus technique, Construction of root loci, Sensitivity of roots of the characteristic equation

Textbook 1: Chapter 6 and 8

Module 4: Frequency Domain & Compensation Techniques — **No. of Hrs: 8**

Frequency Domain Analysis and Stability: Correlation between time and frequency response, Frequency domain specifications, Bode plot, Sensitivity analysis in frequency domain

Control System Performance Measure: Improvement of system performance through compensation: Lead, Lag & Lead-Lag compensation

Textbook 1: Chapter 10 – Section 10.1, 10.2 and 10.7
Chapter 1

Module 5: State Space Analysis & Control System Application — **No. of Hrs: 8**

Introduction to State Space Analysis**:** Concepts of state, state variable and state models for electrical and mechanical systems, Solution of state equations, Concept of controllability & observability, Stability analysis using state space models Block diagram level description of feedback control systems for position control, Speed control of DC motor, Temperature control, Liquid level control, Voltage control of alternator

Textbook 2: Chapter 3 – Section 3.3
Chapter 4 – Section 4.2 and 4.5
Chapter 9

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

1. Develop mathematical models of linear systems
2. Determine performance parameters for second-order systems
3. Model the system in time domain
4. Identify the system performance based on frequency domain specifications
5. Develop state-space models for electrical and mechanical systems and explain the control system application

Textbooks:

1. Norman S Nise, "Nises's Control Systems Engineering", Wiley India Edition, Wiley India Pvt. Ltd, 2022
2. K. Ogata. "Modern Control Engineering", 4th edition, Pearson Education Asia/ PHI, 2012
3. Benjamin C. Kuo, "Automatic Control Systems", 9th Edition, John Wiley India Pvt. Ltd, 2014

Reference Books:

1. Benjamin C. Kuo "Automatic Control Systems", 8th Edition, John Wiley India Pvt. Ltd, 2008
2. J. Nagarath and M. Gopal, "Control Systems Engineering", 7th Edition, New Age International(P) Limited, 2021
3. G. F. Franklin, J. D. Powell, A. Emami, Naini, "Feedback Control of Dynamic Systems", 8th Edition, Pearson Education, 2018
4. S. Ghosh, "Control Systems: Theory and Applications", 2nd Edition, Pearson, 2012

Web Links:

1. Open vs Closed Loop Systems in Control Engineering: https://youtu.be/JGyk957Oyys?si=ZsO-1zruW5v2GJiY
2. Negative and Positive Feedback: https://youtu.be/-EnzfO-kMJo?si=Pjg5du6AfjnTYU2m
3. Control System Lectures by Brain Douglas: https://www.youtube.com/channel/UCq0imsn84ShAe9PBOFnoIrg

Virtual Instrumentation Lab			
Semester	**VI**	CIE Marks	**50**
Course Code	**23MTPC308**	SEE Marks	**50**
Teaching Hrs/Week (L: T:P)	**0:1:3**	Exam Hrs	**2.5**
Total Hrs	**36**	Credits	**2**

Course Learning Objectives: This course is designed to

1. Impart fundamental concepts of structured Programming using LabVIEW
2. Familiarize VI using LabVIEW for solving real-world problems
3. Provide knowledge in handling loops and structures
4. Provide knowledge of VIs for signal processing, data handling and filtering

Introduction to Graphical Programming	**No. of Hrs: 12**

Define VI, Block diagram & Architecture of VI, Data flow techniques, Comparison with conventional programming and Graphical programming, VIs and sub VI, Loops (While Loop and For Loop), Charts, Structures (Case, Formula node, and sequence structures) Arrays, Array Functions, Clusters and Graphs, Strings, String Functions, and File I/O

Sl. No.	**Experiments**
1	Create Virtual Instrumentation for simple applications- invert the state of Boolean indicator twice until program is stopped by user
2	Design a VI to perform half adder and full adder
3	Create a VI to find the roots of a quadratic equation using subVIs. Find both the values of the roots and nature of the roots
4	Design a simple calculator using case structure in virtual instrumentation
5	Design a VI to perform the factorial of a given number using For loop
6	Design a VI to perform functions using flat and stacked sequence
7	Design a VI to create a sine wave using formula node
8	Design a VI to perform convolution of two signals
9	Develop a VI for file input output system
10	Design On – Off Controller Using Switch Button
11	Develop a VI to apply filtering technique for a given input signal
12	Develop a VI to control a 3-floor elevator

Course outcomes: At the end of the course, the student will be able to:

1. Develop Virtual Instrumentation (VI) applications using LabVIEW for mathematical and logical
2. Develop various control applications using LabVIEW tools
3. Design graphical programming utilizing arrays, strings, file I/O operations, loops, graphs, structures, and clusters
4. Develop VIs for signal processing, data handling and filtering tasks

Textbooks:

1. Sanjay Gupta and Joseph John, "Virtual Instrumentation using LabVIEW", 2nd Edition, Tata McGraw-Hill Publishing Company Limited, 2017
2. Jovitha Jerome, "Virtual Instrumentation using LabVIEW", 1st Edition, PHI publication, 2010

Reference Books:

1. J. Travis and J. Kring, "LabVIEW for Everyone: Graphical Programming Made Easy and Fun", 3rd Edition, Prentice Hall, 2007
2. R. H. Bishop, "Learning with LabVIEW", 1st Edition, Pearson Publishing, 2014

Web Links:

1. LabVIEW Software: **https://youtu.be/Sd0RhN7CigY?si=qla2XFp9zm3IZMZp**
2. LabVIEW Program: **https://youtu.be/ZHNlKyYzrPE?si=s5_ccJGfDRLOdiZ3**
3. Using Loops in LabVIEW: **https://youtu.be/hnx9WI2D9zU?si=OQFJND0tGAKuutHQ**
4. LabVIEW Data Types: **https://youtu.be/dvShgNdY_GE?si=3_T-Rt_-USjmDd1e**

