KAMARAJ
COLLEGE OF ENGINEERING & TECHNOLOGY

(An Autonomous Institution - AFFILIATED TO ANNA UNIVERSITY, CHENNAI)

S.P.G.Chidambara Nadar - C.Nagammal Campus

S.P.G.C. Nagar, K.Vellakulam – 625 701 (Near VIRUDHUNAGAR).

B.E. MECHATRONICS ENGINEERING
REGULATIONS – 2021
AUTONOMOUS SYLLABUS
CHOICE BASED CREDIT SYSTEM
V & VI SEMESTER CURRICULUM AND SYLLABUS

VISION:

To make the Department of Mechatronics Engineering of this Institution the unique of its kind in the field of Research and Development activities in this part of world.

MISSION:

To impart highly innovative and technical knowledge in the field of Mechatronics Engineering to the urban and unreachable rural student folks through Total Quality Education.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

PEO 1: Graduates will be able to apply their multi-disciplinary knowledge to formulate, design, develop and analyse Mechatronics Systems.

PEO 2: Graduates will be able to come up with solution for any real time problems in the field of Mechatronics Engineering and allied areas demanded by the Industry and Society.

PEO 3: Graduates will be able to get familiarized with economical issues in Mechatronics Engineering and work in multi-disciplinary teams with ethical code of conduct.

PROGRAM OUTCOMES:

After going through the four years of study, the Mechatronics Engineering graduates will have the ability to

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

7	Environment and sustainability	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9	Individual and team work	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10	Communication	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend andwrite effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11	Project management and finance	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12	Life-long learning	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES (PSOs):

PSO1 : Graduates will be able to apply their knowledge in sensors, drives, actuators, controls, mechanical design and modern software & hardware tools to design & develop cost effective Mechatronics systems.

PSO2 : Graduates will be able to become Technocrats and Entrepreneurs, build the attitude of developing new concepts on emerging fields and pursuing higher studies.

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REGULATIONS - 2021
CHOICE BASED CREDIT SYSTEM
B.E. MECHATRONICS ENGINEERING
CURRICULUM AND SYLLABI FOR SEMESTER V TO VI
SEMESTER V

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	MT2301	Embedded Systems and Programming	PC	3	3	0	0	3
2	MT2302	Kinematics and Dynamics of Machinery	PC	3	3	0	0	3
3		Professional Elective I	PE	3	3	0	0	3
4		Professional Elective II	PE	3	3	0	0	3
5		Professional Elective III	PE	3	3	0	0	3
6		Professional Elective IV	PE	3	3	0	0	3
PRACTICALS								
7	MT2303	Embedded Systems Laboratory	PC	3	0	0	3	1
8	ME2258	Theory of Machines Laboratory	PC	3	0	0	3	1
9	EM2351	Professional Communication	EM	2	0	0	2	1
10	EM2301	Internship**	EM	0	0	0	0	1
			TOTAL	**26**	**18**	**0**	**8**	**22**

**** Credits earned by the student through internship will be given in the final consolidated mark statement.**

SEMESTER VI

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	MT2351	Fluid Power Systems #	PC	4	2	0	2	3
2	MT2352	Industrial Automation#	PC	4	2	0	2	3
3	MT2353	Robotics and Machine Vision System	PC	3	3	0	0	3
4		Professional Elective V	PE	3	3	0	0	3
5		Professional Elective VI	PE	3	3	0	0	3
6		Professional Elective VII	PE	3	3	0	0	3
7		Open Elective I*	OE	3	3	0	0	3
PRACTICALS								
8	MT2354	Design and Fabrication Project for Mechatronics Engineering	EM	3	0	0	3	1
9	MT2355	Robotics and Machine Vision System Laboratory	PC	3	0	0	3	1
			TOTAL	**29**	**19**	**0**	**10**	**23**

PROFESSIONAL ELECTIVE COURSES : VERTICALS

VERTICAL 1 : ROBOTICS

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	VMT311	Design of Robot Elements	PE	3	3	0	0	3
2	VMT312	Robot Operating Systems	PE	3	3	0	0	3
3	VMT313	Autonomous Mobile Robots	PE	3	3	0	0	3
4	VMT314	Collaborative Robotics	PE	3	3	0	0	3
5	VMT315	Medical Robotics	PE	3	3	0	0	3
6	VMT316	Humanoid Robotics	PE	3	3	0	0	3
7	VMT317	Micro Robotics	PE	3	3	0	0	3

VERTICAL 2: AUTOMATION

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	VMT321	Total Integrated Automation	PE	3	3	0	0	3
2	VMT322	Digital Twin and Industry 5.0	PE	3	3	0	0	3
3	VMT323	Virtual Instrumentation	PE	3	3	0	0	3
4	VMT324	Industrial Network Protocols	PE	3	3	0	0	3
5	VMT325	Advanced Manufacturing	PE	3	3	0	0	3
6	VMT326	Farm Automation	PE	3	3	0	0	3
7	VMT327	Computer Aided Inspection and Testing	PE	3	3	0	0	3

VERTICAL 3 : SMART MOBILITY SYSTEMS

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	VMT331	Automobile Engineering	PE	3	3	0	0	3
2	VMT332	Electric and Hybrid Vehicles	PE	3	3	0	0	3
3	VMT333	Automotive Mechatronics	PE	3	3	0	0	3
4	VMT334	Automotive System Modelling and Simulation	PE	3	3	0	0	3
5	VME314	Drone Technology	PE	3	3	0	0	3
6	VMT335	Design of UAV Systems	PE	3	3	0	0	3
7	VMT336	Intelligent Transportation System for Smart Mobility	PE	3	3	0	0	3

OPEN ELECTIVES OFFERED TO OTHER DEPARTMENT

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
OPEN ELECTIVE I								
1	OMT781	Foundation of Robotics	OE	3	3	0	0	3

VERTICAL MINOR: EMBEDDED SYTEMS AND ROBOTICS

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	MMT101	Embedded System Design for Robotics	OE	3	3	0	0	3
2	MMT102	Arduino and Raspberrypi Programming	OE	3	3	0	0	3
3	MMT103	Industrial Robotics	OE	3	3	0	0	3
4	MMT104	Service and Field Robotics	OE	3	3	0	0	3
5	MMT105	Robot Programming Using ROS	OE	3	3	0	0	3
6	MMT106	Robotics in Manufacturing Automation	OE	3	3	0	0	3

Course Code	Course Name	L	T	P	C
MT2301	EMBEDDED SYSTEMS AND PROGRAMMING	3	0	0	3

Category: Professional Core Course

a. Preamble

This course promotes students to familiarize the architecture and fundamental units of microcontroller. It also enables the students to know the microcontroller programming methodology and to acquire the interfacing skills and data exchange methods using various communication protocols.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the various functional units of microcontroller, processors and system-on-chip based on the features and specifications.	K2
CO2	Recognize the role of each functional units in microcontroller, processors and system-on-chip based on the features and specifications.	K2
CO3	Explain the architecture and Instruction set in ARM Processor	K2
CO4	Explain the architecture and fundamental operating concepts behind PIC Microcontroller	K2
CO5	Summarize the basics of Real time operating system and its applications.	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO MICROCONTROLLER **9**

Fundamentals Functions of ALU - Microprocessor - Microcontrollers – CISC and RISC – Types Microcontroller - 8051 Family - Architecture - Features and Specifications - Memory Organization - Instruction Sets – Addressing Modes.

PROGRAMMING AND COMMUNICATION **9**

Fundamentals of Assembly Language Programming – Instruction to Assembler – Compiler and IDE - C Programming for 8051 Microcontroller – Basic Arithmetic and Logical Programming - Timer and Counter - Interrupts – Interfacing and Programming of Serial Communication, I2C, SPI and CAN of 8051 Microcontroller – Bluetooth and WI-FI

interfacing of 8051 Microcontroller.

ARM PROCESSOR **9**

Introduction ARM 7 Processor - Internal Architecture – Modes of Operations – Register Set – Instruction Sets – ARM Thumb - Thumb State Registers – Pipelining – basic programming of ARM 7 - Applications.

PIC MICROCONTROLLER **9**

Architecture - Instruction set - Addressing modes - Timers - Interrupt logic - CCP modules - ADC

REAL TIME OPERATING SYSTEM **9**

Real time operating systems Architecture - Tasks and Task states - Tasks and Data - Semaphore and shared data - Message queues, mail boxes and pipes - Encapsulating semaphores and queues - interrupt routines in an RTOS Environment.

d. Activities

Students shall be exposed to the various programming concepts involved in 8051 microcontroller and PIC microcontroller.

e. Learning Resources

Text Books

1. David E. Simon, *An embedded software primer*, Addison – Wesley, Indian Edition Reprint,2009.
2. Kenneth J. Aylala, *The 8051 Microcontroller, the Architecture and Programming Applications*, 2003.

Reference Books

1. Muhammad Ali Mazidi and Janice Gillispic Mazdi, *The 8051 Microcontroller and Embedded Systems*, Pearson Education, 2006.
2. James W. Stewart, *The 8051 Microcontroller Hardware, Software and Interfacing*, Regents Prentice Hall, 2003.
3. John B. Peatman, *Design with PIC Microcontrollers*, Prentice Hall, 2003.
4. ARM® v7-M Architecture Reference Manual- https://web.eecs.umich.edu/~prabal/teaching/eecs373-f10/readings/ARMv7-M_ARM.pdf

Course Code	Course Name	L	T	P	C
MT2302	KINEMATICS AND DYNAMICS OF MACHINERY	3	0	0	3

Category: Professional Core Course

a. Preamble

This course promotes the students to understand basic concepts of relative motion and its effects in various machine elements.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain various classification of mechanisms and its inversions used in machineries	K2
CO2	Examine the assembly with respect to the displacement, velocity, and acceleration at any point in a link of a mechanism and design cam mechanisms for specified output motions.	K3
CO3	Demonstrate the basic concepts of toothed gearing and the kinematics of gear trains	K3
CO4	Investigate the force-motion relationship in components subjected to external forces and understand the effects of unbalances resulting from prescribed motions in mechanism.	K3
CO5	Illustrate the effect of dynamics of undesirable vibrations.	K3

c. Course Syllabus **Total : 45 Periods**

BASICS OF MECHANISMS **6**

Basic kinematic concepts and definitions - Classification of mechanisms – Degree of freedom, Mobility : Types of Links, Joints, Kinematic pairs – Kutzbach criterion, Gruebler's criterion – Grashof's Law – Kinematic inversions of four bar chain and slider crank chains.

KINEMATICS OF LINKAGE AND CAM MECHANISMS **12**

Displacement, velocity and acceleration analysis of simple mechanisms – Graphical method - Classification of cams and followers – Terminology and definitions – Displacement diagrams – Uniform velocity, simple harmonic and Cycloidal motions.

GEARS AND GEAR TRAINS **9**

Law of toothed gearing – Types of Gears - Involutes and Cycloidal tooth profiles – Spur Gear terminology – contact ratio – Interference and undercutting. Gear trains – Speed ratio – Parallel axis gear trains – Epicyclic Gear Trains.

FORCE ANALYSIS, BALANCING AND GYROSCOPE **9**

D Alembert's principle – Dynamic Analysis in reciprocating engines – Balancing of revolving masses. Gyroscopic effects in airplanes.

VIBRATION AND GOVERNORS **9**

Types of Vibration – natural Frequency for transverse vibration, longitudinal & torsional vibration –Vibration isolation. Governors – Types –Porter governor – Proell governor.

d. Activities

Students shall be given exposure to various kinds of gears to understand the applications of one over the others

e. Learning Resources

Text Book

1. Khurmi, R.S, *Theory of Machines*,14th Edition, S Chand Publications.

Reference Books

1. F.B.Sayyad, *Kinematics of Machinery,* MacMillan Publishers Pvt Ltd., Tech-max educational resources, 2023 .
2. Rattan, S.S, *Theory of Machines*, 5th Edition, Tata McGraw-Hill, 2019.
3 Thomas Bevan, *Theory of Machines*, 3rd Edition, CBS Publishers and Distributors, 2009.
4 Robert L. Norton, *Kinematics and Dynamics of Machinery*, Tata McGraw-Hill,2017.

