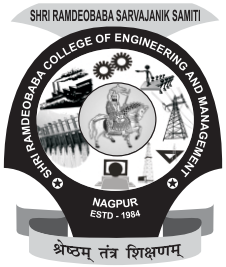

SHRI RAMDEOBABA COLLEGE OF ENGINEERING AND MANAGEMENT, NAGPUR – 440013

An Autonomous College affiliated to
Rashtrasant Tukadoji Maharaj Nagpur University,
Nagpur, Maharashtra (INDIA)

PROGRAMME SCHEME & SYLLABI
2021 – 2022

M. Tech. (Robotics & Automation)

Published By

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About the Department

M. Tech in Robotics and Automation is a full time program offered by the department of Mechanical Engineering. It is the first ever program in central India, offering the state of art technology encompassing digital advancement in manufacturing and service sector. Ready to accommodate majority of the disciplines of Engineering at graduation as eligibility.

Eligibility for Admission

Min. 50% at UG level, Non-zero GATE score OR Two years' of work experience with sponsorship from the company.

B. E. / B. Tech. / AME in the following Engineering disciplines from any recognized university in India:

Mechanical Engineering, Industrial Engineering, Production Engineering, Robotics, Mechatronics, Electrical Engineering, Electrical Engineering (E & P), Electronics Engineering, Electronics design and technology, Computer Engineering, Computer Science, Computer Science and Engineering, Computer Technology, Instrumentation Engineering, Electronics and Communication Engineering, Electronics and telecommunication, Information Technology, Advanced Mechatronics and industrial Automation, Automation and Robotics, Automation Engineering, Automobile Engineering, Automotive Technology, Computer and Communication Engineering, Computer Science and Biosciences, Computer Science and information Technology, Computer Science and Technology, Electrical and Computer Engineering, Electrical and Electronics Engineering, Electrical and instrumentation Engineering, Electrical and Power Engineering, Electrical instrumentation and Control Engineering, Electrical, Electronics and Power Engineering, Electronic instrumentation and Control Engineering, Electronic Science and Engineering, Electronics and Communication Technology, Electronics and Computer Engineering, Electronics and Computer Science, Electronics and Control Systems, Electronics and Electrical Engineering, Electronics and Instrumentation Engineering, Electronics Instrument and Control, Industrial and Production Engineering, Industrial Production Engineering, Information Engineering, Instrument Technology, Instrumentation and Control Engineering, Instrumentation and Electronics, Manufacturing Engineering, Manufacturing Engineering and Technology, Manufacturing Process and Automation Engineering, Manufacturing Science and Engineering, Manufacturing Technology, Mechanical and Automation Engineering, Mechanical and Mechatronics Engineering (Additive Manufacturing), Mechanical and Smart Manufacturing, Mechanical Engineering (Automobile) , Mechanical Engineering (Industry Integrated), Mechanical Engineering (Manufacturing Engineering) , Mechanical Engineering (Production) , Mechanical Engineering (Welding Technology) , Mechanical Engineering Automobile , Mechanical Engineering Design , Mechatronics Engineering, Production and industrial Engineering, Software Engineering

Objective

ThePrograma imstocreatethetechnicalprofessionalsinthefieldofroboticsandautomationbyinculcating strong academic foundation and hands-on exposure to recent technology as per industry needs.

Infrastructure

To achieve the objective RCOEM has established state-of-art research centre in collaboration with TATA Technologies. Centre for Invention, Innovation, Incubation & Training (CIIIT) provides comprehensive technological exposure and hands-on training to the Post-Graduate students fo Robotics and Automation.

CIIIT equipped with YASKAWA welding robot, TAL-BRABO Pick and Place Robot, Manufacturing Execution System (MES) comprised of 12 meter long conveyor automation unit and Vertical Machine Centre (VMC), 3D printer and scanner.