Project Phase-I			
Semester	**VI**	CIE Marks	**100**
Course Code	**23MTSE309**	Credits	**03**
Hours/Week (L: T: P)	**0:0:6**	Mode	**Experiential**

Objectives:

1. To develop the students' ability to independently or collaboratively identify a problem, review literature, define objectives, and propose a preliminary methodology for solving an engineering problem, which will be realized in Project Phase – II
2. The course also aims to develop leadership and interpersonal communication skills within team members

General Guidelines:

1. A project guide (faculty member) will be allocated by the department
2. The HoD shall appoint a project coordinator who will take the responsibility of monitoring all the activities related to the project execution.
3. The HoD shall constitute project evaluation/review committee(s) & the composition shall be as follows:
    a. HOD or one of the HODs in case of an interdisciplinary project, shall be the Chairman of the committee
    b. Project Coordinator shall be member - Convener
    c. Project guide shall be the member
    d. One/Two senior faculty members nominated by the HOD (may be from different departments in case of an interdisciplinary project jointly nominated by the HODs)
4. Each project team shall consist of 2 to 4 students from the same department or different departments.
5. Interdisciplinary projects may be allowed with prior approval from the concerned HODs only.
6. Project teams must arrive at problem statements that address either real-world challenges or research-related issues relevant to their domain of study. Each team must formulate an appropriate project title in consultation with their project guide.
7. Each project team shall maintain a project dairy and record their project progress at regular interval of time. This shall carry signature of the students and the project guide.
8. There is no Semester End Examination (SEE) for this course and evaluation is based entirely on Continuous Internal Evaluation (CIE)
9. Marks may be equally or proportionally distributed among team members based on contribution assessed by the guide and committee.
10. A student shall obtain minimum of 40% of the total marks to pass this course
11. Plagiarism, data fabrication, or copying of work will result in stringent disciplinary action and /or penalties. (Note: Any disciplinary actions or penalties will be as per institutional policy.)

Deliverables:

1. Comprehensive Project Report comprising of:
   - Abstract
   - Introduction
   - Literature Survey
   - Problem Definition
   - Proposed Methodology
   - Design
   - Summary and Work Plan for Phase-II
   - References
   - Appendices

   The project report shall be prepared in the prescribed format provided by the institute.
2. A plagiarism report shall be obtained from the Department of Library. Acceptable similarity threshold is generally below 20%, and hence, the plagiarized content shall not exceed 20%. Similarity above 20% will require resubmission after proper revisions.

Review and Evaluation:

1. There shall be two reviews and a presentation. Total of 100 CIE marks is distributed as follows:

Review - 1	
Topic approval, Problem Definition & Objectives	20 Marks
Literature Review	10 Marks
Innovation/Novelty	10 Marks
Total	**40 Marks**

Review - 2	
Methodology & Design	15 Marks
Report Quality & Formatting	15 Marks
Total	**30 Marks**

Presentation	
Presentation	20 Marks
Team work	10 Marks
Total	**30 Marks**

Grand Total	**100 Marks**

2. First review shall be conducted after one month from the start of the semester. Further, every department shall develop rubrics to assess performance of the students based on the above given parameters

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

1. Identify an engineering or research problem through a thorough review of relevant literature
2. Design an appropriate solution or methodology to address the identified problem
3. Prepare a comprehensive project report
4. Effectively present each component of the project report to a knowledgeable audience
5. Collaborate and contribute effectively as a team member, recognizing the dynamics of both individual and group work

Micro Robotics			
Semester	**VI**	CIE Marks	**50**
Course Code	**23MTPE321**	SEE Marks	**50**
Teaching Hrs/Week (L: T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Provide foundational understanding of microrobots and their mechanics
2. Introduce the physics of micro robotics
3. Familiarize different types of flexures and micro-actuation techniques
4. Equip with knowledge of various sensing technologies for microrobots
5. Impart knowledge of microfabrication techniques for microrobots

Module 1: Introduction to Micro Robots — **No. of Hrs: 8**

Introduction, Applications of microrobots Medicine, Micro assembly, Material Sciences, Mobile microrobots. Mechanics of materials in the context of micro robotics, Material structures across scales

Strength of materials for micro robotics: Classification of micro robots, Drive principles, Micro manipulators, Flexible microrobots

Textbook 1: Chapter 1 and 2

Module 2: Physics for Micro Robotics — **No. of Hrs: 8**

Scaling effects, Effects on various physical properties, Scaling effect on physical forces, Illustration of the scale effect, Microworlds, Vanderwaals forces, Capillary forces, Electrostatic forces, Friction and wear in microscale

Textbook 1: Chapter 4 – Sections 4.1 and 4.2.6
Textbook 2: Chapter 3 – Sections 3.1, 3.2 and 3.6

Module 3: Flexures and Actuators — **No. of Hrs: 9**

Flexures definition, use of flexures, comparison between flexures and traditional joints, Examples of flexures, Elemental flexures cantilever, notch hinge, cross pivot; Flexure systems Linear guidance systems, remote center of rotation, motion amplification Design principles of actuators, Amplification of motion, Bimorph assembly, In-plane motion amplification, Electrostatic actuators, Thermal based actuators, Shape memory alloys, SMA micro actuators Bias Spring, Antagonistic design, SMA bimorphs, Monolithic designs, Piezoelectric actuators

Textbook 1: Chapter 5 and 6

Module 4: Sensors — **No. of Hrs: 8**

Sensing technologies for displacements Electromagnetic sensors: Inductive, capacitive, resistive optical-based sensors Beam tracking methods, Shadow-Projection sensors, Interferometers, Waveguides coupling

Motion tracking with microscopes: pattern recognition techniques, optical microscope, scanning electron microscope; Miniature Cameras