Course Code	Course Name	L	T	P	C
MT2303	EMBEDDED SYSTEMS LABORATORY	0	0	3	1

Category: Professional Core Course

a. Preamble

This course promotes students to understand the programming concepts related to embedded system applications.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Apply the assembly language programming concepts in 8085 Microprocessor.	K3
CO2	Apply the assembly language programming concepts in 8051 Microcontroller.	K3
CO3	Apply the programming concepts in ARM Processor.	K3
CO4	Apply the programming concepts in PIC Microcontroller.	K3
CO5	Apply the GPIO Programming concepts of Real Time Embedded Operating Systems.	K3

c. Course Syllabus **Total : 45 Periods**

1. Assembly Language Programming and Simulation of 8085.
2. Assembly Language Programming and Simulation of 8051.
3. Alphanumeric and Graphic LCD Interfacing using 8051 Microcontroller.
4. Timer, Counter and Interrupt Program Application for 8051.
5. UART Serial and Parallel Port Programming of 8051.
6. I2C, SPI and CAN Programming of 8051.
7. Programming of PIC Microcontroller - I/O Programming, Interrupts and Timer application
8. Interfacing Keypad, LCD, ADC/DAC with PIC Microcontroller
9. Programming of ARM Processors.
10. GPIO Programming of Real Time Embedded Operating Systems.

d. Activities

Students shall be exposed to the various programming concepts related to 8085, 8051, PIC Microcontroller and RTOS.

e. Learning Resources

Text Books

1. Krishna Kant, *Microprocessor and Microcontrollers*, Eastern Company Edition, Prentice Hall of India, New Delhi,2016.

Reference Books

1. John B. Peatman, *Design with PIC Microcontrollers*, Prentice Hall, 2003.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	8085 Microprocessor Trainer with Power Supply	15
2.	8255 Interface board	5
3.	8251 Interface board	5
4.	8259 Interface board	5
5.	8279 keyboard/Display Interface board	5
6.	8254 timer counter	5
7.	ADC and DAC card	5
8.	Traffic Light Control System	5
9.	8051 Assembler (open source)	30
10.	Desktop with FreeRTOS (open source)	30

Course Code	Course Name	L	T	P	C
ME2258	THEORY OF MACHINES LABORATORY	0	0	3	1

Category: Professional Core Course

a. Preamble

Students will be demonstrated with the principles learnt in Kinematics and Dynamics of Machinery.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Analyze the kinematics principles of gears, mechanisms, cam profile	K3
CO2	Understand the mass moment of inertia of connecting rod and turn table apparatus	K3
CO3	Analyze the balancing of rotary masses.	K3
CO4	Analyze motorized gyroscopic effect, couple, whirling of shaft & governors.	K3
CO5	Analyze the frequency of free and forced vibration, torsional vibration and transverse vibration for shaft and spring.	K3

c. Course Syllabus **Total : 45 Periods**

1. Study of gear and its parameters
2. Kinematics of four bar mechanism and its inversion
3. Determination of mass moment of inertia using turn table apparatus
4. Determination of mass moment of inertia of a connecting rod
5. Motorized gyroscope
6. Universal governer
7. Cam
8. Spring mass system
9. Determination of torsional natural frequency of single and double rotor systems
10. Tuned vibration absorber
11. Determination of critical speeds of shaft
12. Balancing of rotating mass
13. Determination of natural frequency of a cantilever beam using transverse vibration setup
14. Determination of natural frequency of a fixed beam using transverse vibration setup

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	Cam follower setup	1
2.	Motorized gyroscope	1
3.	Governor apparatus - Watt, Porter, Proell and Hartnell governors.	1
4.	Whirling of shaft apparatus.	1
5.	Dynamic balancing machine.	1
6.	Torsional vibration setup.	1
7.	Spring mass vibration system	1
8.	Gear Models	1
9.	Kinematic Models to study various mechanisms.	1
10.	Turn table apparatus.	1
11.	Transverse vibration setup	1

Course Code	Course Name	L	T	P	C
EM2351	PROFESSIONAL COMMUNICATION	0	0	2	1

Category: Employability Enhancement Courses

a. Preamble

The course aims to:

• Enhance the Employability and Career Skills of students.

• Orient the students towards grooming as a professional.

• Make them Employable Graduates.

• Develop their confidence and help them attend interviews successfully.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Apply hard and soft skills to enhance their employability	K3
CO2	Utilize adequate presentation skills to present a PPT	K3
CO3	Demonstrate the proper usage of grammar in GD	K3
CO4	Make use of the acquired skills while attending interviews	K3
CO5	Develop adequate Soft Skills required for the workplace	K3

c. Course Syllabus **Total : 30 Periods**

SOFT SKILLS **6**

Introduction to Soft Skills– Hard skills & soft skills – employability and career Skills—Grooming as a professional with values—Time Management—General awareness of Current Affairs.

EFFECTIVE PRESENTATIONS **6**

Self-Introduction-organizing the material – Introducing oneself to the audience – introducing the topic – answering questions – individual presentation practice— presenting the visuals effectively – 5 minute presentations.

GROUP DISCUSSION **6**

Introduction to Group Discussion— Participating in group discussions – understanding group dynamics – brainstorming the topic -– questioning and clarifying –GD strategies-activities to improve GD skills.

INTERVIEW ETIQUETTE **6**

Interview etiquette – dress code – body language – attending job interviews– telephone/skype interview -one to one interview &panel interview – FAQs related to job interviews.

CAREER PLAN **6**

Recognizing differences between groups and teams- managing time-managing stress-networking professionally- respecting social protocols-understanding career management-developing a long-term career plan-making career changes.

d. Activities

Students shall be trained in Individual Presentation, Group Discussion and Mock Interview.

e. Learning Resources

Reference Books

1. Butterfield, Jeff Soft Skills for Everyone. Cengage Learning: New Delhi, 2015
2. E. Suresh Kumar et al. Communication for Professional Success. Orient Blackswan: Hyderabad, 2015
3. Interact English Lab Manual for Undergraduate Students,. Orient BlackSwan: Hyderabad, 2016.
4. Raman, Meenakshi and Sangeeta Sharma. Professional Communication. Oxford University Press: Oxford, 2014
5. S. Hariharanet al. Soft Skills. MJP Publishers: Chennai, 2010.WEB SOURCES

Course Code	Course Name	L	T	P	C
EM2301	INTERNSHIP	0	0	0	1

Category: Employability Enhancement Course

a. Preamble

To enable the students to

- Get connected with industry/ laboratory/research institute.
- Get practical knowledge on production process in the industry and develop skills to solve industry related problems.
- Develop skills to carry out research in the research institutes/laboratories.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Validate system-level processes, techniques, manufacturing and production processes in the industry/research facilities of the laboratory/research institute.	K5
CO2	Analyse the solutions of industry/research problems.	K4
CO3	Document system specifications, design methodologies, process parameters, testing parameters and results.	K2
CO4	Comprehend the process followed in the industry/research institute in the form of presentation .	K2
CO5	Demonstrate the technical knowledge observed in the industry/research institute with the courses studied.	K2

c. Course Instruction

The students individually undergo training in reputed industry/ research institutes / laboratories for the specified duration. After completion of the training, a detailed report should be submitted within ten days from the commencement of next semester. The evaluation will be done as per the Regulations. Credits shall be awarded to the students who satisfy the clauses for industrial training/ internship of the Regulation concerned.

Course Code	Course Name	L	T	P	C
MT2351	FLUID POWER SYSTEMS	2	0	2	3

Category: Professional Core Course

a. Preamble

This course introduces to understand the fundamentals of fluid power principles, Pneumatic and hydraulic circuits used in the Industries.

b. Course Outcome

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

THEORY

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the working principle of Hydraulic components.	K2
CO2	Understanding working principles of Hydraulics to design the Hydraulic circuits for Industrial applications.	K2
CO3	Explain the working principle of Pneumatic components.	K2
CO4	Understanding working principles of pneumatics to design the Pneumatic circuits for Industrial applications.	K2
CO5	Understand various troubles shooting methods and applications of fluid power systems.	K2

LABORATORY

CO. No.	Course Outcome	Knowledge Level
CO1	Select the actuators and valves for the design of Pneumatic circuits.	K3
CO2	Select the actuators and valves for the design of Electro Pneumatic circuits.	K3
CO3	Select the actuators and valves for the design of Hydraulic circuits.	K3
CO4	Design and simulate the Pneumatic circuits using software tool.	K3
CO5	Design and simulate the Hydraulic circuits using software tool.	K3

c. Course Syllabus **Total : 60 Periods**

HYDRAULIC SYSTEMS AND CONTROL COMPONENTS **6**

Basic Components of Hydraulic power pack: Direction control, Flow control and Pressure control valves-Types and working. Hydraulic Actuators: Cylinders– Types and construction, Hydraulic cushioning - Hydraulic motors. ANSI Symbols.

DESIGN OF HYDRAULIC CIRCUITS **6**

Accumulators, Intensifiers. Hydraulic circuits - Regenerative, Pump Unloading, Double-pump, Air-over oil, Sequence, Fail-safe, Speed control, Electro hydraulic circuits.

PNEUMATIC SYSTEMS AND CONTROL COMPONENTS **6**

Basic Components of Pneumatics system: Screw Compressor- Filter, Regulator, Lubricator, Muffler, Air control Valves types, Quick Exhaust valves, Pneumatic actuators. ANSI Symbols.

DESIGN OF PNEUMATIC CIRCUITS **6**

Design of pneumatic circuits: Pilot operated Sequence circuits, cascade method– KV Mapping. Electro pneumatic circuits, Introduction to Fluidics and Pneumatic logic circuits.

TROUBLE SHOOTING AND APPLICATIONS **6**

Trouble Shooting and Remedies in Hydraulic and Pneumatic systems. Design of hydraulic circuits for Drilling, Planning, Shaping, Surface grinding, Press and Forklift applications. Design of Pneumatic circuits for a Pick and Place application and tool handling in a CNC machine.

FLUID POWER SYSTEMS LABORATORY: LIST OF EXPERIMENTS **30**

Design of pneumatic circuits:

1. Perform Sequencing of Two Pneumatic Cylinders using pilot operated Directional Control Valves.
2. Sequencing of Two Pneumatic Cylinders using Electro Pneumatic Trainer Kit (without Timer).
3. Sequencing of Two Pneumatic Cylinders using Electro Pneumatic Trainer Kit (with Timer).
4. Design a Pneumatic Two Cylinder Cascade Circuit Using Pneumatic Kit.

Design of hydraulic circuits:

5. Design of electro hydraulic circuit for Double Acting Cylinder Reciprocating System with flow control.
6. Design of electro hydraulic circuit for bi directional Motor System.

Design of Pneumatic and hydraulic circuits using software (AUTOMATION STUDIO / AUTOSIM):

7. Design and simulate a Pneumatic Three Cylinder Sequencing Circuit Using Software.
8. Design and simulate a Pneumatic Two Cylinder Cascade Circuit Using Software.

9. Design and simulate of electro hydraulic circuit for Double Acting Cylinder Reciprocating System with flow control Using Software.
10. Design and simulate Sequencing of Two Electro Pneumatic Cylinders Using Software.

d. Activities

Students shall be exposed to design the fluid power circuits for various industrial applications.

e. Learning Resources

Text Books

1. Anthony Esposito, *Fluid Power with Applications*, Prentice Hall, 2018.
2. Srinivasan.R, *Hydraulic and Pneumatic Controls*, Vijay Nicole Imprints, 3rd edition, 2019.

Reference Books

1. Majumdar, S.R, *Oil Hydraulics Systems – Principles and Maintenance, TataMcGraw* Hill, 2015.
2. Shanmugasundaram.K, *Hydraulic and Pneumatic Controls,* Chand & Co, 2013.

Requirements for a batch of 30 students (3 students per batch)

Sl. No	Name of the Equipments / Software	Quantity Required (R)
Hydraulics:		
1	Pressure relief valve	4
2	Pressure reducing valves	2
3	Flow control valves	2
4	Pressure switch	1
5	Limit switches	2
6	Linear actuator	1
7	Rotary actuator	1
8	Double solenoid actuated DCV	1
9	Single solenoid actuated DCV	1
10	Hydraulic power pack with pump and pressure relief valve	1

Pneumatics:		
11	Pneumatic trainer kit with FRL Unit, Single acting cylinder, push button	1
12	Pneumatic training kit with FRL unit, Double acting cylinder, manually actuated DCV	1
13	Pneumatic trainer kit with FRL unit, Double acting cylinder, Pilot actuated DCV	1
14	Pneumatic trainer kit with FRL unit Double acting cylinder, Double solenoid actuated DCV, DCV with sensor / magnetic reed switches	1
15	Automation studio software	1

Course Code	Course Name	L	T	P	C
MT2352	INDUSTRIAL AUTOMATION	2	0	2	3

Category: Professional Core Course

a. Preamble

This course introduces the basic concepts of Industrial Automation. It comprehensively details the programmable logic controllers and its applications in process industries. It describes the various intelligent controllers in process control.

b. Course Outcome

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

THEORY

CO. No.	Course Outcome	Knowledge Level
CO1	Interpret the architecture, I/O modules of PLC, and different types of switches.	K2
CO2	Develop PLC programs using various timer and counter functions of PLCs for a given application.	K3
CO3	Design the SCADA system with its supervisory functions for utility applications.	K3
CO4	Describe DCS architecture, operator interface, engineering interface, and communication facilities	K2
CO5	Select the PID, Neural Network controller, and Fuzzy Logic Controller for advanced process control.	K3

LABORATORY

CO. No.	Course Outcome	Knowledge Level
CO1	Choose the appropriate PLC for and explain the architecture, installation procedures, and troubleshooting.	K3
CO2	Develop Structured Text, Functional Block Diagram, and Ladder Logic diagram for simple applications.	K3
CO3	Develop a ladder logic program for material handling applications.	K3
CO4	Integrate PID controllers with PLC for Process Control applications.	K3

CO5	Interface the PLC with Flow, Level, Temperature Process Loops.	K3

c. Course Syllabus **Total : 60 Periods**

INTRODUCTION **6**

Role of automation in industries, Benefits of automation –Introduction to automation tools: Low cost automation- Automation strategy evolution (PLC,SCADA)

PROGRAMMABLE LOGIC CONTROLLER **6**

Introduction — Principles of operation – PLC Architecture and specifications – PLC hardware components Analog & digital I/O modules, Special I/O Modules, CPU & memory module of PLC. Manually operated switches – Mechanically operated switches - Latching relays

PROGRAMMING OF PLC **6**

Programming devices – PLC Programming Languages - PLC ladder diagram, Converting simple relay ladder diagram into ladder diagram. PLC programming - Simple instructions, Timer instructions - On delay, Off delay, Cyclic and Retentive timers, Up /Down Counters, control instructions – Data manipulating instructions, math instructions.

APPLICATIONS OF PLC **6**

Motor start and stop, Simple materials handling applications, Automatic water level controller, Automatic lubrication of supplier Conveyor belt, Automatic car washing machine.

SCADA SYSTEM & ARCHITECTURE **6**

Data acquisition systems, Various SCADA architectures, SCADA System Components: Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED), Communication technologies-types, Communication Networks-types.