ManyprofessionalandcommercialsoftwarelikeMSCADAMS,NASTRAN,PATRON,Easy5,Marc,Dassault Delmia, 3D Experience, FEAST from ISRO, scFLOW, Internet of Things (IoT) etc. are available to design, develop and simulate robotic and automation systems.

Career Prospects

The domain of Robotics and Automation is the most sought after by post graduate aspirants. The field of robotics and automation has an enormous range of job opportunities for the candidates.

After completing the program, students can take jobs in the field of robotics and automation such as Robotics Programmers, Robot Design Engineer, Robotics Test Engineers, Automated Product Design Engineer, Robotics System Engineer and Maintenance Engineers in manufacturing and service industry. Moreover, they can also pursue PhD. Program Educational Objectives (PEOs)

1. To prepare the postgraduates who will search and/or create new avenues as an application of robots for industrial and societal needs.
2. Calling concern of continuous learning is a must with digital sciences. With this habit students should come out with an exalted status as a competent professional.
3. To impart adequate programming skills for robotics and languages there by enabling them to front line research and state of art application.

Program Outcomes (POs)

1. Students will be confident to handle robotic applications independently, so as to automate entire industrial/businessprocess.
2. Studentswillpossesscommunicationandinterpersonalskillstoensureharmoniousteamworking.
3. Overview of safety, awareness of economic and social impacts will be exhibited by teh students.
4. Students will be able to demonstrate the ability to take up intricate self-studies related to engineering applications.

Scheme of Examination of Master of Technology

I Semester M. Tech. (Robotics & Automation)

Sr. No.	Subject Code	Subject Name	L	P	Total	Credits	Internal Assess-ment	Semester Exam	Total	Exam Duration Hrs.	Category
1	MET751	Robot Kinematics and Dynamics	3	-	3	3	40	60	100	3 Hrs.	PC
2	MET752	Control system theory	3	-	3	3	40	60	100	3 Hrs.	PC
3	MET753	Robotic drives and actuators	3	-	3	3	40	60	100	3 Hrs.	PC
4	MET754	Robotic Sensors	3	-	3	3	40	60	100	3 Hrs.	PC
5	MET755	Program Elective-1	3	-	3	3	40	60	100	3 Hrs.	PE
6	MEP756	Lab Practice-1	-	4	4	2	25	25	50	----	PC
7	MEP757	Lab Practice-2	-	4	4	2	25	25	50	----	PC
8	MEP758	Seminar (Project based learning)	0	2	2	1	50	0	50	----	PC
9	MET759	Audit course: Professional Practices and Ethics-I	2	0	2	0	0	0	SF/USF	----	PC
		Total	**17**	**10**	**27**	**20**	**300**	**350**	**650**		

Course Code	Program Elective-1
MET755-1	IoT
MET755-2	Integrated advance manufacturing
MET755-3	Field and Service Robots

II Semester M. Tech. (Robotics & Automation)

Sr. No.	Subject Code	Subject Name	L	P	Total	Credits	Internal Assess-ment	Semester Exam	Total	Exam Duration Hrs.	Category
1	MET761	Mobile Robots	3	-	3	3	40	60	100	3 Hrs.	PC
2	MET762	Artificial Intelligence and Machine Learning in robotics	3	-	3	3	40	60	100	3 Hrs.	PC
3	MET763	Industrial Automation and Flexible Manufacturing System	3	-	3	3	40	60	100	3 Hrs.	Pc
4	MET764	Robot path planning	3	-	3	3	40	60	100	3 Hrs.	PC
5	MET765	Program Elective -2	3	-	3	3	40	60	100	3 Hrs.	PE
6	MET599	Open Elective-1	3	-	3	3	40	60	100	3 Hrs.	OE
7	MEP767	ROS and robot Programming	-	4	4	2	25	25	50	----	PC
8	MEP768	Lab Practice-3	-	4	4	2	25	25	50	----	PC
9	MET769	Audit course: Professional Practices and ethics II	2	0	2	0	0	0	SF/USF	----	PC
		Total	**20**	**8**	**28**	**22**	**290**	**410**	**700**		