Textbook 1: Chapter 7

Module 5: Microrobots Fabrication and Applications — **No. of Hrs: 9**

Manufacturing requirements for microrobots – Microfabrication principles, Surface micromachining and lithography, High aspect ratio micromachining, LIGA, EDM, Laser micromachining, Design selection criteria, Actuators and micromachining process, Flexures micromachining

State-of-the-art and future prospects: Applications in medicine, microbots for material science study, Microgrippers, Micro assembly platforms and manipulators

Textbook 1: Chapter 8 and 9

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

1. Describe the fundamentals of micro robotics
2. Apply the basic concepts of physics at a micro level
3. Explain the concept of flexures and micro actuators
4. Illustrate various sensing techniques for micro robotics
5. Identify the various fabrication techniques for micro robots

Textbooks:

1. Yves Bellouard, "Microrobotics – Methods and Applications", 1st Edition, CRC Press, 2010
2. Metin Sitti, "Mobile Microrobotics", 1st Edition, MIT Press, 2017

Reference Books:

1. Minjun Kim, Anak A. Julius, and U Kei Cheang, "Microrobotics – Biologically inspired microscale robotic systems", 2nd Edition, Elsevier, 2017
2. Nicholas Chaillet and Stephane Regnier, "Microrobotics for Micromanipulation", 1st Edition, Wiley, 2010

Web Links:

1. EdX – Microrobotics: https://www.edx.org/learn/engineering/eth-zurich-microrobotics
2. Harvard Microrobotics lab: https://www.youtube.com/watch?v=tyvjDaXOsWU&list=PLMwwxVHzFgh7LOdq5F6P M4U7BrG-mwDjy

Electric and Hybrid Vehicles			
Semester	**VI**	CIE Marks	**50**
Course Code	**23MTPE322**	SEE Marks	**50**
Teaching Hrs/Week (L: T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Familiarize key components of electric and hybrid vehicle, examining their contributions to reducing emissions
2. Impart Newton's laws of motion to analyze vehicle movement and forces acting on a vehicle
3. Provide approaches to HEV powertrain sizing to maximize energy efficiency and enhance hybrid vehicle performance
4. Inculcate the basic model to estimate battery performance in electric vehicles
5. Familiarize various types of motors and power converters used in electric and hybrid vehicles

Module 1: Introduction to Electric Vehicle and Hybrid Vehicle	**No. of Hrs: 8**

Electric and Hybrid Vehicle Components, Vehicle Mass and Performance, Electric and Hybrid Vehicle History, EV/ICV Comparison-Efficiency Comparison, Pollution Comparison, Capital and Operating Cost Comparison, Electric Motor and Engine Ratings

Textbook 1: Chapter 1 – Section 1.3, 1.4, 1.5, 1.6 and 1.8

Module 2: Vehicle Mechanics	**No. of Hrs: 8**

Roadway Fundamentals, Laws of Motion, Vehicle Kinetics, Dynamics of Vehicle Motion, Propulsion Power, Velocity and Acceleration, Constant FTR Level Road, Velocity Profile, Distance Traversed, Tractive Power, Energy Required, Non-constant FTR General Acceleration, Tire Road Force Mechanics, Slip, Traction Force at Tire Road Interface, Force Transmission at Tire Road Interface

Textbook 1: Chapter 2 – Section 2.1, 2.2, 2.3, 2.4, 2.5, 2.6 and 2.7

Module 3: Vehicle Architectures and Design	**No. of Hrs: 8**

Hybrids Based on Architecture, Hybrids Based on Transmission Assembly, Hybrids Based on Degree of Hybridization, Plug-in Hybrid Electric Vehicle, EV Powertrain Sizing, HEV Powertrain Sizing, HEV Powertrain Sizing Example, Mass Analysis and Packaging

Textbook 1: Chapter 3 – Section 3.2, 3.3, 3.5 and 3.6

Module 4: Energy Storage	**No. of Hrs: 9**

Battery Basics, Battery Parameters, Electrochemical Cell Fundamentals, Battery Modeling, Electric Circuit Models, Basic Battery Model, Run-Time Battery Model, Impedance-Based Model, Empirical Models, Range Prediction with Constant Current Discharge, Range Prediction with Power Density Approach, Battery Management System, SOC Measurement, Battery Cell Balancing, Battery Charging

Textbook 1: Chapter 5 – Section 5.2, 5.3, 5.4, 5.5 and 5.7

Module 5: Electric Motor and Power Electronic Converters	**No. of Hrs: 9**

PM Brushless DC Motor, Buck Converter, Boost Converter, Buck-Boost Converter, On-Board Battery Charger, Cell-Balancing Converters, Passive Balancing Methods, Active Balancing Methods

Textbook 1: Chapter 7 – Section 7.6.2
Chapter 9 – Section 9.2, 9.3 and 9.4

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

1. Explain key milestones in the development of electric and hybrid vehicles
2. Apply laws of motion to calculate velocity, power and forces acting on a vehicle
3. Classify different hybrid architectures and transmission assemblies
4. Develop battery model based on open-circuit voltage and internal resistance
5. Design power electronics converters for electric and hybrid vehicles

Textbook:

1. Iqbal Husain**,** "Electric and Hybrid vehicles: design fundamentals", 3rd Edition, CRC Press, 2021

Reference Books:

1. Ashhar Ahmed Shaikh," EV Engineering Fundamentals - A beginner's guide to e-mobility," 1st Edition, Pearson Education, 2023
2. A.K Babu, "Electric and Hybrid Vehicles", 2nd Edition, Khanna Publishing, 2022
3. Sunil R Pawar, "Electrical Vehicle Technology: The Future Towards Eco-Friendly", 2nd Edition, Notion Press, 2021

Web Links:

1. Introduction to Electric Vehicles & Vehicles subsystem requirements: https://www.youtube.com/playlist?list=PLZnygY81tHUyzqioA7oXed6qsztizMH8c
2. Hybrid Electric Vehicle workshops: https://www.youtube.com/playlist?list=PL9-f9hWLZS62VF18qPQ1gC7NqIAjaClsl
3. Fundamentals of Electric Vehicles: https://www.youtube.com/watch?v=UgtjRob5qMg&list=PLyqSpQzTE6M9spod-UH7Q69wQ3uRm5thr
4. A Comprehensive Introduction To EV Technology & Sustainability: https://www.youtube.com/watch?v=s9dKXL60RkQ&list=PLTP1vMkMQYuJJPDL2PzAYiK DJ3GuYB1F6

Micro and Smart System Technology			
Semester	**VI**	CIE Marks	**50**
Course Code	**23MTPE323**	SEE Marks	**50**
Teaching Hrs/Week (L: T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Apply the fundamental principles of micro and smart systems in real world applications
2. Interpret the design and operation of micro-scale actuators and electronic circuits used in micro and smart systems
3. Utilize micromachining technologies, including silicon processing and fabrication techniques, in the development of microsystems
4. Examine integration and packaging approaches of Microsystems
5. Develop basic control systems for MEMS applications using PID controllers

Module 1: Introduction to Micro and Smart systems	**No. of Hrs: 8**

Microsystems versus MEMS, Smart Materials, Structures & Systems, Integrated Microsystems, Application of Smart Materials & Microsystems, salient features of sensors, silicon capacitive accelerometer, Piezoresistive pressure sensor, Portable blood analyzer, Conductometric gas sensor

TextBook-1: Chapter 1, Chapter 2 Section 2.1, 2.2, 2.3 and 2.8

Module 2: Actuators and Electronics Circuits for Micro and Smart Systems	**No. of Hrs: 9**

Salient features of Actuators: Micro mirror Array for Video Projection, Piezo-electric based inkjet print head, electrostatic comb-drive, Magnetic micro relay, Schottky diode, Tunnel diode, MOSFET, and CMOS circuits: Inverter and NAND Gate, Micro system-based Op-amp

Textbook-1: Chapter 2- Sections 2.5, 2.6, 2.9 and 2.10
Chapter 7- Section 7.1

Module 3: Micromachining Technologies	**No. of Hrs: 9**

Silicon as a Material for Micromachining, Silicon wafer preparation, thin-film deposition techniques, Lithography, Etching, Silicon micromachining: surface micromachining bulk micromachining. Specialized Materials for Microsystems

Textbook -1: Chapter 3- Sections 3.1 to 3.8

Module 4: Integration of Microsystem and Packaging	**No. of Hrs: 8**

CMOS first, MEMS first, other approaches of integration
Microsystem packaging: objectives of packing special issues in microsystem packaging, types of microsystem packages, reliability and key failure mechanism

Textbook-1: Chapter 8- Sections 8.1 and 8.2

Module 5: Implementation of Controllers for MEMS	**No. of Hrs: 8**

Design Methodology, PID controller, Circuit Implementation, Digital controller, Microcontroller & PLC. pressure sensor, design considerations, performance parameters, Smart Structure in vibration control, PZT transducers

Textbook-1: Chapter 7- Section 7.6,
Chapter 8- Sections 8.4 and 8.4.1

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

1. Employ the principles of micro and smart systems to examine their structure, materials, and applications
2. Illustrate the operation of micro-scale actuators and essential electronic circuits used in microsystems
3. Apply micromachining processes and fabrication techniques to develop microsystem components
4. Evaluate integration and packaging strategies for microsystems while addressing design challenges and performance reliability
5. Develop control strategies for MEMS devices using PID controllers, digital controllers, and microcontroller-based systems

Textbook:

1. G. K. Ananthasuresh, K.J. Vinoy, S. Gopalakrishnan, K.N. Bhat, V.K. Aatre, "Micro and Smart Systems", Wiley India, 2012

Reference Book:

1. Tai-Ran Hsu, "MEMS & Microsystems: Design and Manufacture", Tata McGraw Hill, 2002

Web Links:

1. Smart Materials and Systems: https://youtu.be/b5IPJeCDEPw?si=obpjDH7hLmOVj37z
2. Microsensors: https://youtu.be/jCgmjv9lhZI?si=HJevef8hIwbAbXmK
3. Micro actuators: https://youtu.be/T09ONHU6OnY?si=GcITKdIGUjv8dfYh

Robotics and Automation			
Semester	**VI**	CIE Marks	**50**
Course Code	**23MTOE321**	SEE Marks	**50**
Teaching Hrs/Week (L: T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Familiarize with the fundamentals of robotics
2. Impart knowledge of robot anatomy
3. Provide an understanding of robot drives system
4. Impart knowledge of automation principles
5. Familiarize with material handling systems design

Module 1: Introduction to Robotics	**No. of Hrs: 8**

Definition and origin of robotics, Different types of robotics, Various generations of robots, Asimov's laws of robotics, Basic components of robot, Robot specifications, Classification of robots, Human system and robotics, Safety measures in robotics, Social impact, Robotics market and the future prospects, Advantages and Disadvantages of robots

Textbook 1: Chapter 1 - Sections 1.1, 1.2, 1.3 and 1.4

Module 2: Robot Anatomy, Motion Analysis and Sensors	**No. of Hrs: 8**

Anatomy of a Robot, Robot configurations: Polar, Cylindrical, Cartesian and Jointed arm configurations, Robot links and joints, Types of movements, Vertical, Radial and Rotational traverse, Roll, Pitch and Yaw, Work volume/envelope, Machine Vision, Ranging Sensors Ranging laser, Acoustic, Magnetic, Fiber optic and Tactile sensors

Textbook 1: Chapter 2 - Sections 2.1, 2.2, 2.4 and 2.5
Chapter 6 - Sections 6.1, 6.2, 6.3 and 6.4