PLC PROGRAMMING LAB **30**

1. Study of Selection Criteria Considerations of PLCs based on their specification.
2. Study of Installations and troubleshooting of PLC
3. Design a Ladder Logic Program for various Logic Gates AND, OR, NOT, NOR, NAND, EX-OR and EX-NOR.
4. Development of an application by using timer and counter of PLC.
5. Pneumatic Cylinder Sequencing using PLC.

6. Develop PLC Program to Control Traffic Light.
7. Interfacing between PLC and Process loop (Pressure)
8. Interfacing between PLC and Process loop (Temperature)
9. AC motor speed control using PLC and VFD.

d. Activities

Students shall be exposed to the different PLCs and its programming languages in lab premises.

e. Learning Resources

Text Books

1. Frank D Petruzella, *Programmable Logic Controllers*, 5th edition, McGraw-Hill Companies, March 2019.
2. Krishna Kant, *Computer Based Process Control,* Prentice Hall of India, Second Revised edition 2011.

Reference Books

1. Bela G. Liptak, Kriszta Venczel , *Instrument and Automation Engineers - Handbook Process Measurement and Analysis,* Fifth Edition - Two Volume Set , CRC Press,2016.
2. A.K. Gupta, S.K. Arora, Jean Riescher Westcott, *Industrial Automation and Robotics An Introduction* , Mercury Learning and information,2016.
3. Jinkun Liu, *Intelligent Control Design and MATLAB Simulation,* Springer Singapore, 2017.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Name of the Equipments / Software	Quantity Required
1.	PLC panel board kit with power supply Any three PLCs from the following list can be used but not limited to 1.Allen Bradley (Micro Logix 1200) 2. Siemens (SIMATIC S7 200) PLC 3. DELTA (DVP-SS Series) PLC 4. Schineder Modicon (M238 series) PLC 5. Mitsubishi Nexgenie (1000 series)	7
2.	Computer with any three PLC simulation software from the following list can be used but not limited to 1.Allen Bradley (Micro Logix 1200) 2. Siemens (SIMATIC S7 200) PLC 3. DELTA (DVP-SS Series) PLC	7

S.No.	Name of the Equipments / Software	Quantity Required
	4. Schineder Modicon (M238 series) PLC 5. Mitsubishi Nexgenie (1000 series)	
3.	Process control station	1
4.	½ HP AC motor	1
5.	VFD to control ½ HP AC motor	1
6.	Delta PLC software – free ware and corresponding PLC programming software.	1
7.	Open source SCADA software such as Free SCADA, Open SCADA, Indigo SCADA CodeSys Open source for PLC programming and interfacing with real time PLC.	1

Course Code	Course Name	L	T	P	C
MT2353	ROBOTICS AND MACHINE VISION SYSTEM	3	0	0	3

Category: Professional Core Course

a. Preamble

This course introduces the basic concepts of a robot, robot mechanics, robot programming and basics of machine vision applications in robotics.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the basic concepts and terminologies of robots.	K2
CO2	Understand the Procedures of Kinematics, Dynamics for Various Robots.	K2
CO3	Describing the various programming techniques used in industrial robots.	K2
CO4	Explain basis of machine vision systems used in robotics.	K2
CO5	Understand the various applications in machine vision systems.	K2

c. Course Syllabus **Total : 45 Periods**

BASICS OF ROBOTICS **9**

Introduction- Basic components of robot-Laws of robotics- Classification of robot – robot architecture-work space-accuracy- resolution and repeatability of robot. Applications of Robots.

ROBOT MECHANICS **9**

Robot kinematics: Introduction- Matrix representation- Rigid motion & homogeneous transformation- Forward & Inverse kinematics. Robot Dynamics: Introduction - Manipulator dynamics.

ROBOT PROGRAMMING **9**

Robot programming: Robot Languages- Classification of robot language-Computer control and robot software-Val system and Languages.

MACHINE VISION SYSTEMS **9**

Machine vision: image acquisition, digital images-sampling and quantization-levels of computation Feature extraction-windowing technique- Segmentation- Thresholding-Edge

detection- Binary morphology – Grey morphology.

MACHINE VISION APPLICATIONS **9**

Machine vision applications in manufacturing, electronics, printing, pharmaceutical, textile, applications in non-visible spectrum, metrology and gauging, OCR and OCV, vision guided robotics – Field and Service Applications – Agricultural, and Bio medical field, augmented reality, surveillance, bio-metrics

d. Activities

Students shall be exposed to the basics of robot's technology and machine vision systems.

e. Learning Resources

Text Books

1. Groover Mikell .P, *Industrial Robotics -Technology Programming and Application*, McGraw Hill, 2016.
2. Eugene Hecht, A. R. Ganesan, *Optics*, Fourth Edition, 2019.
3. K.S.FU, R.C. Gonzalez, and C.S.G.Lee, *Robotics control, Sensing, Vision, and Intelligence*, McGrawHill, 2013.

Reference Books

1. Mikell P Groover , *Automation, Production Systems, and Computer-Integrated Manufacturing*, Pearson Education, New York, 2019.
2. Rafael C. Gonzales, Richard. E. Woods, *Digital Image Processing*, Pearson Publishers, Fourth Edition, 2018.

Course Code	Course Name	L	T	P	C
MT2354	DESIGN AND FABRICATION PROJECT FOR MECHATRONICS ENGINEERING	0	0	3	1

Category: Employability Enhancement Course

a. Preamble

The main objective is to give an opportunity to the student to get hands on training in the fabrication of one or more components of a complete working model, which is designed by them.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Identify specific problems prevailing in the society or industry in the field of Mechatronics Engineering& allied areas.	K3
CO2	Carry out the literature survey for the identified problem.	K3
CO3	Develop Mechatronics product from various systems.	K3
CO4	Develop an appropriate solution for the identified problem using modern tool or methodology	K3
CO5	Impart communication and presentation skills through effective documentation and delivery.	K3

c. Course Instruction **Total : 45 Periods**

The students may be grouped into 2 to 4 and work under a project supervisor. The device/ system/component(s) to be fabricated may be decided in consultation with the supervisor and if possible with an industry. A project report to be submitted by the group and the fabricated model, which will be reviewed and evaluated for internal assessment by a Committee constituted by the Head of the Department. At the end of the semester examination the project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

Course Code	Course Name	L	T	P	C
MT2355	ROBOTICS AND MACHINE VISION SYSTEM LABORATORY	0	0	3	1

Category: Professional Core Course

a. Preamble

This course promotes students to understand the programming concepts in Robot Operating Systems.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Demonstrate the programming of robot in various industrial tasks.	K3
CO2	Write Robot programming for pick and Place operation.	K3
CO3	Write Robot programming for Colour and Shape identification.	K3
CO4	Create a machine vision setup for various industrial tasks.	K3
CO5	Write the programs for robot and machine vision applications.	K3

c. Course Syllabus **Total : 45 Periods**

1. Determination of maximum and minimum position of links.
2. Verification of transformation (Position and orientation) with respect to gripper and world coordinate system
3. Study of Robot Operating System -Publisher & Subscriber, ROSSERVICE AND ROSACTION.
4. Robot programming and simulation for pick and place
5. Robot programming and simulation for Colour identification
6. Robot programming and simulation for Shape identification
7. 2 DOF manipulator simulation using ADAMS
8. Cylindrical configuration robot simulation using ADAMS
9. Study on different kinds of vision sensors.
10. Experimentation on image acquisition towards the computation platform.
11. Pre-processing techniques in image processing
12. Edge detection and region of interest extraction.
13. Experimentation with image processing algorithm for feature extraction.
14. Experimentation with pattern recognition.
15. Vision based classification of objects.

d. Activities

Students shall be exposed to the hands on experience on Robot Operating System and Opencv Python module.

e. Learning Resources

Text Book

1. Lentin Joseph, Jonathan Cacace, *Mastering ROS for Robotics Programming*, Third Edition, Packt Publishing, 2021.

Reference Books

1. Lentin Joseph, Aleena Johny, *Robot Operating System (ROS) for Absolute Beginners Robotics Programming Made Easy*, Second Edition, Apress, 2022.
2. Lentin Joseph, *ROS Robotics Projects*, Packt publishing, 2017.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	ROS (Robotic Operating System)	30 No.
2.	1DOF "R-configuration" robot.	3 No.
3.	2DOF "R-R-configuration" robot.	2 No.
4.	ADAMS software package	10 No.

Course Code	Course Name	L	T	P	C
VMT311	DESIGN OF ROBOT ELEMENTS	3	0	0	3

Category: Professional Elective Course

a. Preamble

This course introduces the fundamentals of design, Computer Graphics and modelling of robot elements.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	State the design parameters for designing the components of a robot.	K2
CO2	Apply the concepts to design the Links, Joints, shafts and couplings.	K3
CO3	Apply the concept of design the belt, ropes and chain drives subjected to static and dynamic loads.	K3
CO4	Understand the CAD modelling techniques in designing a Robot.	K2
CO5	Design the various types of robot grippers.	K3

c. Course Syllabus **Total : 45 Periods**

FUNDAMENTALS OF MECHANICAL DESIGN **9**

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

DESIGN OF LINKS AND JOINTS **9**

Types of Links and Joints, Loads and Forces on Links and Joints - Design of solid and hollow shafts - Rigid and flexible Couplings.

DESIGN OF FLEXIBLE ELEMENTS **9**

Design of Flat belts and pulleys - Selection of V belts and pulleys – Selection of hoisting wire ropes and pulleys – Design of Transmission chains and Sprockets.

FUNDAMENTALS OF COMPUTER GRAPHICS, CURVES AND MODELLING **9**

Computer graphics – co-ordinate systems- 2D and 3D transformations - Clipping- viewing

transformation. Representation of curves - Hermite cubic spline curve, Bezier curve. Fundamentals of solid modeling, Boundary representation (B-rep), Constructive solid geometry (CSG).

SELECTION OF ROBOTS AND DESIGN OF GRIPPERS **9**

Factors influencing the selection of a robot- robot performance testing - economics of robotization. Grippers – Types of Grippers Mechanisms – Gripping Methods – Gripping Force analysis – Gripper Design – Two Finger gripper – Magnetic Gripper Design – Vacuum Gripper Design – Hooks – Scoops – Spools – Miscellaneous Grippers.

d. Activities

Students shall be exposed to the design of robot elements and types of grippers.

e. Learning Resources

Text Books

1. Bhandari. V.B, *Design of Machine Elements*, Tata McGraw-Hill Education, 5th edition, 2020.
2. Ibrahim Zeid, *Mastering CAD/CAM*, Tata McGraw Hill, second edition, 2016.
3. Gareth J.Monkman, Stefan Hesse, Ralf Steinmann, Henrik Schunk, *Robot Grippers*, Wiley, 2017.

Reference Book

1. Mikell P. Groover, *Industrial Robotics*, McGraw Hill, second edition, 2017.

Course Code	Course Name	L	T	P	C
VMT312	ROBOT OPERATING SYSTEMS	3	0	0	3

Category: Professional Elective Course

a. Preamble

This course promotes students to understand basic concepts of robot operating systems and programming.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Recognize the concept of ROS and programming.	K2
CO2	Evaluate the various robot algorithms in ROS programming.	K2
CO3	Deploy mapping, navigation and motion planning ROS with Move-it.	K2
CO4	Simulate robots in ROS with GAZEBO and V-REP.	K2
CO5	Program a robot using ROS and its tool boxes.	K2

c. Course Syllabus **Total : 45 Periods**

ROS ESSENTIALS **9**

Introduction to ROS- Advantages and Disadvantages of ROS - ROS Framework- ROS package C++, Python – ROS computation Graph – nodes, Messages, topics, services, bags, ROS Master- ROS Community- Basic programming and Syntax overview in C++ and Python – start with ROS programming - Creating Environment - Services-Actions and Nodes- Simple Interaction with the Simulation environment.

BUILD YOUR OWN ROBOT ENVIRONMENT **9**

CAD Tools for Robot Modelling – ROS Packages for robot modelling – Unified Robot Description Format and Tags- Kinematics and Dynamics Library – Create URDF Model - Robot Modelling using Unified Robot Description Format (URDF),-ROS parameter server and adding real-world object representations to the simulation environment _ Create Robot description using 7 DOF: joint number, name, type and angle limits – Xacro – Rviz – viewing of 7 DOF arm – creation of wheeled robot.

SIMULATION ROBOTS IN ROS WITH GAZEBO **9**

Robot simulation - Gazebo –create simulation model at Gazebo- Adding colors, textures, transmission tags, 3D vision sensor to Gazebo- Moving robot joints using ROS controllers.ROS controller interacts with Gazebo, interfacing state controller, simulation of moving the robot joints – simulation of differential wheeled robot in Gazebo.

ROS WITH VREP **9**

V-REP(Coppeliasim) is a multi-platform robotic simulator - Simulating the robotic arm using V-REP - Adding the ROS interface to V-REP joint - Simulating a differential wheeled robot, Adding a laser sensor , 3D vision sensor.

MAPPING, NAVIGATION AND MOTION PLANNING ROS WITH MOVEIT **9**

Move it Installation - Generating the Self-Collision matrix .virtual joints, planning groups, robot poses, robot end effector - MoveIt Architecture Diagram - Trajectory from RViz GUI executing in Gazebo - Planning scene overview diagram- Collision Checking - Motion Planning, Pick and Place Behaviors using Industrial Robots with ROS Moveit – ROS with MATLAB.

d. Activities

Students shall be exposed to the various simulation tools in ROS

e. Learning Resources

Text Book

1. Lentin Joseph, Jonathan Cacace, *Mastering ROS for Robotics Programming*, Third Edition, Packt Publishing, 2021.

Reference Books

1. Lentin Joseph, Aleena Johny, *Robot Operating System (ROS) for Absolute Beginners Robotics Programming Made Easy*, Second Edition, Apress, 2022.
2. Lentin Joseph, *ROS Robotics Projects*, Packt publishing, 2017.