Course Code	Program Elective - 2
MET765-1	Multibody dynamic system
MET765-2	Robotic Process Automation
MET765-3	Bioinspired robotics

Course Code	Open Elective
MET599-3	Industrial Robotics
MET599-4	Mechatronics
MET599-5	Automobile Engineering

III Semester M. Tech. (Robotics & Automation)

Sr. No.	Subject Code	Subject Name	L	P	Total	Credits	Internal Assess-ment	Semester Exam	Total	Exam Duration Hrs.	Category
1	MET851	Research Methodology	3	-	3	3	40	60	100	3 Hrs.	PC
2	MET852	Group Elective - I	4	-	4	4	40	60	100	3 Hrs.	GE
3	MET853	Group Elective - II	4	-	4	4	40	60	100	3 Hrs.	GE
4	MET854	Project Phase - I	-	3	3	6	100	100	200	----	PC
		Total	**11**	**3**	**14**	**17**	**220**	**280**	**500**		

OR

1	MET855	Research Methodology (MOOC / Any online platform)				3			100	----	----
2	MET856	Industry Internship Phase - I / Research Internship Phase - I / TBI Internship - Phase - I				14	180	220	400	----	----
		Total				**17**			**500**		

Course Code	Group Elective - 1
MET852-1	Embedded System Design
MET852-2	Machine Vision
MET852-3	Industry 4.0
INT651-1	Total Quality Management
INT651-2	Value Engineering
INT651-3	System Design Engineering
INT651-4	Productivity Improvement Techniques

Course Code	Group Elective - 2
MET853-1	Automation in supply chain
MET853-2	MEMS and Microsystems
MET853-4	Wireless Sensor Network for robotics
INT652-1	Computer & Database Management System
INT652-2	Manufacturing Economics and Analysis
INT652-3	Business Communications

IV Semester M. Tech. (Robotics & Automation)

Sr. No.	Subject Code	Subject Name	L	P	Total	Credits	Internal Assess-ment	Semester Exam	Total	Exam Duration Hrs.	Category
1	MEP861	Project Phase - II **OR** Industry Internship-Phase-II / Research Internship-phase-II / TBI Internship-Phase-II	-	7	7	12	200	200	400	----	PC

Total Credits: 20 + 22 + 17 + 12 = 71

Department of Mechanical Engineering
Syllabus for Semester I, M. Tech (Robotics and Automation)

Course Code : MET751 **Course : Robot kinematics and dynamics**

L: 3 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 03**

Objectives

To impart knowledge about kinematic and dynamic analysis of robot manipulators.

Course Outcomes

The students will able to

CO1 : Understand the history, evolution and anatomy of robot.

CO2 : Comprehend the concept of Mapping and Transformations for kinematic of manipulator.

CO3 : Understand and apply the concept of forward and inverse kinematics of manipulator.

CO4 : Explore the computational challenges of Manipulator differential motion.

CO5 : Develop dynamic modeling of manipulator

Unit - I : Introduction to robotics

Evolution of robots and robotics, Laws of robotics, Progressive advancement in robots, Robot anatomy: links, joint and joint notation scheme, degree of freedom, arm configuration, wrist configuration, End- effector and Grippers, Classification of robot, Human arm characteristics, Design and control issues, Manipulation and control, Sensors and vision, Programming robot, Future aspect.

Unit - II : Coordinate Frames, Mapping and Transformations

Coordinate frames : Mapping, Mapping between rotated frames, Mapping between translated frames, Mapping between rotated and translated frames. Description of object in space.

Transformation of vectors : Rotation of vector, translation of vector, combined rotation and translation of vectors, composite transformation, inverting a homogeneous transform.

Fundamental Rotation matrix : Principal axis rotation, fixed angle representation, Euler angle representation, Equivalent angle axis representation.