Module 3: Robot Drives and End Effectors	**No. of Hrs: 8**

Robot drive systems: Hydraulic, Pneumatic and Electric drive systems, Classification of end effectors, Mechanical grippers, Vacuum grippers, Magnetic grippers, Adhesive gripper, Gripper force analysis and Gripper design, 1 DoF, 2 DoF, Multiple degrees of freedom, Robot control types - Limited sequence control, Point-to-point control, Playback with continuous path control, and Intelligent control

Textbook 1: Chapter 5 - Sections 5.1, 5.2, 5.3 and 5.4
Chapter 2 - Sections 2.3

Module 4: Industrial Automation	**No. of Hrs: 9**

Automation in production system, Principles and Strategies of automation, Basic elements of an automated system, Advanced automation functions, Levels of automations. Production economics: Methods of evaluating investment alternatives, Costs in manufacturing, Break- Even analysis, Unit cost of production, Cost of manufacturing lead time and Work-in process

Textbook 2: Chapter 4 - Sections 4.1, 4.2 and 4.3

Module 5: Material handling and Identification Technologies	**No. of Hrs: 9**

Overview of material handling systems, Types of material handling equipment, Conveyor system, Automated guided vehicle system, Automated storage systems, Interfacing handling and storage with manufacturing, Overview of Automatic Identification Methods

Textbook 2: Chapter 10 - Sections 10.1, 10.2 and 10.3
Chapter 12 - Sections 12.1, 12.2 and 12.3

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

1. Explain the fundamentals of robotics and its future prospects
2. Explain robot anatomy and sensor technologies in robotic systems
3. Apply knowledge of robot drive systems
4. Apply knowledge of automation concepts in manufacturing processes
5. Apply knowledge of material handling systems and identification methods in automation

Textbooks:

1. Mikell P. Groover, Mitchel Weiss, Roger N. Nagel, Nicholas G. Odrey and Ashish Dutta, "Industrial Robotics: Technology, Programming and Applications", 2nd Edition, Tata McGraw Hill, 2012
2. M.P. Groover, "Automation, Production Systems and Computer Integrated Manufacturing", 5th Edition, Pearson Education, 2009

Reference Books:

1. Ghosh, "Control in Robotics and Automation: Sensor Based Integration", 1st Edition, Allied Publishers, Chennai, 1998
2. Asfahl C.R., "Robots and Manufacturing Automation", 1st Edition, John Wiley, 1992

Web Links:

1. Introduction to Robotics: https://youtu.be/GdDTYEmUNcg
2. Robot Anatomy, Motion Analysis and Sensors: https://youtu.be/HeJtogwoUCw
3. Robot Drives and End Effectors: https://youtu.be/PlC52HPDFs4
4. Industrial Automation: https://youtu.be/tw-79FiRYKA
5. Material handling and Identification Technologies: https://youtu.be/m1xUOCeFZ_k

PLC and SCADA Technology			
Semester	**VI**	CIE Marks	**50**
Course Code	**23MTOE322**	SEE Marks	**50**
Teaching Hrs/Week (L: T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Familiarize purpose and function of each component in a PLC system, including the CPU, input/output modules, power supply, and communication interfaces
2. Impart basic ladder logic programs to implement control systems such as start/stop circuits, motor control, incorporating data manipulation instructions for practical applications
3. Familiarize components of a SCADA system, Remote Terminal Units, PLCs communication networks, and HMI

Module 1: Introduction to Programmable Logic Controllers — **No. of Hrs: 8**

Parts of a PLC, Principles of Operation, Modifying the Operation, PLCs versus Computers, PLC Application, The I/O Section, Discrete I/O Modules, Analog I/O Modules, Special I/O Modules, I/O Specifications, The Central Processing Unit (CPU), Memory Design, Memory Types, Programming Terminal Devices, Recording and Retrieving Data, Human Machine Interfaces (HMIs)

Textbook 1: Chapter 1 – Section 1.2, 1.3, 1.4, 1.5 and 1.6
Chapter 2 – Section 2.5, 2.6, 2.7, 2.8, 2.9, 2.10 and 2.11

Module 2: PLC Wiring Diagrams and Ladder Logic Programs — **No. of Hrs: 8**

Developing Fundamental PLC Wiring Diagrams and Ladder Logic Programs Electromagnetic Control Relays, Contactors, Motor Starters, Manually Operated Switches, Mechanically Operated Switches, Sensors, Output Control Devices, Seal-In Circuits, Latching Relays, Converting Relay Schematics into PLC Ladder Programs, Writing a Ladder Logic Program Directly from a Narrative Description Programming Timers: Mechanical Timing Relays, Timer Instructions, On-Delay Timer Instruction, Off-Delay Timer Instruction, Retentive Timer, Cascading Timers

Textbook 1: Chapter 6 – Section 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.9, 6.10 and 6.11
Chapter 7 – Section 7.1, 7.2, 7.3, 7.4, 7.5 and 7.6

Module 3: Programming Counters — **No. of Hrs: 8**

Programming Counters: Counter Instructions, Up-Counter, Down-Counter, Cascading Counters, Incremental Encoder- Counter Applications, Combining Counter and Timer Functions

Program Control Instructions: Master Control Reset Instruction, Jump Instruction, Subroutine Functions, Immediate Input and Immediate Output Instructions, Forcing External I/O Addresses, Safety Circuitry, Selectable Timed Interrupt, Fault Routine, Temporary End Instruction, Suspend Instruction

Textbook 1: Chapter 8 – Section 8.1, 8.2, 8.3, 8.4, 8.5 and 8.6
Chapter 9 – Section 9.1, 9.2, 9.3, 9.4, 9.5, 9.6, 9.7, 9.8, 9.9 and 9.10

Module 4: Data Manipulation Instructions — **No. of Hrs: 9**

Data Manipulation Instructions: Data Manipulation, Data Transfer Operations, Data Compare Instructions, Data Manipulation Programs, Numerical Data I/O Interfaces, Closed-Loop Control