Course Code	Course Name	L	T	P	C
VMT313	AUTONOMOUS MOBILE ROBOTS	3	0	0	3

Category: Professional Elective Course

a. Preamble

To impart knowledge on working of different types of robots, concept of localization, planning and navigation.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the basic components of wheeled robots.	K2
CO2	Control mobile robots of different geometry.	K2
CO3	Select and device suitable sensor for any mobile robots.	K2
CO4	Identify and map the location of mobile robots.	K2
CO5	Navigate mobile robots by avoiding obstacles.	K2

c. Course Syllabus **Total : 45 Periods**

LOCOMOTION **9**

Introduction, key issue for locomotion, legged mobile robots, leg configuration and stability, examples of legged robot locomotion, wheeled mobile robots, wheeled locomotion: the design space, wheeled locomotion: case studies.

MOBILE ROBOT KINEMATICS **9**

Kinematic models and constraints, representing robot position, forward kinematic models, wheel kinematic constraints, robot kinematic constraints, examples: robot kinematic model and constraints, mobile robot maneuverability, degree of mobility, degree of steerability, robot maneuverability, mobile robot workspace, degree of freedom, motion control- open loop control (trajectory-following), feedback control.

SENSORS FOR MOBILE ROBOTS **9**

Sensor classification, characterizing sensor performance, wheel/motor sensor, Heading sensors, Ground based beacons, active ranging, motion/speed sensor, vision based sensor, representing uncertainty, statistical representation, error propagation: combining uncertain measurements.

MOBILE ROBOT LOCALIZATION **9**

The challenge of localization: noise and aliasing, sensor noise, sensor aliasing, effector noise, an error model for odometric position estimation, localization-based navigation versus programmed solutions, belief representation, map representation, probabilistic map-based localization, autonomous map building – the stochastic map technique

PLANNING AND NAVIGATION **9**

Competences for navigation: planning and reacting, path planning, obstacle avoidance, navigation architectures, modularity for code reuse and sharing, control localization, techniques for decomposition, case studies: tiered robot architectures.

d. Activities

Students shall be exposed to the various simulations related to concept of localization, planning and navigation.

e. Learning Resources

Text Books

1. Todd, D, J, Walking Machines, *An Introduction to Legged Robots,* Springer, 2012.
2. Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzz, *Introduction to Autonomous Mobile Robots,* Bradford Company Scituate, USA, 2011.

Reference Books

1. Mason, M. *Mechanics of Robotics Manipulation*, Cambridge, MA, MIT Press, 2001.
2. Borenstein, J., Evereat., Feng, L, *Navigation Mobile Robots, System and Techniques*. A.K.Peters, Ltd., USA,1996.
3. Craig, J.J, *Introduction to Robotics: Mechanics and Control*, Pearson Education India, 2022.
4. Cox, I.J., Wilfong, G.T. (Editors), *Autonomous Robot Vehicles*, New York, Springer Verlag, 1990.

Course Code	Course Name	L	T	P	C
VMT314	COLLABORATIVE ROBOTICS	3	0	0	3

Category: Professional Elective Course

a. Preamble

This course promotes the students to understand the fundamentals of Collaborative Robotics and apply Swarm robots technology in real time applications.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Recognize the fundamentals of Collaborative Robotics	K2
CO2	Explain Swarm robots technology in real time applications	K2
CO3	Select the suitable concept of Modular Robotics and its Mechanics for modelling a collaborative robot	K2
CO4	Illustrate the various natural models for robot collaboration	K2
CO5	Summarize the concept of Reconfigurable robot	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO COBOTICS **9**

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

SWARM ROBOTICS **9**

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

MODULAR ROBOTICS **9**

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

NATURALLY INSPIRED COLLABORATION **9**

Collective Decision-Making. Group Decision Making in Animals, Collective Motion as Decision Process, Models for Collective Decision-Making Processes, Urn Models, Voter

Model ,Majority Rule , Hegselmann and Krause , Kuramoto Model , Axelrod Model, Ising Model, Fiber Bundle Model, Sznajd Model, Bass Diffusion Model, Sociophysics and Contrarians.

RECONFIGURABLE ROBOTS **9**

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

d. Activities

Students shall be exposed to the various models related to Collaborative Robotics.

e. Learning Resources

Text Books

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

Reference Book

1. Heiko Hamann, *Collective Decision-Making in Swarm Robotics: A Formal Approach,* Springer, 2019.

Course Code	Course Name	L	T	P	C
VMT315	MEDICAL ROBOTICS	3	0	0	3

Category: Professional Elective Course

a. Preamble

This course introduces the basic knowledge for identifying and describing different types of medical robots and their potential applications.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Identify various medical robots and their potential applications.	K2
CO2	Recognize the position tracking and hybrid systems.	K2
CO3	Apply Robotics and its concepts in medical fields.	K3
CO4	Understand the MIS procedure and be aware of the state of art in surgical and oncology robotics.	K2
CO5	Design a medical robotic system given the specific requirements for Rehabilitation and Medical care.	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **9**

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

LOCALIZATION AND TRACKING **9**

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

DESIGN OF MEDICAL ROBOTS **9**

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

SURGICAL ROBOTICS **9**

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

ROBOTS IN REHABILITATION AND MEDICAL CARE **9**

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

d. Activities

Students shall be exposed to the different medical robots technology and types of medical robots.

e. Learning Resources

Text Books

1. Achim Ernst FlorisSchweikard, *Medical Robotics*, Springer, 2016.
2. Paula Gomes, *Medical robotics Minimally invasive surgery*, Wood head, 2013.

Reference Books

1. Jaydev P Desai, Rajni V Patel, Antoine Ferreira; Sunil Kumar Agrawal, *The Encyclopedia of Medical Robotics*, World Scientific Publishing Co. Pvt. Ltd, 2019.
2. Farid Gharagozloo, *Robotic Surgery*, Springer, 2022.

Course Code	Course Name	L	T	P	C
VMT316	HUMANOID ROBOTICS	3	0	0	3

Category: Professional Elective Course

a. Preamble

To impart knowledge on design, kinematics and dynamics of humanoid robot and walking pattern generation.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Describe about the evolution of Humanoid robots.	K2
CO2	Expose the basic knowledge in kinematics of humanoids.	K2
CO3	Calculate the Humanoid Robot Motion and Ground Reaction Force.	K2
CO4	Identify two-dimensional walking pattern on different terrain.	K2
CO5	Summarize the Walking Pattern models.	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **9**

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

KINEMATICS **9**

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

ZMP AND DYNAMICS **9**

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

BIPED WALKING **9**

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

WALKING PATTERN GENERATION **9**

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

d. Activities

Students shall be exposed to the various mathematical relations related to humanoid robotics.

e. Learning Resources

Text Books

1. Dragomir N. Nenchev, Atsushi Konno, *Humanoid Robots Modeling and Control*, Butterworth Heinemann, 2019
2. Shuuji K, Hirohisa H,Kensuke H, Kazuhito ,*Introduction to Humanoid Robotics*, Springer, London,2013.
3. Goswami Ambarish, VadakkepatPrahlad, *Humanoid Robotics: A Reference*, Springer, 2019.
4. J. Craig, *Introduction to Robotics: Mechanics and Control*, Fourth Edition, Pearson, 2022.

Reference Books

1. J K. Harada, E. Yoshida, K. Yokoi (Eds.), *Motion Planning for Humanoid Robots*, Springer, London, 2010.
2. Lorenzo Sciavicco and Bruno Siciliano, *Modelling and Control of Robot Manipulators*, second edition, Springer, 2000.
3. Jean-Claude Latombe, *Robot Motion Planning*, Kluwer Academy Publishers, 2004.

Course Code	Course Name	L	T	P	C
VMT317	MICRO ROBOTICS	3	0	0	3

Category: Professional Elective Course

a. Preamble

This course promotes students to understand the fundamental aspects of the emerging field of micro robotics.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the concepts of mass, energy, and momentum balance in micro robotics.	K2
CO2	Adapt and synthesize learned engineering skills to create micro robot.	K2
CO3	Describe flexures, actuators and sensors used in micro robotics for different robotics applications	K2
CO4	Summarize the fabrication technology concepts used in micro robotics	K2
CO5	Illustrate the implementation concepts of Microrobots	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO MICRO ROBOTICS **9**

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

SCALING LAWS AND MATERIALS FOR MEMS **9**

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

FLEXURES, ACTUATORS AND SENSORS **9**

Elemental flexures - Flexure systems - Mathematical formalism for flexures - Electrostatic

actuators - Piezo-electric actuators - Magneto-strictive actuators - Electromagnetic sensors - Optical-based displacement sensors - Motion tracking with microscopes

MICROROBOTICS **9**

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

IMPLEMENTATION OF MICROROBOTS **9**

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

d. Activities

Students shall be exposed to the various sensors related to microrobotics

e. Learning Resources

Text Books

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

Reference Books

1. Nadim Maluf and Kirt Williams, *An Introduction to Microelectromechanical systems Engineering*, Second edition, Artech House, 2004.
2. Julian W Gardner, *Microsensors: Principles and Applications*, Second edition, Wiley, 2007.
3. MetinSitti, *Mobile Microrobotics*, MIT Press, 2017
4. Nicolas Chaillet, Stephane Rangier, *Microrobotics for Micromanipulation*, John Wiley & Sons, 2013.

Course Code	Course Name	L	T	P	C
VMT321	TOTAL INTEGRATED AUTOMATION	3	0	0	3

Category: Professional Elective Course

a. Preamble

This course promotes students to understand basic concepts of PLC and PAC automation and impart knowledge on SCADA and communication protocols in automation systems. It also enables the students to design and develop automatic control system using distributed control systems

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Understand the basics of PLC & PAC automation	K2
CO2	Understand the basics in HMI systems and to integrate it with other systems	K2
CO3	Use SCADA and C programming for report generation	K2
CO4	Acquire information on communication protocols in automation systems	K2
CO5	To design and develop automatic control system using distributed control systems.	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **9**

Need, components of TIA systems, advantages, Programmable Automation Controllers (PAC), Vertical Integration structure.

HUMAN MACHINE INTERFACE (HMI) **9**

Necessity and Role in Industrial Automation, Need for HMI systems. Types of HMI- Text display - operator panels - Touch panels - Panel PCs - Integrated displays (PLC & HMI)

SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) **9**

Overview – Developer and runtime packages – architecture – Tools – Tag – Internal & External graphics, Piping and Instrumentation diagram (P & I diagram) - Alarm logging – Tag logging – structured tags– Trends – history– Report generation, VB & C Scripts for

SCADA application.

COMMUNICATION PROTOCOLS OF SCADA **9**

Proprietary and open Protocols – OLE/OPC- UPC UA/DA – DDE – Server/Client Configuration – Messaging – Recipe – User administration – Interfacing of SCADA with PLC, drive, and other field device

DISTRIBUTED CONTROL SYSTEMS (DCS) **9**

DCS – architecture – local control unit- programming language – communication facilities – operator interface – engineering interfaces. APPLICATIONS OF PLC & DCS: Case studies of Machine automation, Process automation, Introduction to SCADA Comparison between SCADA and DCS.

d. Activities

Students shall be given exposure to SCADA and C programming for report generation

e. Learning Resources

Text Books

1. David Bailey, Edwin Wright, *Practical SCADA for industry, Newnes, An imprint of Elsevier,* 2005.
2. Michael P. Lukas, *Distributed Control systems,* Van Nostrand Reinfold Company, 2016.

Reference Books

1. John. W. Webb & Ronald A. Reis, *Programmable logic controllers: Principles and Applications*, Prentice Hall India, 2015.
2. Win CC Software Manual, 2019, Siemens.
3. RS VIEW 32 Software Manual, 2011, Allen Bradly.
4. CIMPLICITY SCADA Packages Manual, 2022, Fanuc India Ltd.

Course Code	Course Name	L	T	P	C
VMT322	DIGITAL TWIN AND INDUSTRY 5.0	3	0	0	3

Category: Professional Elective Course

a. Preamble

This course introduces the basic concepts of digital twin and industry 5.0. It comprehensively details the digital twin in discrete and process industries. It describes the various applications of industry 5.0.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Summarize the basics concepts in digital twin.	K2
CO2	Describe the concepts in digital twin in a discrete Industry.	K2
CO3	Recognize the concepts in digital twin in a process Industry.	K2
CO4	Attain the knowledge in industry 5.0	K3
CO5	Apply the advantages of digital twin in industry 5.0 with various applications.	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **9**

Digital twin – Definition, types of Industry and its key requirements, Importance, Application of Digital Twin in process, product, service industries, History of Digital Twin, DTT role in industry innovation, Technologies/tools enabling Digital Twin – Virtual CAD Models – control Parameters- Real time systems – control Parameters – Handshaking Through Internet – cyber physical systems.

DIGITAL TWIN IN A DISCRETE INDUSTRY **9**

Basics of Discrete Industry, Trends in the discrete industry, control system requirements in a discrete industry, Digital Twin of a Product, Digital Thread in Discrete Industry, Data collection & analysis for product & production improvements, Automation simulation, Digital Enterprise.

DIGITAL TWIN IN A PROCESS INDUSTRY **9**

Basics of Process Industry, Trends in the process industry, control system requirements in a process industry, Digital Twin of a plant, Digital Thread in process Industry, Data collection

and analysis for process improvements, process safety, Automation simulation, Digital Enterprise.