Unit - III : Direct/Forward kinematics modeling

Mechanical Structure and notation, Description of links and joints, Kinematic modeling of manipulator, Denavit - hartenbergnotation, Kinematic relationship between adjacent links, Manipulator transformation matrix.

Inverse kinematic modeling : Manipulator workspace, Solvability of inverse kinematic model: existence of solution, multiple solution, Solution technique, closed form solution.

Unit - IV : Manipulator differential motion and statics

Linear and angular velocity of rigid body, relationship between transformation matrix and angular velocity, mapping velocity vector, velocity propagation along links, Manipulator Jacobian, Jacobian inverse, Jacobian singularity, static analysis.

Unit - V : Dynamic modeling

Lagrangian Mechanics, Dynamic modeling of two degree of freedom manipulator, Langrange-Euler Formulation, Newtion-Euler formulation, Comparison of Langrange-Euler Formulation and Newtion-Euler formulation, Inverse dynamics.

Text Books

1. John J. Craig, Introduction to Robotics Mechanics and Control, Second Edition, Addison Wesly Longman Inc. International Student edition, 1999.
2. R. K. Mittal and I J Nagrath, Robotics and Control, McGraw Hill Education (India) Private Limited, 2017.

Reference Books

1. R. N Nazar, Theory of Applied Robotics: Kinematics, Dynamics, and Control, Springer; 2nd Ed. 2010.

Department of Mechanical Engineering
Syllabus for Semester I, M. Tech (Robotics and Automation)

Course Code : MET752 | **Course : Control System Theory**

L: 3 Hrs. T: 0 Hrs. P: 0 Hrs. Per week | **Total Credits : 03**

Course Objective

To design the control strategy of the robotic systems.

Course Outcome

The students will able to:

1. Understand the concept of system modelling for control strategy.
2. Understand and apply the concept of linear control
3. Understand and apply the concept of non-linear control
4. Understand and apply the concept of joint and task space for trajectory planning
5. Understand the various methods for system stability.

Unit - I : Introduction and System Modeling

Introduction to manipulator control problem, open and closed loop control, forward and inverse dynamics considerations, properties of the dynamic model, introduction to nonlinear systems and control schemes.

Unit - II : Linear Control

Introduction, control techniques, block diagram, transfer function, signal flow diagram, state space representation, performance and stability of feedback control, Proportional-Derivative- Integral (PID) control, selection of PID controller gains, state feedback control, joint controllers.

Unit - III : Nonlinear Control

Introduction, multivariable robot control, linearized control, Proportional-Derivative (PD) control, computed torque control, robust control, adaptive control, cartesian control, hybrid control.

Unit - IV : Joint Space and Task Space Control Schemes

Introduction, manipulator interaction with environment, compliance control, impedance control, force control, position control, velocity control, trajectory control.

Unit - V : System Stability and Optimal Control

Introduction to Lyapunov stability analysis, direct and indirect methods, time varying optimal control, applications and examples.

Text Books

1. Huang, A., Chien, M. (2010). Adaptive Control Of Robot Manipulators: A Unified Regressor-free Approach. Singapore: World Scientific Publishing Company.
2. Santibáñez, V., Loría Perez, J. A., Loría, A., Davila, V. S., Kelly, R. (2006). ControlofR o b o t Manipulators in Joint Space. Germany: Springer London.
3. Siciliano, B., Bastin, G., Canudas de Wit, C. (2012). Theory of Robot Control. United Kingdom: Springer London.

Reference Books

1. Villani, L., Oriolo, G., Siciliano, B., Sciavicco, L. (2009). Robotics: Modelling, Planning and Control. Germany: Springer.
2. Park, F. C., Lynch, K. M. (2017). Modern Robotics: Mechanics, Planning, and Control. United Kingdom: Cambridge University Press.
3. Dawson, D. M., Abdallah, C. T., Lewis, F. L. (2003). Robot Manipulator Control: Theory and Practice. Ukraine: CRC Press.
4. Hutchinson, S., Spong, M. W., Vidyasagar, M. (2020). Robot Modeling and Control. United Kingdom: Wiley.