Math Instructions: Math Instructions, Addition Instruction, Subtraction Instruction Multiplication Instruction, Division Instruction, Other Word-Level Math Instructions, File Arithmetic Operations. Sequencer and Shift Register Instructions: Mechanical Sequencers, Sequencer Instructions, Sequencer Programs, Bit Shift Registers, Word

Shift Operations, Programs

Textbook 1: Chapter 10 – Section 10.1, 10.2, 10.3, 10.4, 10.5 and 10.6
Chapter 11 – Section 11.1, 11.2, 11.3, 11.4,11.5, 11.6 and 11.7
Chapter 12 – Section 12.1, 12.2, 12.3, 12.4 and 12.5

Module 5: Supervisory Control and Data Acquisition System	**No. of Hrs: 9**

SCADA system evolution, definition and basic architecture, application, SCADA system in the critical infrastructure, employment of SCADA system, nuclear power generation, boiling water reactor, water purification system

Textbook 2: Chapter 1 – Section 1.5, 1.6, 1.7 and 1.10
Chapter 2 – Section 2.23, 2.26, 2.27 and 2.34

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

1. Explain purpose and function of the Power Supply, CPU, I/O Modules, Memory, and Communication Modules within a PLC system
2. Develop ladder logic programs that enable motor control operations, including forward/reverse control, speed control, and emergency stop functions
3. Apply timer instructions in ladder logic programs to control time-dependent operations such as delays, on/off cycles, and time intervals in industrial processes
4. Apply data manipulation instructions to process input and control output based on manipulated data, ensuring proper system response
5. Describe the purpose and function of the field devices, Remote Terminal Units PLCs, communication networks, and Human-Machine Interface in a SCADA system

Textbooks:

1. Frank D Petruzella. "Programmable Logic Controllers", 4th Edition,McGraw-Hill Science, 2011
2. Ronald L. Krutz "Securing SCADA System", 1st Edition, Wiley, 2006

Reference Books:

1. Madhuchhandan Gupts and SamarjitSen Gupta. "PLC and Industrial application", Pernram International Pub. (Indian) Pvt. Ltd, 2011
2. Gary Dunning. "Introduction to Programmable Logic Controllers", 2nd edition, Thomson. 2001
3. John W Webb and Ronald A Reis, "Programmable Logic Controllers: Principles and Application", PHI Learning, 5th Edition, 2005

Web Links:

1. Program Logic Controllers: https://www.youtube.com/watch?v=MS3qJq2jvu0
2. PLC Programming Tutorial for Beginners: https://www.youtube.com/watch?v=y2eWdLk0- Ho
3. Fundamentals of SCADA: https://www.youtube.com/watch?v=aZ8ytIiSBY0
4. PLC Training - Introduction to Ladder Logic: https://www.youtube.com/watch?v=E4_HqzUFBs

Autonomous Mobile Robots			
Semester	**VI**	CIE Marks	**50**
Course Code	**23MTOE323**	SEE Marks	**50**
Teaching Hrs/Week (L: T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Impart the fundamentals of mobile robotics and sensor technologies
2. Familiarize concept of kinematics in mobile robots and path-planning techniques
3. Impart concepts of multi-robot systems and swarm robot control

Module 1: Introduction to Mobile Robots	**No. of Hrs: 8**

Introduction, Autonomous robots, locomotion, key issues for locomotion, types of mobile robots, legged robots, bipeds, quadruped, hexapod, wheeled robots, wheel design, stability, maneuverability, wheel configurations, aerial mobile robots, UAV configurations

Textbook 1: Chapter 1

Module 2: Sensors and Perception	**No. of Hrs: 8**

Basic perception, basic scheme of sensors, Sensors for mobile robots, sensor classification, sensor characteristics, error propagation, optical encoders, compass and gyroscopes, accelerometer, GPS, obstacle sensor, odometry sensors, distance sensor, range finders, active ranging, vision-based sensors

Textbook 1: Chapter 4 – Section 4.1

Module 3: Kinematics of Mobile Robots	**No. of Hrs: 9**

Kinematic models and constraints, robot position and orientation representation, forward kinematics, trajectory tracking, maneuverability, degree of mobility, steerability, mobile robot workspace, kinematic motion control, open loop control, feedback control

Textbook 1: Chapter 3

Module 4: Navigation and Path Planning	**No. of Hrs: 9**

Introduction, competencies for navigation, path planning, graph search, breadth-first search, depth-first search, Dijkstra's algorithm, A* algorithm, D* algorithm, randomized graph search, obstacle avoidance, bug algorithm, offline planning

Textbook 1: Chapter 6 - Section 6.4.1

Module 5: Multi-Robot Systems and Swarming	**No. of Hrs: 8**

Multi-agent systems – Principles, Swarming, Basic flocking, Methods of aggregation and collision avoidance, Control and positioning of swarms, Agent based models, Probabilistic models, Communication between mobile robots, Simple communication protocols

Textbook 2: Chapter 9
Chapter 11 – Section 11.1, 11.2

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

1. Describe the foundational concepts of mobile robotics
2. Explain the working of various sensors for mobile robots
3. Apply kinematic principles to model and analyze the motion of mobile robotic systems
4. Apply navigation and path planning strategies
5. Explain principles of multi robot systems and swarming

Textbooks:

1. Roland Siegwart, Illah. R Nourbakhsh, and Davide Scaramuzza, "Introduction to autonomous mobile robots", 2nd Edition, MIT press, 2011
2. Eugene Kagan, Nir Shvalb, and Irad Ben-Gal, eds., "Autonomous mobile robots and multirobot systems: Motion-planning, communication, and swarming", 1st Edition, John Wiley & Sons, 2019

Reference Books:

1. George A. Bekey, "Autonomous Robots: From Biological Inspiration to Implementation and Control", MIT Press, 2005
2. G. Dudek and M. Jenkin, "Computational Principles of Mobile Robotics", 3rd Edition, Cambridge University Press, 2024

Web Link:

1. Autonomous mobile robots: https://www.edx.org/learn/autonomous-robotics/eth-zurich- autonomous-mobile-robots

Yoga-IV			
Semester	**VI**	CIE Marks	**100**
Course Code	**23NMCC325**	SEE Marks	**-**
Teaching Hours/Week (L: T: P)	**0:0:1**	Exam Hrs	**-**
Total Hours	**13**	Credits	**-**

Course Learning Objectives: This course is designed to

1. Empower students to achieve and maintain good health
2. Promote the practice of mental hygiene
3. Facilitate students in attaining emotional stability
4. Impart moral values and higher level of consciousness

Contents	**No. of Hrs: 13**

- Ashtanga Yoga 1. Dharana 2. Dhyana (Meditation) 3. Samadhi
- Asana by name, technique, precautionary measures and benefits of each asana
- Suryanamaskar13 count- 4 rounds of practice
- Different types of Asanas
  a) Sitting
     1. Bakasana
     2. Hanumanasana
     3. Ekapada Rajakapotasana
     4. Yogamudra in Vajrasana
  b) Standing
     1. Vatayanasana
     2. Garudasana
  c) Balancing
     1. Veerabhadrasana
     2. Sheershasana
  d) Supine line
     1. Sarvangasana
     2. Setubandha Sarvangasana
     3. Shavasanaa (Relaxation posture).
- Revision of Kapalabhati practice 40 strokes/min - 3 rounds
- Meaning by name, technique, precautionary measures and benefits of Pranayama Bhramari.

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

1. Describe the meaning, aim and objectives of Yoga
2. Perform Suryanamaskar and able to analyze its benefits
3. Exhibit the different Asanas by name, its importance, methods and benefits
4. Perform Kapalabhati
5. Perform the different types of Pranayama by its name, precautions, procedure and uses

Textbooks:

1. Ajitkumar," Yoga Pravesha in Kannada"1st Edition, Raashtroththaana ahithya, 2017, ISBN-13: 978-8175310124
2. BKS Iyengar, "Light on Yoga", 1st Edition, Thorsons, 2017, ISBN-13: 978-0008267919
3. Dr. M L Gharote & Dr. S K Ganguly, "Teaching Methods for Yogic practices", 1st Edition, Kaivalyadhama, 2001, ISBN-13 : 978-8189485252

Reference Book:

1. Yamini Muthanna, "Yoga for Children step by step", 1st Edition, Om Books International, 2022, ISBN-13: 978-9394547018

Web links:

1. My Life My Yoga , https://youtu.be/KB-TYlgd1wE
2. Adiyoga, https://youtu.be/aa-TG0Wg1Ls

Scheme and Assessment:		
Sl. No.	Activity	Marks
1	Quiz	20
2	Practical demonstration	50
3	Final Report	30

Physical Education-IV			
Semester	**VI**	CIE Marks	**100**
Course Code	**23NMCC326**	SEE Marks	**-**
Teaching Hours/Week (L: T: P)	**0:0:1**	Exam Hrs	**-**
Total Hours	**13**	Credits	**-**

Course Learning Objectives: This course is designed to

1. Impart the fundamental concepts and skills of Physical Education, Health, Nutrition and Fitness
2. Familiarization of health-related Exercises, Sports for overall growth and development
3. Build a strong foundation for the professionals in Physical Education and Sports

Contents **No. of Hrs: 13**

- Importance of nutrition for optimal performance and healthy eating habits. (Lectures)
- Mindfulness and stress management techniques like meditation. (Practical Sessions)
- Emphasis on teamwork, communication, and sportsmanship. (Practical Sessions)
- Specific Games (Students continue prior semester's game by practicing (**Advanced Skills**)

Basket Ball Behind-the-back dribble - Spin moves - Alley-oop passes - Shooting off the dribble - Advanced footwork and shot creation techniques

Cricket Reverse swing and googly bowling - Spin bowling variations (leg spin, off spin) - Captaincy skills - Advanced batting techniques (switch hitting)

Football Advanced dribbling techniques (stepovers, fakes) - First touch passing and control - Volley control and shooting - Set pieces (free kicks, corner kicks) Advanced heading techniques - Goalkeeper diving and shot-stopping

Hockey Deke moves and advanced stickhandling - Aerial control - Passing variations (chip pass, scoop pass) - Penalty corner techniques - Advanced defensive strategies

Kabaddi Advanced raiding maneuvers (super raid) - Quick and deceptive raiding holds - Strategic raiding based on game situation - Strong team defense coordination - Advanced anti-raid tactics

Karate Advanced kumite strategies and tactics - Complex combinations of attacks and counters - Throwing and takedown techniques (sweeps, trips) - Advanced conditioning and strength training

Table Advanced footwork for quick movement - Smashing technique - Serving

Tennis Variations (sidespin, flick serve) - Deceptive spins and tactics - Advanced match play strategies

Throwball Jump shot and other variations - No-look passes and behind-the-back passes - Quick throws and fast breaks - Advanced dodging techniques and footwork - Zone defense and press defense strategies

Volleyball Offensive spiking mechanics (jumping and hitting the ball

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

1. Demonstrate an understanding of the link between nutrition, performance, and healthy eating habits
2. Demonstrate improved self-awareness, stress management skills, and effective teamwork through participation in sportsmanship-focused activities
3. Perform in the selected sports or athletic events

Textbooks:

1. Muller, J. P., "Health, Exercise and Fitness", 1st Edition, Sports Publication, 2018.
2. Uppal, A.K., "Physical Fitness", Friends Publication New Delhi, 1992.
3. Russell R.P., "Health & Fitness through Physical Education: Human Kinematics", Human Kinetics Publishers, 1994