INTRODUCTION TO INDUSTRY 5.0 **9**

Industrial Revolutions, Industry 5.0 – Definition, principles, Application of Industry 5.0 in process & discrete industries, Benefits of Industry 5.0, challenges in Industry 5.0, Smart manufacturing, Internet of Things 5.0, Industrial Gateways, Basics of Communication requirements – cognitive systems 5.0

ADVANTAGES OF DIGITAL TWIN **9**

Improvement in product quality, production process, process Safety, identify bottlenecks and improve efficiency, achieve flexibility in production, continuous prediction and tuning of production process through Simulation, reducing the time to market.

d. Activities

Students shall be exposed to the different digital twin technologies and its applications in industrial 5.0 in the college premises.

e. Learning Resources

Text Books

1. Alp Ustundag and Emre Cevikcan, *Industry 4.0: Managing The Digital Transformation*, Springer Series in Advanced Manufacturing., Switzerland, 2018.
2. Andrew Yeh Chris Nee, Fei Tao, and Meng Zhang, *Digital Twin Driven Smart Manufacturing*, Elsevier Science., United States, 2019.

Reference Books

1. Uthayan Elangovan, *Industry 5.0: The Future of the Industrial Economy*, CRC Press, 2022.
2. Alasdair Gilchrist, *Industry 4.0: The Industrial Internet of Things*, Apress., United States ,2015.
3. Christoph Jan Bartodziej, *The Concept Industry 4.0 an Empirical Analysis of Technologies and Applications in Production Logistics*, Springer Gambler., Germany, 2017.
4. Ronald R. Yager and Jordan Pascual Espada, *New Advances in the Internet of Things*, Springer., Switzerland, 2018.

Course Code	Course Name	L	T	P	C
VMT323	VIRTUAL INSTRUMENTATION	3	0	0	3

Category: Professional Elective Course

a. Preamble

This course introduces the basic concepts of virtual instrumentation. It comprehensively details the programming in LabVIEW software and DAQ card in LabVIEW hardware. It describes the different types of interfaces and the applications of VI in medical applications.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	To comprehend and appreciate the significance and role of this course in the present contemporary world.	K2
CO2	Identify salient traits of a virtual instrument.	K2
CO3	Understand the use of VI for data acquisition.	K2
CO4	Experiment various types of interfacing and toolboxes.	K3
CO5	Apply the virtual instrumentation technologies for medical applications.	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **9**

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

VI USING LABVIEW **9**

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

DATA ACQUISITION AND CONTROL IN VI **9**

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

INSTRUMENT INTERFACES **9**

Current loop, RS 232C/RS 485, GPIB, System basics, Interface basics: USB, PCMCIA, networking basics for office & industrial application VISA & IVI, image acquisition &

processing, Motion Control. ADC, DAC, DIO, DMM, waveform generator.

APPLICATION OF VI IN BIOMEDICAL ENGINEERING 9

Design of virtual applications for Electrocardiography (ECG), Electromyography (EMG), Air Flow and Lung Volume, Heart Rate variability analysis, Noninvasive Blood Pressure Measurement, Biofeedback, Virtual Reality & 3D graphical modeling, Virtual Prototyping.

d. Activities

Students shall be exposed to the NI Labview Software &Hardware.

e. Learning Resources

Text Books

1. Jerome, Jovitha, *Virtual Instrumentation and LABVIEW*, PHI Learning, New Delhi, 1st Edition, 2010.
2. Jivan Shrikrishna Parab, Ingrid Anne Nazareth, Rajendra S. Gad, *Learning by Doing with National Instruments Development Boards*, CRC Press,2020.

Reference Books

1. Rick Bitter, Taqi Mohiuddin, Matt Nawrocki, *LabView Advanced Programming Techniques* , CRC Press, Second Edition,2017.
2. Sanjay Gupta and Joseph John, *Virtual Instrumentation using LabVIEW*, Tata Mc Graw – Hill Publishing Company Limited, New Delhi, 1st Edition, 2010.
3. Jon B. Olansen, Eric Rosow, *Virtual Bio-Instrumentation: Biomedical, Clinical, and Healthcare Applications in Lab VIEW*" Pearson Education, 2011.
4. Gary Johnson, *LABVIEW Graphical Programming*, McGraw Hill, 4th edition, 2006.
5. Lisa K. Wells and Jeffrey Travis, *LABVIEW for Everyone*, PHI, 2006.

Course Code	Course Name	L	T	P	C
VMT324	INDUSTRIAL NETWORK PROTOCOLS	3	0	0	3

Category: Professional Elective Course

a. Preamble

This course introduces the basic concepts of different types of wired and wireless protocols. It comprehensively details the wired and wireless protocols in automation. It describes the wired and wireless protocols in smart product development.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Interpret wired protocols for electronic system.	K2
CO2	Interpret wireless protocols for electronic system.	K2
CO3	Categories industrial wired protocols in automation.	K2
CO4	Categories wireless protocols for industrial automation	K2
CO5	Demonstrate the wired and wireless functions of various protocols in application development.	K3

c. Course Syllabus **Total : 45 Periods**

WIRED BUSES AND PROTOCOLS **9**

Wireless - Wired Networks Comparison - Serial Communication Protocols - RS232-UART-SPI - I2C –UNI/O Bus -1 Wire -Camera Link - Parallel Communication -PPI - Wishbone Bus – AMBA – JTAG - Fireware IEEE 1394 Bus - Ethernet Overview - RS485.

WIRELESS PROTOCOLS **9**

Antenna Technology- Network Topologies - Wireless Local Area Networks (WLAN) - Wireless Personal Area Networks (WPAN) - Wimedia – Wimax - RF – Bluetooth- Wi-Fi – Zigbee – OTA-Wireless Industrial Automation Protocols.

INDUSTRIAL AND AUTONOMOUS SYSTEMS WIRED NETWORKS **9**

Overview of Industrial Wired Networks – Terminal Bus- Modbus - HART Network - Mechatrolink-II – EtherCAT- Sercos II/III – CAN- Canopen - Modbus IDA-PROFINETPROFIBUS-Ethernet/IP- Ethernet Powerlink- AG Automation and Drives (AS-I) - Device Net

INDUSTRIAL WIRELESS NETWORKS **9**

Overview of Industrial Wireless Networks - IWLAN - ISA100 Standards – Remote NetworksController-Based Networks - Wireless HART Technology - 3G/4G for Automation – RFID Data

APPLICATION OF COMMUNICATION PROTOCALS **9**

Wired Machine Networking of Sub-elements and Machines - Wireless Machine Networking of Sub-elements and Machines – Networking of Industry - Communication Network Layout Design - Networking for TIA- Cloud Computing – IOT - Case Studies in Automation Applications.

d. Activities

Students shall be exposed to the different wired and wireless protocols and the case studies in the college premises.

e. Learning Resources

Text Books

1. Richard Zurawski, *Industrial Communication Technology Handbook*, CRC Press, 2017.
2. Xuemin (Sherman) Shen, Xiaodong Lin, Kuan Zhang, *Encyclopedia of Wireless Networks,*Springer,2020.

Reference Books

1. Olaf Pfeiffer, Andrew Ayre and Christian Keydel, *Embedded Networking with CAN and CANopen*, Copperhill Technologies Corporation, 2016.
2. Wolfram Behardt and Jorg Wollert, *The wireless B: Evolution and Communication*, Stetue Germany, 2016.
3. Honggang Zhang, Jinsong Wu, Sundeep Rangan, *Green Communications Theoretical Fundamentals, Algorithms, and Applications*, CRC Press 2016.
4. Mubashir Husain Rehmani, Riadh Dhaou, *Cognitive Radio, Mobile Communications and Wireless Networks*, Springer International Publishing, 2018.
5. Dick Caro, *Wireless Networks for Industrial Automation*, ISA Publisher , 2014.

Course Code	Course Name	L	T	P	C
VMT325	ADVANCED MANUFACTURING	3	0	0	3

Category: Professional Elective Course

a. Preamble

The students are expected to understand special machining processes, micro & nano fabrication processes and rapid prototyping. It also enables the students to generate G & M codes for various CNC machining applications

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	To study the principle and working of different methods of precision machining process	K2
CO2	To describe the advancements in metal forming processes	K2
CO3	To outline the working principles of various micro and nanofabrication processes	K2
CO4	To explain the various classifications of Rapid prototyping techniques	K2
CO5	Demonstrate the CNC Programs through planning, writing codes and setting up CNC machine tools to manufacture a given component.	K2

c. Course Syllabus **Total : 45 Periods**

PRECISION MACHINING **9**

Introduction to Precision Engineering, Need for precision manufacturing, Four Classes of Achievable Machining Accuracy – Normal, Precision, High-precision, Ultra-precision Processes and Nanotechnology. Ultra Precision turning and grinding: Chemical Mechanical Polishing (CMP) - ELID process – Partial ductile mode grinding-Ultra precision grinding-Binderless wheel – Free form optics. aspherical surface generation Grinding wheel- Design and selection of grinding wheel-High-speed grinding - Diamond turning.

ADVANCES IN METAL FORMING **9**

Orbital forging, Isothermal forging, Warm forging, Overview of Powder Metal techniques – Hot and Cold isostatic pressing - high speed extrusion, rubber pad forming, micro blanking –Powder rolling – Tooling and process parameters

MICRO MACHINING AND NANO FABRICATION **9**

Theory of micromachining-Chip formation-size effect in micromachining-microturning, micromilling, microdrilling- Micromachining tool design-Micro EDM-Microwire EDM-Nano fabrication: LIGA, Ion beam etching, Molecular manufacturing techniques –Atomic machining- Nano machining techniques –Top/Bottom up Nano fabrication techniques - Sub micron lithographic technique, conventional film growth technique, Chemical etching, Quantum dot fabrication techniques – MOCVD

RAPID PROTOTYPING **9**

Introduction – Classification – Principle advantages limitations and applications- Stereo lithography –Selective laser sintering –FDM, SGC, LOM, 3D Printing

PROGRAMMING OF CNC MACHINE TOOLS **9**

Coordinates, axis and motion, Absolute vs Incremental, Interpolators, Polar coordinates, Program planning, G and M codes, Manual part programming for CNC machining centers and Turning centers – Fixed cycles, Loops and subroutines, Setting up a CNC machine for machining, Maintenance and Troubleshooting of CNC Machines.

d. Activities

Students shall be given exposure to generate G codes and M codes for various lathe/mill operations through simulation.

e. Learning Resources

Text Books

1. Kalpakjian. S, *Manufacturing Engineering and Technology*, Pearson Education 8th Edition,2022.
2. Jackson, M.J, *Micro fabrication and Nanomanufacturing*, CRC Press,2018.

Reference Books

1. Franssila. S, *Introduction to Micro Fabrication*, John Wiley and sons Ltd., UK, ISBN: 978-0-470-85106-7, 2016.
2. Madou, M.J, *Fundamentals of Micro fabrication: The Science of Miniaturization*, Second Edition, CRC Press (ISBN: 0849308267), 2018.
3. McGeough, J.A, *Advanced methods of Machining*, Springer,2011.
4. Michael Fitzpatrick, *Machining and CNC Technology*, McGraw-Hill Education; 4th edition, 2018.
5 Hajra Chouldhary S.K and Hajra Choudhury. AK.,2016, (15th Edition) Elements of workshop Technology, volume I and II, Media promoters and Publishers.

Course Code	Course Name	L	T	P	C
VMT326	FARM AUTOMATION	3	0	0	3

Category: Professional Elective Course

a. Preamble

The students are expected to understand farming related machines, information systems, traction & testing and machine selection

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Classify robot for agriculture purposes.	K2
CO2	Integrate sensors and systems for agricultural applications	K2
CO3	Use suitable testing and tracking devices for agricultural applications	K2
CO4	Infer suitable Weed Management system	K2
CO5	Describe and select suitable machinery for specific tasks	K2

c. Course Syllabus **Total: 45 Periods**

INTRODUCTION **9**

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

PRECISION AGRICULTURE **9**

Sensors – types and agricultural applications, Global Positioning System (GPS) - GPS for civilian use, Differential GPS, Carrier-phase GPS, Real-time kinematic GPS, Military GPS, Geographic Information System, Variable Rate Applications and Controller Area Networks.

TRACTION AND TESTING **9**

Hitching- Principles of hitching, Types of hitches, Hitching and weight transfer, Control of hitches, Tires and Traction models, Traction predictor spreadsheet, Soil Compaction, Traction Aids, Tractor Testing

SOIL TILLAGE AND WEED MANAGEMENT **9**

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

MACHINERY SELECTION **9**

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

d. Activities

Students will be given exposure to various communication protocols used in agricultural fields.

e. Learning Resources

Text Books

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

Reference Books

1. Qin Zhang, Francis J. Pierce, *Agricultural Automation Fundamentals and Practices*, CRC Press, 2016.
2. Stephen L. Young, Francis J.Pierce , *Automation: The Future of Weed Control in Cropping Systems*, Springer, Dordrecht Heidelberg New York London, 2016.

3 R.A.Kepner, Roy Bainer, E.L.Barger, *Principles of Farm Machinery*, 3rd Edition, CBS Publishers, New Delhi , 2017.

4 Guangnan Chen , *Advances in Agricultural Machinery and Technologies*, 1st Edition, CRC Press , 2018.

Course Code	Course Name	L	T	P	C
VMT327	COMPUTER AIDED INSPECTION AND TESTING	3	0	0	3

Category: Professional Elective Course

a. Preamble

This course enables the students to make use of basic and advanced measuring instruments for inspection and testing.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Practice the standards in measurements and to avoid the various forms of errors in measurements	K2
CO2	Use of basic and advanced metrology instruments for measurements	K2
CO3	Acquire the knowledge on non-contact opto-electronics device for measurements.	K2
CO4	Describe various measurement techniques using laser metrology.	K2
CO5	Recognize the computer aided inspection and advances in metrology.	K2

c. Course Syllabus **Total : 45 Periods**

FUNDAMENTALS AND CONCEPTS IN METROLOGY **9**

Standards of measurement – Analog and digital measuring instruments-comparators – Limits, Fits and Tolerances – Gauge design – Surface Roughness – Form errors and measurements.