Department of Mechanical Engineering
Syllabus for Semester I, M. Tech (Robotics and Automation)

Course Code : MET753 **Course : Robotic Drives and Actuators**

L: 3 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 03**

Course Objective

To introduce the various drives and actuator systems used in robots.

Course Outcomes

The students will be able to

CO1 : Understand the various drives and actuators of robotic system.

CO2 : Recognize the application of electric drives in robotic system.

CO3 : Understand and apply pneumatic and hydraulic system in robotic application.

CO4 : Appreciate the use of servo systems to design a robot.

CO5 : Demonstrate the application of various drives and actuators.

Unit - I : Introduction to Robot Drives and Actuators

Introduction, drives and actuators, classification of actuator systems, open loop control, closed loop control with feedback, functions and classification of drive systems, chain and linkages, lead screw, ball screws, belt drives, gear drives, precision gear boxes, harmonic drives, speed reducers, classification of grippers.

Unit - II : Electric Drives

Introduction, classification, AC motors, DC motors, stepper motors, types of stepper motors, half step mode operation, micro step mode, linear actuators, direct drive actuators.

Unit - III : Pneumatic Drives

Introduction, advantages and disadvantages, components of pneumatic control drives, linear pistons, rotary pistons, flow control valves, pneumatic proportional controller, applications.

Unit - IV : Hydraulic Drives

Introduction, advantages and disadvantages, components of hydraulic control drives, piston and transfer valves, hydraulic circuit with control amplifiers, fluid consideration, rotary and linear hydraulic actuators, hydraulic components in robots.

Unit - V : Servo Systems

Introduction, arrangement of actuators in robots, fundamentals of control techniques, modelling of robot servos, error response, steady state errors in robot servos, feedback and feed forward compensations, hydraulic position servo, computer controlled servosystems, selection of robot drives.

Text Books

1. Knapczyk, J. (2014). Basics of Robotics: Theory and Components of Manipulators and Robots. Austria: Springer Vienna.
2. De Silva, C. W. (2015). Sensors and Actuators: Engineering System Instrumentation, Second Edition. United States: CRC Press.
3. Pawlak, A. M. (2017). Sensors and Actuators in Mechatronics: Design and Applications. United Kingdom: CRC Press.
4. Ida, N. (2014). Sensors, Actuators, and Their Interfaces: A Multidisciplinary Introduction. United Kingdom: Institution of Engineering and Technology.
5. Actuators: Basics and Applications. (2004). Germany: Springer.

Reference Books

1. Agrawal, S. K., Kinzel, G. L., Waldron, K. J. (2016). Kinematics, Dynamics, and Design of Machinery. United Kingdom: Wiley.
2. Norton, R. L. (2014). Machine Design: An Integrated Approach. United Kingdom: Prentice Hall.

Department of Mechanical Engineering
Syllabus for Semester I, M. Tech (Robotics and Automation)

Course Code : MET-754 **Course : Robotic Sensors**

L: 3 Hrs, T: 0 Hr, P: 0 Hrs. Per week **Total Credits : 3**

Course Objective

To introduce various sensors to make robot autonomous and intelligent.

Course Outcomes

This course is to prepare the students

1. To understand the concepts of sensors and transducers with their characteristics
2. Know the different sensors in robotics
3. To understand the various types of advanced sensors in Robotics
4. To study the different vision sensors in robotics
5. To understand calibration of sensors and multisensory controlled robot assembly.

UNIT - I : Introduction to sensors and transducers

An Introduction to sensors and Transducers, Characteristics of instrument and measurement systems. Smart Sensing, AI sensing, Need of sensors in Robotics.