Reference Books:

1. Anaika , "Play Field Manual", Friends Publication New Delhi, 2005.
2. IAAF Manual
3. Pinto John & Roshan Kumar Shetty, "Introduction to Physical Education"

Web links:

1. https://www.youtube.com/watch?v=wvlztaJYKYI
2. https://www.youtube.com/watch?v=d393LzvqG3E&list=PL94CA1fTzfEd8FkpCa0W NTF7y1pFWNFKc
3. https://www.youtube.com/watch?v=m7EhWv4wgP4

Scheme & Assessment of students for auditing the course & Grades		
Sl. No.	Activity	Marks
1	Participation of students	20
2	Quizzes-2, each of 15 marks	30
3	Final presentation/Exhibition/Participation in Competitions (Certificate of participation in National/International)	50
	Total	**100**

National Service Scheme-IV			
Semester	**VI**	CIE Marks	**100**
Course Code	**23NMCC327**	SEE Marks	
Teaching Hours/Week (L: T: P)	**0:0:1**	Exam Hrs	
Total Hours	**13**	Credits	**-**

Course Learning Objectives: This course is designed to

1. Develop discipline, character, brotherhood, the spirit of adventure and ideals of selfless service amongst young citizens
2. Develop youth leadership in the students
3. Induce social consciousness among students through various societal activities.
4. Impart knowledge in finding practical solutions to individual and community problems

NSS -Contents	**No. of Hrs: 13**

Introduction:

- Basic first aid skills
- Disaster preparedness, emergency evacuation

Activities:

- Environment Awareness and Conservation
- Obstacle management Training, conflict management and negotiation skills

Note:

- Students in individual or in a group should select any one activity in the beginning of each semester till end of that respective semester for successful completion as per the instructions of NSS officer with the consent of HOD of the department.
- At the end of every semester, activity report should be submitted for evaluation.

Course outcomes: At the end of the course, the student will be able to

1. Understand the importance of nation building and individual contribution to the betterment of the society.
2. Discover grassroots challenges of community and solve them by technological intervention.
3. Create societal impact by upholding the value of one for all and all for one.
4. Maintain discipline and team spirit.

Textbooks:

1. Ministry of Youth Affairs & Sports, Government of India (2022) "National Service Scheme Manual"
2. Rajiv Gandhi National Institute of Youth Development, Ministry of Youth Affairs & Sports, Government of India, (2017) "Introduction Training Module for National Service Scheme (NSS) Program officers",
3. Gurmeet Hans (1996), "Case material as Training Aid for field workers" TISS

Reference Books: 1. Dr. G R Bannerjee, (2012), Social service opportunities in Hospitals, TISS 2. Ram Ahuja (Third Edition, 2014), Social Problems in India, Rawat publications
Web links: 1. History of NSS https://thebetterindia.com/140/national-service-scheme-nss/ 2. NSS – an introduction https://www.youtube.com/@nationalserviceschemeoffic4034/videos

Assessment details (CIE): Students will be assessed with the	
Weightage	CIE Marks
Participation of students	30
Individual contribution to success of the program	40
Report preparation	30
Total	**100**

Arts-IV			
Semester	**VI**	CIE Marks	**100**
Course Code	**23NMCC328**	SEE Marks	**-**
Teaching Hours/Week (L: T: P)	**0:0:1**	Exam Hrs	**-**
Total Hours	**13**	Credits	**-**

Course Learning Objectives: This course is designed to

1. To impart an understanding of the creative process from initial concept to final execution.
2. Create and demonstrate proficiency in a chosen arts discipline through practical application.
3. Analyze and appreciate diverse art forms and styles
4. To participate in art competitions at regional, state, national, and international levels, as well as in cultural events

Contents	**No. of Hrs.: 13**

Note: Student will continue the arts form selected in previous semester.

Performing Arts (Dance)	Orientation, Cinema Script Writing, Audition Techniques, Shooting Script, Basics Direction and Camera, Group Assignments, Group Presentation, Evaluation.
Music	Orientation, Western Songs, Voice Culture, Voice Modulation, Rap Singing, Folk Song Revision, Film Song Revision, Group Presentation Evaluation
Arts & Crafts	Orientation, Puppetry: Glow Puppetry- Head Puppets -Animal Puppetry - POP Puppetry- Group Presentation- Evaluation
Theatre	Orientation, Theatre Music, Theatre Choreography, Script Writing, Group Production, Grand Rehearsals, Group Show, Evaluation.

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

1. To be capable of creating choreography and delivering live performances for an audience.
2. Employ a range of acting techniques and use them to create a performance.
3. Evolve into creative, effective, independent, and reflective individuals capable of making informed decisions in both process and performance.
4. Acquire knowledge and comprehension of the roles and processes used in current theatre arts practice.

Textbooks:

1. Music in Theory and Practice by Bruce Benward and Marilyn Sake, McGraw-Hill Education,2014
2. Art Fundamentals: Theory and Practice by Otto G. Ocvirk, Robert E. Stinson, Philip R. Wigg, Robert Bone, and David L. Cayton, McGraw-Hill Education,2012
3. The Viewpoints Book: A Practical Guide to Viewpoints and Composition by Anne Bogart and Tina Landau, Theatre Communications Group,2004

Reference Books:

1. Dance Composition: A practical guide to creative success in dance making, Jacqueline M. Smith
2. The Artist's handbook of method and materials by Ralph Mayer
3. Glimpses of Indian music and dance by Dr. Arun Bangre.

Web links:

1. https://ccrtindia.gov.in/audio-visual-catalogue/

Scheme & Assessment of students for auditing the course & Grades		
Sl. No.	Activity	Marks
1	Students Participation	20
2	Quizzes-2 (each of 15 marks)	30
3	Final presentation/Exhibition/Participation in Competitions	50
	Total	**100**