INSPECTION AND GENERAL MEASUREMENTS **12**

Linear Measuring Instruments – Evolution – Types – Classification – Limit Gauges – Gauge Design – Terminology – Procedure – Concepts of Interchange Ability and Selective Assembly – Angular Measuring Instruments – Types – Bevel Protractor, Clinometers, Angle Gauges, Spirit Levels, Sine Bar – Angle Alignment Telescope – Autocollimator – Applications Inspection of gears and threads – Tool makers' microscope – Universal measuring machine

OPTO ELECTRONICS IN ENGINEERING INSPECTION **6**

Use of opto electronics in Tool wear measurements – Micro hole measurement and surface roughness – Applications in In-Process measurement and on-line Inspection

LASER METROLOGY **9**

Precision instrument based on Laser - Use of Lasers - Principle –Interferometers, Interference microscope -Optical flats - Laser Interferometer - Application in Linear and Angular measurements- Testing of machine tools using Laser Interferometer. Use of Laser Interferometer in Machine Tool Inspection – Uses of Laser in On-Line Inspection – Laser Micrometer – Laser Alignment Telescope.

COORDINATE METROLOGY AND QUALITY CONTROL **9**

Co-ordinate Measuring Machines - Constructional features - Types - Applications of CMM – Measurement arms, Laser tracker - Fundamentals of Computer Aided Inspection - Introduction to Nano metrology.

d. Activities

Students shall be given exposure to recognize measurement techniques through automated inspection systems

e. Learning Resources

Text Books

1. Jain R.K, *Engineering Metrology*, Khanna Publishers, 2021.
2. John Wilson, John Hawkes, *Optoelectronics*, Pearson India, 2018.

Reference Books

1. Anil.K.Jain, *Fundamentals of Digital Image Proce*ssing, Prentice Hall of India Pvt. Ltd, 2019.
2. Dale.H. Besterfield, *Total Quality Management*, Pearson Education Asia, 2018.
3. Beckwith, Marangoni, Lienhard, *Mechanical Measurements*, Pearson Education, 2020.
4. Robert J. Hocken, Paulo H. ,*Coordinate Measuring Machines and systems*, CRC Press, Second edition, 2016.
5. Robert G. Seippel, *Opto Electronics for Technology and Engineering*, Prentice Hall, New Jersey.

Course Code	Course Name	L	T	P	C
VMT331	AUTOMOBILE ENGINEERING	3	0	0	3

Category: Professional Elective Course

a. Preamble

This course introduces the different types of automobiles and basic components of a vehicle.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the various parts of the automobile with their functions and materials.	K2
CO2	Discuss the engine auxiliary systems and engine emission control.	K2
CO3	Distinguish the working of different types of transmission systems.	K2
CO4	Explain the Steering, Brakes and Suspension Systems.	K2
CO5	Describe the possible alternate sources of energy for IC Engines.	K2

c. Course Syllabus **Total : 45 Periods**

VEHICLE STRUCTURE AND ENGINES **9**

Types of automobiles vehicle construction and different layouts, chassis, frame and body, Vehicle aerodynamics (various resistances and moments involved), IC engines – components-functions and materials, variable valve timing (VVT).

ENGINE AUXILIARY SYSTEMS **9**

Electronically controlled gasoline injection system for SI engines, Electronically controlled diesel injection system (Unit injector system, Rotary distributor type and common rail direct injection system), Electronic ignition system (Transistorized coil ignition system, capacitive discharge ignition system), Turbo chargers (WGT, VGT), Engine emission control by three way catalytic converter system, Emission norms (Euro and BS).

TRANSMISSION SYSTEMS **9**

Clutch-types and construction, gear boxes- manual and automatic, gear shift mechanisms, Over drive, transfer box, fluid flywheel, torque converter, propeller shaft, slip joints, universal joints, Differential and rear axle, Hotchkiss Drive and Torque Tube Drive.

STEERING, BRAKES AND SUSPENSION SYSTEMS **9**

Steering geometry and types of steering gear box-Power Steering, Types of Front Axle, Types of Suspension Systems, Pneumatic and Hydraulic Braking Systems, Antilock Braking System(ABS), electronic brake force distribution (EBD) and Traction Control.

ALTERNATIVE ENERGY SOURCES **9**

Use of Natural Gas, Liquefied Petroleum Gas, Bio-diesel, Bio-ethanol, Gasohol and Hydrogen in Automobiles- Engine modifications required –Performance, Combustion and Emission Characteristics of SI and CI engines with these alternate fuels - Electric and Hybrid Vehicles, Fuel Cells and their types (PEM & SOFC)

d. Activities

Students shall be exposed to different components of an automobile.

e. Learning Resources

Text Books

1. Rajput R K , *A Textbook of Automobile Engineering*, Laxmi Publications, Second Edition, 2017.
2. Kirpal Singh, *Automobile Engineering*, Vol 1 & 2, Standard Publishers, New Delhi, 2021.

Reference Books

1. Ganesan V, *Internal Combustion Engines*, Fourth Edition, Tata McGraw-Hill, 2017.
2. Devendra Vashist and Mukhtar Ahmad, *Automobile Engineering*, Dream tech Press, 2020.

Course Code	Course Name	L	T	P	C
VMT332	ELECTRIC AND HYBRID VEHICLES	3	0	0	3

Category: Elective Course

a. Preamble

The objective of this course is to prepare the students to know about the general aspects of Electric and Hybrid Vehicles (EHV), including architectures, modeling, sizing, and sub system design and hybrid vehicle control

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Understand the operation and architecture of Electric and Hybrid Vehicles.	K2
CO2	Identify various energy source options like battery and fuel cell.	K2
CO3	Select suitable electric motor for applications in Electric and Hybrid Vehicles.	K2
CO4	Describe the role of Power Electronics in Electric and Hybrid Vehicles.	K2
CO5	Explain the energy and design requirement for Electric and Hybrid Vehicles.	K2

c. Course Syllabus **Total : 45 Periods**

DESIGN CONSIDERATIONS FOR ELECTRIC VEHICLES 9

Need for Electric vehicle- Comparative study of diesel, petrol, hybrid and electric Vehicles. Advantages and Limitations of hybrid and electric Vehicles. - Design requirement for electric vehicles- Range, maximum velocity, acceleration, power requirement, mass of the vehicle. Various Resistance- Transmission efficiency- Electric vehicle chassis and Body Design, Electric Vehicle Recharging and Refueling Systems

ENERGY SOURCES 9

Battery Parameters-Different types of batteries – Lead Acid- Nickel Metal Hydride - Lithium ion-Sodium based- Metal Air. Battery Modeling - Equivalent circuits, Battery charging-Quick Charging devices. Fuel Cell- Fuel cell Characteristics- Fuel cell types-Half reactions of fuel cell. Ultra capacitors. Battery Management System.

MOTORS AND DRIVES **9**

Types of Motors- DC motors- AC motors, PMSM motors, BLDC motors, Switched reluctance motors working principle, construction and characteristics.

POWER CONVERTERS AND CONTROLLERS **9**

Solid state Switching elements and characteristics – BJT, MOSFET, IGBT, SCR and TRIAC - Power Converters – rectifiers, inverters and converters - Motor Drives - DC, AC motor, PMSM motors, BLDC motors, Switched reluctance motors – four quadrant operations – operating modes

HYBRID AND ELECTRIC VEHICLES **9**

Main components and working principles of a hybrid and electric vehicles, Different configurations of hybrid and electric vehicles. Power Split devices for Hybrid Vehicles – Operation modes - Control Strategies for Hybrid Vehicle - Economy of hybrid Vehicles - Case study on specification of electric and hybrid vehicles.

d. Activities

Students shall be exposed to simulation of E,Vehicles performance using MATLAB SIMULINK

e. Learning Resources

Text Books

1. Iqbal Husain, *Electric and Hybrid Vehicles-Design Fundamentals*, CRC Press,2003.
2. Mehrdad Ehsani, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles*, CRC Press,2005.

Reference Book

1. James Larminie and John Lowry, *Electric Vehicle Technology Explained*, John Wiley & Sons,2003.

Course Code	Course Name	L	T	P	C
VMT333	AUTOMOTIVE MECHATRONICS	3	0	0	3

Category: Professional Elective Course

a. Preamble

This course introduces the different types of sensors and actuators used in the modern vehicle. It discusses about the euro norms, bharath norms, ignition systems, injection systems, engine control systems and safety systems.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Identify the importance of emission standards in automobiles.	K2
CO2	Understand the electronic fuel injection/ignition components and their function.	K2
CO3	Describe the function of sensors and actuators used in an automobile.	K2
CO4	Elucidate the working of engine control systems in modern automobile.	K2
CO5	Explain the function of chassis and safety system used in an automobile.	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **8**

Evolution of electronics in automobiles – emission laws – introduction to Euro I, Euro II, Euro III, Euro IV, Euro V standards – Equivalent Bharat Standards. Charging systems: Working and design of charging circuit diagram – Alternators – Requirements of starting system - Starter motors and starter circuits.

IGNITION AND INJECTION SYSTEMS **10**

Ignition systems: Ignition fundamentals - Electronic ignition systems - Programmed Ignition – Distribution less ignition - Direct ignition – Spark Plugs. Electronic fuel Control: Basics of combustion – Engine fueling and exhaust emissions – Electronic control of carburetion – Petrol fuel injection – Diesel fuel injection.

SENSOR AND ACTUATORS IN AUTOMOTIVES **9**

Working principle and characteristics of Airflow rate sensor, Engine crankshaft angular position sensor, Hall effect sensor, Throttle sensor, Temperature sensor, Exhaust gas oxygen sensor– study of fuel injector, exhaust gas recirculation actuators, stepper motor actuator, vacuum operated actuator.

ENGINE CONTROL SYSTEMS **9**

Control modes for fuel control-engine control subsystems – ignition control methodologies – different ECU's used in the engine management – block diagram of the engine management system– diagnostics systems in modern automobiles- Introduction to multicore ECU, AUTOSAR-CAN standard, format of CAN Standard -Introduction to CAN tools-CANoe, CANalyzer.

CHASSIS AND SAFETY SYSTEMS **9**

Traction control system – Cruise control system – electronic control of automatic transmission – antilock braking system – electronic suspension system – working of airbag and role of MEMS in airbag systems – centralized door locking system – climate control of cars.

d. Activities

Students shall be exposed to different sensors and actuators used in an automotive.

e. Learning Resources

Text Books

1. William Ribbens, *Understanding Automotive Electronics: An Engineering Perspective*, Butterworth-Heinemann, 8th edition, 2017.
2. Babu A K, *Automotive Electrical and Electronics*, Khanna Book Publishing, Second edition, 2017.

Reference Books

1. Robert Bosch GmbH, *Bosch Automotive Electrics and Automotive Electronics Systems and Components Networking and Hybrid Drive*, Springer, 2013.
2. Kai Borgeest, *EMC and Functional Safety of Automotive Electronics*, Institution of Engineering & Technology, 2018.

Course Code	Course Name	L	T	P	C
VMT334	AUTOMOTIVE SYSTEM MODELLING AND SIMULATION	3	0	0	3

Category: Professional Elective Course

a. Preamble

This course introduces various steps involved in the design of automotive components.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Analyse the stress and strain imparted on automotive components.	K2
CO2	Compute the design and find the dimension of the vehicle components.	K2
CO3	Identify optimal design solutions to real-world problems in compliance with industry standards.	K2
CO4	Demonstrate the design skill by creating new design strategy with the application of the knowledge	K2
CO5	Interpret the modern system in vehicle and would help in developing the system with less impact to the environment.	K2

c. Course Syllabus **Total : 45 Periods**

DESIGN OF CYLINDER, PISTON AND CONNECTING ROD 9

Choice of material for cylinder and piston, design of cylinder, design of piston, piston pin, piston rings and piston assembly. Material for connecting rod, design of connecting rod assembly. Case study on piston for car with Modelling and simulation.

DESIGN OF CRANK SHAFT AND VALVES 9

Material for crankshaft, design of crankshaft under bending and twisting. Design aspects of intake & exhaust manifolds, inlet & exhaust valves, valve springs, tappets and valve train. Design of cam& camshaft. Design of rocker arm. Cam profile generation. 3D Engine simulation: Introduction to thermal and flow analysis in engine cylinder, modeling of cylinder and piston for combustion analysis.

DESIGN OF CLUTCHES AND GEARS 9

Design of single plate clutch, multiplate clutch and cone clutch assembly. Torque capacity of clutch. Design of clutch components. Gear train calculations, layout of gearboxes.

Calculation of bearing loads and selection of bearings. Design of three speed and four speed gearboxes. Modelling and simulation: braking system.

DESIGN OF VEHICLE FRAME AND SUSPENSION 9

Study of loads-moments and stresses on frame members. Design of frame for passenger and commercial vehicle - Design of leaf Springs-Coil springs and torsion bar springs. Case study on development of frame for ATV. Modelling and simulation of suspension system

DESIGN OF FRONT AND REAR AXLE 9

Design of propeller shaft. Design details of final drive gearing. Design details of full floating, semi-floating and three quarter floating rear shafts and rear axle housings. Analysis of loads moments and stresses at different sections of front axle. Determination of optimum dimensions and proportions for steering linkages, Design of front axle beam. Modelling and simulation of steering system, transmission system.

d. Activities

Students shall be exposed to the different machine parts, starters and the drive in the college premises.

e. Learning Resources

Text Books

1. Giancarlo Genta, Lorenzo Morello, *The Automotive Chassis Volume 1, Components Design*, Springer International Edition, Second edition,2020
2. Khurmi. R.S. & Gupta. J.K., *A text book of Machine Design*, Eurasia Publishing House (Pvt) Ltd, 25th edition, 2022.
3. Alec Stokes, *Manual gearbox design*, Butterworth-Heinemann 1992.

Reference Books

1. *Design Data Hand Book*, PSG College of Technology, 2013- Coimbatore.
2. Dean Averns, *Automobile Chassis Design*, Il life Book Co., 2001.
3. Kolchin-Demidov , *Design of Automotive Engines*,Mir Publishers (1984)
4. Lukin P G G and Rodionov V, *Automobile Chassis Design and Calculations*, Mir Publishers, Moscow, 1989.
5. Robert C. Juvinall and Kurt M. Marshek, *Fundamentals of Machine component Design*, 6th Edition, Wiley, 2017.

Course Code	Course Name	L	T	P	C
VME314	DRONE TECHNOLOGY	3	0	0	3

Category: Professional Elective Course

a. Preamble

This course introduces the basic knowledge about the Drone technology, types of drones and components and applications of drones.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Understand the drone technology and types of Drones.	K2
CO2	Comprehend the drone fabrication and programming.	K2
CO3	Recognize the sensors and actuators for Drones.	K2
CO4	Develop a drone mechanism for specific applications.	K3
CO5	Understand about the regulation and standardization of Drones.	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO DRONE TECHNOLOGY **9**

Drone Concept - Vocabulary Terminology- History of drone - Types of current generation of drones based on their method of propulsion- Drone technology impact on the businesses- Drone business through entrepreneurship- Opportunities/applications for entrepreneurship and employability.

DRONE DESIGN, FABRICATION AND PROGRAMMING **9**

Classifications of the UAV -Overview of the main drone parts- Technical characteristics of the parts -Function of the component parts -Assembling a drone- The energy sources- Level of autonomy- Drones configurations -The methods of programming drone- Download program - Install program on computer- Running Programs- Multi rotor stabilization- Flight modes -Wi-Fi connection.

DRONE FLYING AND OPERATION **9**

Concept of operation for drone -Flight modes- Operate a small drone in a controlled environment- Drone controls Flight operations –management tool –Sensors-Onboard storage capacity -Removable storage devices- Linked mobile devices and applications.

DRONE COMMERCIAL APPLICATIONS **9**

Choosing a drone based on the application -Drones in the insurance sector- Drones in delivering mail, parcels and other cargo- Drones in agriculture- Drones in inspection of transmission lines and power distribution -Drones in filming and panoramic picturing.

FUTURE DRONES AND SAFETY **9**

The safety risks- Guidelines to fly safely -Specific aviation regulation and standardization- Drone license- Miniaturization of drones- Increasing autonomy of drones -The use of drones in swarms.

d. Activities

Students shall be exposed to know the components of Drones and standardization.

e. Learning Resources

Text Books

1. Daniel Tal and John Altschuld, *Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation*, John Wiley & Sons, Inc, 2021.
2. Terry Kilby and Belinda Kilby, *Make:Getting Started with Drones* ,Maker Media, Inc, 2016.

Reference Books

1. John Baichtal, *Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs*, Que Publishing, 2016.
2. Zavrsnik, *Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance*, Springer, 2018.

Course Code	Course Name	L	T	P	C
VMT335	DESIGN OF UAV SYSTEMS	3	0	0	3

Category: Professional Elective Course

a. Preamble

To make the students to understand the basic concepts of UAV systems design.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain UAV system with hardware specifications	K2
CO2	Describe the requirements for an unmanned aerial vehicle	K2
CO3	Perform system testing for unmanned aerial vehicles.	K2
CO4	Integrate various systems of unmanned aerial vehicle.	K2
CO5	Design micro aerial vehicle systems by considering practical limitations.	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO UAV **9**

History of UAV –classification – Introduction to Unmanned Aircraft Systems--models and prototypes – System Composition-applications

THE DESIGN OF UAV SYSTEMS **9**

Introduction to Design and Selection of the System- Aerodynamics and Airframe Configurations- Characteristics of Aircraft Types- Design Standards and Regulatory Aspects-UK, USA and Europe-Design for Stealth--control surfaces-specifications

AVIONICS HARDWARE **9**

Autopilot – AGL-pressure sensors-servos-accelerometer –gyros-actuators- power supply processor, integration, installation, configuration, and testing

COMMUNICATION PAYLOADS AND CONTROLS **9**

Payloads-Telemetry-tracking-Aerial photography-controls-PID feedback-radio control frequency range –modems-memory system-simulation-ground test-analysis-trouble shooting

THE DEVELOPMENT OF UAV SYSTEMS **9**

Waypoints navigation-ground control software- System Ground Testing- System In-flight Testing- Future Prospects and Challenges-Case Studies – Mini and Micro UAVs

d. Activities

Simulation of Aerodynamic Models Using MATLAB SIMULINK

e. Learning Resources

Text Books

1. Paul G Fahlstrom, Thomas J Gleason, *Introduction to UAV Systems*, UAV Systems, Inc, 1998.
2. Reg Austin, *Unmanned Aircraft Systems UAV design, development and deployment*, Wiley, 2010.

Reference Books

1. Armand J. Chaput, *Design of Unmanned Air Vehicle Systems*, Lockheed Martin Aeronautics Company, 2001
2. Kimon P. Valavanis, *Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy*, Springer, 2007
3. Robert C. Nelson, *Flight Stability and Automatic Control*, McGraw-Hill, Inc, 1998.

Course Code	Course Name	L	T	P	C
VMT336	INTELLIGENT TRANSPORTATION SYSTEM FOR SMART MOBILITY	3	0	0	3

Category: Professional Elective Course

a. Preamble

This course introduces roles and responsibilities of Intelligent Transportation Systems. It discuss about its architecture, hardware, Advanced transport management system, Advanced traveler information system and ITS for smart cities.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the fundamentals of Intelligent Transportation Systems.	K2
CO2	Understand the architecture and hardware of Intelligent Transportation Systems.	K2
CO3	Recognize the Integrated Traffic Management and Junction Management Strategies.	K2
CO4	Comprehend Advanced Traveler Information Systems.	K2
CO5	Illustrate the intelligent transport systems for smart cities.	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO INTELLIGENT TRANSPORT SYSTEM **9**

Introduction to Intelligent Transportation Systems (ITS) -Definition – Role and Responsibilities – Advanced Traveller Information System – Fleet Oriented ITS Services – Electronic Toll Collection – Critical issues – Security – Safety.

ITS ARCHITECTURE AND HARDWARE **9**

Architecture – ITS Architecture Framework – Hardware Sensors – Vehicle Detection – Techniques – Dynamic Message Sign – GPRS – GPS – Toll Collection.

ADVANCED TRANSPORT MANAGEMENT SYSTEM **9**

Video Detection – Virtual Loop - Cameras - ANPR – IR Lighting – Integrated Traffic Management – Control Centre – Junction Management Strategies- ATMS – Advanced Traveler Information Systems (ATIS)- Route Guidance – Issues -– Historical – Current – Predictive Guidance – Data Collection – Analysis – Dynamic Traffic Assignment (DTA) – Components – Algorithm.

ADVANCED TRAVELLER AND INFORMATION SYSTEM **9**

Travel Information – Pre Trip and Enroute Methods- Basic ATIS Concepts – Smart Route System – Data Collection – Process – Dissemination to Travelers – Evaluation of Information – Value of Information – Business Opportunities.

ITS FOR SMART CITIES **9**

Strategies And Approaches To Smart City, ITS Solutions For Smart Cities, ITS Technologies For Smart Cities, E-Mobility, Freight Solutions artificial Intelligence For Smart Transportation Systems, Examples For Smart City Initiatives In India

d. Activities

Students shall be exposed to various applications of intelligent transportation systems like electric vehicle charging, electronic toll collection, etc.,

e. Learning Resources

Text Books

1. Srinivasa R Kumar, *Intelligent Transportation Systems*, Orient Blackswan Pvt Ltd, 2021.
2. khisty lal, *Transportation Engineering- An Introduction*, Pearson India, 3rd Edition, 2017.

Reference Books

1. Pradip Kumar Sarkar, Amit Kumar Jain, *Intelligent Transportation Systems*, PHI Learning Private Limited, 2018.
2. Pierluigi Coppola, Domokos Esztergar-kis, *Autonomous Vehicles and Future Mobility*, Elsevier Publications, 2019.

Course Code	Course Name	L	T	P	C
OMT781	FOUNDATION OF ROBOTICS	3	0	0	3

Category: Open Elective Course

a. Preamble

This course promotes students to familiarize the fundamental principles of robotics, including robot architecture, drive systems, end effectors and sensing. It also enables the students to explore the concept of machine vision, image processing and applications of robots in material transfer and processing operations.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the fundamentals components and specifications of Robot.	K2
CO2	Explain the various drive systems and parts of end effectors compare various end effectors and grippers used in robots.	K2
CO3	Explain the use of various sensors in robotics.	K2
CO4	Demonstrate the concept of machine vision and image processing.	K2
CO5	Discuss the applications of robots in material transfer and processing operations.	K2

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c. Course Syllabus **Total : 45 Periods**

FUNDAMENTALS OF ROBOTICS **9**

Automation and Robotics – Definition and scope – Historical overview – Robot anatomy – Co-ordinate systems, Work Envelope, types and classification – specifications – Robot Parts and their functions.

ROBOT DRIVE SYSTEMS AND END EFFECTORS **9**

Pneumatic Drives – Hydraulic Drives – Mechanical Drives – Electrical Drives – D.C. Servo Motors, Stepper Motor, A.C. Servo Motors. End Effectors – Grippers – Mechanical Grippers, Pneumatic and Hydraulic Grippers, Magnetic grippers, vacuum grippers, internal grippers and external grippers, selection and design considerations of a grippers.

SENSORS IN ROBOTICS **9**

Force sensors, touch and tactile sensors, proximity sensors, non-contact sensors, safety considerations in robotic cell, proximity sensors, camera, fail safe hazard sensor systems, and compliance mechanism – Sensor data acquisition and processing – Sensor fusion techniques – Localization and mapping.

ROBOT VISION **9**

Machine vision fundamentals – Sensing and Digitizing function – Image processing and feature extraction – Object recognition and tracking – training the vision system – Robotic Applications.

APPLICATIONS OF ROBOT **9**

Material transfer – machine loading and unloading – Processing operations – Assembly and Inspection – Safety, Training, Maintenance and Quality.

d. Activities

Students shall be exposed to the working of 1DoF, 2DoF and 4DoF robots in college premises.

e. Learning Resources

Text Books

1. Mikell. P. Groover, *Industrial Robotics – Technology, Programming and applications*, McGraw Hill 2nd edition, 2017.
2. Ganesh. S. Hedge, *A textbook of Industrial Robotics*, Lakshmi Publications,2015.

Reference Books

1. Fu K.S. Gonalz R.C. and ice C.S.G, *Robotics Control, Sensing, Vision and Intelligence*, McGraw Hill book co, 2007.
2. YoramKoren, *Robotics for Engineers*, McGraw Hill Book, Co,2002.
3. Janakiraman P.A, *Robotics and Image Processing*, Tata McGraw Hill ,2005.
4. John. J.Craig,*Introduction to Robotics: Mechanics and Control*, Fourth Edition, Pearson publication,2022.
5. Jazar, *Theory of Applied Robotics: Kinematics, Dynamics and Control*, Springer India reprint, 2022.

Course Code	Course Name	L	T	P	C
MMT101	EMBEDDED SYSTEM DESIGN FOR ROBOTICS	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course promotes the students to familiarize the basic concepts in Embedded system Design Principles, Real time Operating System and Embedded Networking. This course also enables the students to learn PIC Microcontroller architecture and Programming.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the overview of embedded system design principles	K2
CO2	Summarize the basics of Real time operating system and its applications	K2
CO3	Explain the architecture and fundamental operating concepts behind PIC Microcontroller	K2
CO4	Illustrate the concepts involved in Embedded Networking	K2
CO5	Describe the embedded system development tools using basic programming techniques	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO EMBEDDED SYSTEMS **9**

Overview of embedded systems, embedded system design process, challenges - common design metrics and optimizing them. Hardware - Software codesign embedded product development.

REAL TIME OPERATING SYSTEM **9**

Real time operating systems Architecture - Tasks and Task states - Tasks and Data - Semaphone and shared data - Message queues, mail boxes and pipes - Encapsulating semaphores and queues - interrupt routines in an RTOS Environment.

PIC MICROCONTROLLER **9**

Architecture - Instruction set - Addressing modes - Timers - Interrupt logic - CCP modules

EMBEDDED NETWORKING **9**

Introduction - CAN BUS - I2C - GSM - GPRS

EMBEDDED PROGRAMMING **9**

I/O Programming- Interrupts and Timer application- Interfacing Keypad-Interfacing LCD - Interfacing ADC/DAC.

d. Activities

Students shall be exposed to the programming of PIC microcontroller at the college premises.

e. Learning Resources

Text Books

1. David E. Simon, *An embedded software primer*, Addison – Wesley, Indian Edition Reprint,2009.
2. Frank Vahid, Tony John Givargis, *Embedded System Design: A Unified Hardware/ Software Introduction* - Wiley & Sons, Inc.2002 .

Reference Books

1. John B. Peatman, *Design with PIC Microcontrollers*, Prentice Hall, 2003.
2. Steve Heath, *Embedded System Design*, II edition, Elsevier, 2003.

Course Code	Course Name	L	T	P	C
MMT102	ARDUINO AND RASPBERRYPI PROGRAMMING	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course promotes the students to familiarize programming in Arduino and Raspberrypi. This course also promotes the students to the interfacing of various types of sensors with Arduino and Raspberrypi.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the basic concepts of Arduino Platform.	K2
CO2	Make use of C language in programming Arduino microcontroller.	K2
CO3	Interfacing various sensors with Arduino microcontroller.	K2
CO4	Wire Raspberry Pi and create a fully functional computer.	K2
CO5	Implement various communication protocols for wired and wireless communication.	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **9**

Arduino platform, Prototyping environment, Electronic component overview, Arduino Development Environment, setting up the Arduino board, creating sketches, Arduino Sketch Structure, using Libraries, using example codes, Debugging Using the Serial Monitor.

LET US (ARDUINO) C **9**

Arduino C, Data types, Operators, Decision making, Loops, Switch& Break Functions, Arrays, Strings, Serial Input.

COMMUNICATION USING ARDUINO **9**

Sensors, Digital and Analog signals, Temperature sensors, Humidity sensors, Obstacle sensors, Ultrasonic sensor, Accelerometer and gyro. Wired and Wireless Communication, Communication Protocols, Interfacing Communication Modules with Arduino. Interfacing Alphanumeric LCD Display, Formatting Text, Creating custom characters, Interfacing Graphical LCD Display.

GETTING STARTED WITH RASPBERRY PI **9**

Basic functionality of the Raspberry Pi board and its Processor, setting and configuring the board, differentiating Raspberry Pi from other platform. Overclocking, Component overview. Implications of an operating system on the behaviour of the Raspberry Pi, Overview of Linux and its terminal command, apt get-update, apt get-upgrade, navigating the file system and managing processes, text-based user interface through the shell, overview of graphic user interface.

COMMUNICATION USING RASPBERRY PI **9**

Communication facilities on raspberry Pi (I2C, SPI, UART), working with RPi.GPIO library, Interfacing of Sensors and Actuators. Wired and Wireless communication, TCP IP configurations, SSH, Putty Terminal usage.

d. Activities

Students shall be exposed to the working of Arduino and Raspberrypi in the college premises.

e. Learning Resources

Text Books

1. Michael Margolis, *Arduino Cookbook*, O'Reilly Media, Inc., 3rd edition,2020.
2. John Baichtal , *Arduino for beginners : Essential Skills Every Maker Needs* , Person Education, Inc., 1st edition, 2014.
3. Gary Mitnick, *Raspberry Pi 3 : An Introduction to Using with Python Scratch, Javascript and more*, CreateSpace Independent Publishing Platform, 2017
4. Tim Cox , *Raspberry Pi for Python Programmers Cookbook* , Packt Publishing Limited; Second Revised edition, 2016.

Reference Books

1. Jack Purdum , Beginning C for Arduino (ebook).
2. Eben Upton and Gareth Halfacree , *Raspberry Pi User Guide*, John Wiley & Sons, 2016

Course Code	Course Name	L	T	P	C
MMT103	INDUSTRIAL ROBOTICS	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course promotes students to familiarize the basic concepts of a robot, robot mechanics, robot programming and basics of machine vision applications.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the functions of the basic components of a Robot	K2
CO2	Demonstrate the use of various types of Robot Drives and End of Effectors.	K2
CO3	Summarize the use of sensors in machine vision system.	K2
CO4	Express knowledge in Robot Kinematics and Programming	K2
CO5	Outline the Robot safety issues and economics.	K2

c. Course Syllabus **Total : 45 Periods**

FUNDAMENTALS OF ROBOT **6**

Robot - Definition - Robot Anatomy - Co ordinate Systems, Work Envelope Types and Classification- Specifications-Pitch, Yaw, Roll, Joint Notations, Speed of Motion, Pay Load Robot Parts and their Functions-Need for Robots-Different Applications.

ROBOT DRIVE SYSTEMS AND END EFFECTORS **9**

Pneumatic Drives-Hydraulic Drives-Mechanical Drives-Electrical Drives-D.C. Servo Motors, Stepper Motors, A.C. Servo Motors-Salient Features, Applications and Comparison of all these Drives, End Effectors-Grippers-Mechanical Grippers, Pneumatic and Hydraulic-Grippers, Magnetic Grippers, Vacuum Grippers; Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers; Selection and Design Considerations

SENSORS AND MACHINE VISION **12**

Requirements of a sensor, Principles and Applications of the following types of sensors-Position sensors - Piezo Electric Sensor, LVDT, Resolvers, Optical Encoders, pneumatic Position Sensors, Range Sensors Triangulations Principles, Structured, Lighting Approach, Time of Flight, Range Finders, Laser Range Meters, Touch Sensors ,binary Sensors., Analog

Sensors, Wrist Sensors, Compliance Sensors, Slip Sensors, Camera, Frame Grabber, Sensing and Digitizing Image Data- Signal Conversion, Image Storage, Lighting Techniques, Image Processing and Analysis-Data Reduction, Segmentation, Feature Extraction, Object Recognition, Other Algorithms, Applications- Inspection, Identification, Visual Serving and Navigation.

ROBOT KINEMATICS AND ROBOT PROGRAMMING 13

Forward Kinematics, Inverse Kinematics and Difference; Forward Kinematics and Reverse Kinematics of manipulators with Two, Three Degrees of Freedom (in 2 Dimension), Four Degrees of freedom (in 3 Dimension) Jacobians, Velocity and Forces-Manipulator Dynamics, Trajectory Generator, Manipulator Mechanism Design-Derivations and problems. Lead through Programming, Robot programming Languages-VAL Programming-Motion Commands, Sensor Commands, End Effector commands and simple Programs.

IMPLEMENTATION AND ROBOT ECONOMICS 5

RGV, AGV; Implementation of Robots in Industries-Various Steps; Safety Considerations for Robot Operations - Economic Analysis of Robots.

d. Activities

Students shall be exposed to the working of 1DOF,2DOF and 4DOF robots in college premises.

e. Learning Resources

Text Books

1. Groover M.P , *Industrial Robotics -Technology Programming and Applications*, McGraw Hill, 2017.
2. Klafter R.D., Chmielewski T.A and Negin M, *Robotic Engineering - An Integrated Approach*, Prentice Hall, 2003.

Reference Books

1. Craig J.J, *Introduction to Robotics Mechanics and Control*, Pearson Education, 2017.
2. Rajput R.K, *Robotics and Industrial Automation*, S.Chand and Company, 2008.

Course Code	Course Name	L	T	P	C
MMT104	SERVICE AND FIELD ROBOTICS	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course promotes the students to familiarize the concept of localization, planning and navigation of Service and Field Robots.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Illustrate the basic concepts of working of robot	K2
CO2	Explain about the concept of localization	K2
CO3	Explain about the path planning and obstacle avoidance	K2
CO4	Illustrate the different types of field robots and its applications	K2
CO5	Illustrate the different types of humanoid robots	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **9**

History of service robotics – Present status and future trends – Need for service robots - Applications- Examples and Specifications of service and field Robots.

LOCALIZATION **9**

Introduction-Challenges of Localization- Map Representation- Probabilistic Map based Localization- Monte carlo localization- Landmark based navigation-Globally unique localization- Positioning beacon systems- Route based localization.

PLANNING AND NAVIGATION **9**

Introduction-Path planning overview- Road map path planning- Cell decomposition path planning-Potential field path planning-Obstacle avoidance - Case studies: tiered robot architectures

FIELD ROBOTS **9**

Ariel robots- Collision avoidance-Robots for agriculture, mining, exploration, underwater, civilian and military applications, nuclear applications, Space applications.

HUMANOIDS **9**

Wheeled and legged - Legged locomotion and balance - Arm movement - Gaze and auditory orientation control - Facial expression - Hands and manipulation - Sound and speech generation - Motion capture/Learning from demonstration - Human activity recognition using vision, touch, sound – Vision - Tactile Sensing.

d. Activities

Students shall be exposed to the simulation of localization, planning and navigation concept of Service and Field Robots.

e. Learning Resources

Text Books

1. Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzz , *Introduction to Autonomous Mobile Robots*, Bradford Company Scituate, USA,2011.
2. Riadh Siaer, *The future of Humanoid Robots- Research and applications*, Intech Publications,2012.

Reference Book

1. Kelly, Alonzo, Iagnemma, Karl, Howard, Andrew, *Field and Service Robotics*, Springer, 2011.

Course Code	Course Name	L	T	P	C
MMT105	ROBOT PROGRAMMING USING ROS	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course promotes students to understand basic concepts of robot operating systems and programming.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Recognize the concept of ROS and programming.	K2
CO2	Evaluate various robot algorithms in ROS programming.	K2
CO3	Deploy mapping, navigation and motion planning ROS with Move-it.	K2
CO4	Simulate robots in ROS with GAZEBO and V-REP.	K2
CO5	Program a Robot using ROS and its tool boxes.	K2

c. Course Syllabus **Total : 45 Periods**

ROS ESSENTIALS **9**

Introduction to ROS- Advantages and Disadvantages of ROS - ROS Framework- ROS package C++, Python – ROS computation Graph – nodes, Messages, topics, services, bags, ROS Master- ROS Community- Basic programming and Syntax overview in C++ and Python – start with ROS programming - Creating Environment - Services-Actions and Nodes- Simple Interaction with the Simulation environment.

BUILD YOUR OWN ROBOT ENVIRONMENT **9**

CAD Tools for Robot Modelling – ROS Packages for robot modelling – Unified Robot Description Format and Tags- Kinematics and Dynamics Library – Create URDF Model - Robot Modelling using Unified Robot Description Format (URDF),-ROS parameter server and adding real-world object representations to the simulation environment _ Create Robot description using 7 DOF: joint number, name, type and angle limits – Xacro – Rviz – viewing of 7 DOF arm – creation of wheeled robot.

SIMULATION ROBOTS IN ROS WITH GAZEBO **9**

Robot simulation - Gazebo –create simulation model at Gazebo- Adding colors, textures, transmission tags, 3D vision sensor to Gazebo- Moving robot joints using ROS controllers.ROS controller interacts with Gazebo, interfacing state controller, simulation of moving the robot joints – simulation of differential wheeled robot in Gazebo.

ROS WITH VREP **9**

V-REP(Coppeliasim) is a multi-platform robotic simulator - Simulating the robotic arm using V-REP - Adding the ROS interface to V-REP joint - Simulating a differential wheeled robot, Adding a laser sensor , 3D vision sensor.

MAPPING, NAVIGATION AND MOTION PLANNING ROS WITH MOVEIT **9**

Move it Installation - Generating the Self-Collision matrix .virtual joints, planning groups, robot poses, robot end effector - MoveIt Architecture Diagram - Trajectory from RViz GUI executing in Gazebo - Planning scene overview diagram- Collision Checking - Motion Planning, Pick and Place Behaviors using Industrial Robots with ROS Moveit – ROS with MATLAB.

d. Activities

Students shall be exposed to the various simulation tools in ROS

e. Learning Resources

Text Book

1. Lentin Joseph, Jonathan Cacace, *Mastering ROS for Robotics Programming*, Third Edition, Packt Publishing, 2021.

Reference Books

1. Lentin Joseph, Aleena Johny, *Robot Operating System (ROS) for Absolute Beginners Robotics Programming Made Easy*, Second Edition, Apress, 2022.
2. Lentin Joseph, *ROS Robotics Projects*, Packt publishing, 2017.

Course Code	Course Name	L	T	P	C
MMT106	ROBOTICS IN MANUFACTURING AUTOMATION	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course promotes the students to understand the need of robots in Industries. This course also provides basic understanding of the selection of robot for a given task.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Understand the fundamentals of Industrial Automation.	K2
CO2	Describe about the various Automation system components.	K2
CO3	Illustrate the applications of robots in industries.	K2
CO4	Describe the process of choosing a robot for a specific task.	K2
CO5	Explain about the various issues in implementation of robotics in manufacturing.	K2

c. Course Syllabus **Total : 45 Periods**

INDUSTRIAL AUTOMATION **9**

Scope and Introduction to Industrial Automation - Evolution of Robots - Development of Robot Applications – Robot Structures - Robot Performance - Robot Selection - Benefits of Robots - Robots Versus Humans and Employment.

AUTOMATION SYSTEM COMPONENTS **9**

Handling Equipment - Vision Systems - Process - Grippers and Tool Changers - Tooling and Assembly Automation- Components - System Controls - Safety and Guarding

APPLICATIONS IN MANUFACTURING **9**

Applications and case studies in the following domains - Arc, spot and laser welding - Painting, Adhesive and sealant dispensing - Mechanical, Waterjet and laser cutting - grinding and deburring - polishing - Casting - Plastic Moulding - Stamping and Forging - Machine Tool Tending - Measurement, Inspection, and Testing - Palletising - Picking and Packing.

SOLUTION DEVELOPMENT **9**

Determining Application Parameters - Initial Concept Design - Controls and Safety Design

- Testing and Simulation - Refining the Concept. Functional Elements of a Specification - Scope of Supply - Buy-Off Criteria - Covering Letter for off – specification parts.

FINANCIAL ISSUES IN IMPLEMENTATION **9**

Financial Analysis - Identifying Cost Savings - Developing the Justification - Need for Appropriate Budgets - Project Planning - Vendor Selection - System Build and Buy-Off - Installation and Commissioning - Operation and Maintenance - Staff and Vendor Involvement - Avoiding Problems.

d. Activities

Students shall be exposed to the applications of Robotics in manufacturing.

e. Learning Resources

Text Books

1. Mike Wilson, *Implementation of Robot Systems: An introduction to robotics, automation, and successful systems integration in manufacturing*, Butterworth-Heinemann, 1st edition, 2014.
2. Mehta, B. R., Reddy, Y. Jaganmohan, *Industrial process automation systems: design and implementation*, Wiley, Elsevier, 2015.

Reference Books

1. A.K. Gupta, *Industrial Automation and Robotics: An Introduction*, Mercury Learning & Information, 2016.
2. Zongwei Luo, *Robotics, Automation, and Control in Industrial and Service Settings*, IGI Global, 2015.