UNIT : II : Robotics sensors and transducers

Position sensors– optical, non-optical, Velocity sensors, Accelerometers, Proximity Sensors – Contact, non-contact, Range Sensing, touch and Slip Sensors, Force and Torque Sensors.Bend Sensor, Odor Sensor

UNIT - III : Miscellaneous Sensors in Robotics

Different sensing variables – smell, Heat or Temperature, Humidity, Light, Speech or Voice recognition Systems, Telepresence and related technologies.,Pyroelectric Sensor, IMU,MEMS, Camera, SONAR, LiDAR, RADAR, GPS

UNIT - IV : Vision Sensors in Robotics

Robot Control through Vision sensors, Robot vision locating position, Robot guidance with vision system, End effectors, camera Sensor.

UNIT - V : Calibration of sensors and multisensor Controlled Robot Assembly

Calibration of sensors, Control Computer, Vision Sensor modules, Software Structure, Vision Sensor software, Robot programming, Handling, Gripper and Gripping methods, accuracy – A Case study

Text Books

1. D.V.S. Murthy, "Transducers and Instrumentation", PHI 20032. B.C. Nakra and K.K. Chaudhary, “Instrumentation, Measurement and Analysis”: Tata McGraw Hill.
2. Paul W Chapman, “Smart Sensors”, an Independent Learning Module Series, 1996.
3. SabrieSoloman, “Sensors and Control Systems in Manufacturing”, McGraw-Hill Professional Publishing, 2nd Edition, 2009.
4. Khatib et al. ,Springer Handbook of Robotics (2nd Edition)
5. Peter Corke, Robotics,Vision and Control

Reference Books

1. Doeblin and Ernest, "Measurement Systems Application and Design", Tata McGrawHill 2004.
2. Scherz& Monk, Practical Electronics for Inventors.
3. Julian W Gardner, “Micro Sensor MEMS and Smart Devices”, John Wiley & Sons, 2001
4. Albert D Helfrick and William D Cooper, "Modern Electronic Instrumentation and Measurement Techniques" 2004, PHI.

Department of Mechanical Engineering
Syllabus for Semester I, M. Tech (Robotics and Automation)

Course Code : MET 755-1 **Course : Internet of Things (IoT)**

L: 3 Hrs., T: 0 Hrs., P: 0 Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students:

1. To understand the interconnection and integration of the physical world and the cyber space.
2. To develop IoT based engineering applications.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand the application areas of IoT.
2. Formulate building blocks of IoT.
3. Apply memory management in IoT.
4. AnalyzeIoT implementation though various platforms.
5. Create IoT system in specific engineering domain.

UNIT - I : The Internet of Things

An Overview, The Flavor of the Internet of Things, The Technology of the Internet of Things, Enchanted objects, Affordances, M2M, WoT

UNIT - II : Internet Principles

An Overview, IP, TCP, The IP Protocol Suite (TCP/IP), UDP, IP Addresses, DNS, Static IP Address Assignment, Dynamic IP Address Assignment, IPv6, MAC Addresses, TCP and UDP Ports, Application Layer Protocols: HTTP, Encrypted HTTP, Other Application Layer Protocols

UNIT - III : Thinking About Prototyping

Prototypes and Production, Costs versus Ease of Prototyping, Changing Embedded Platform, Open Source versus Closed Source, Why Closed? Why Open? Mixing Open and Closed Source, Memory Management, Types of Memory, Making the Most of Your RAM, Performance and Battery Life, Libraries

UNIT - IV : Introduction to Python Programming and Raspberry PI

General syntax of Python Programming, Libraries (NumPy, SciPy, Pnadas, Tensor Flowetc), Raspberry PI, Implementation of IoT with Python, Implementation of IoT with Raspberry PI (Domain based application)

UNIT - V : Seven Generation of IoT Sensors to Appear

Industrial sensors – Description & Characteristics– First Generation – Description & CharacteristicsAdvanced Generation – Description & Characteristics– Integrated IoT Sensors – Description & Characteristics– Polytronics Systems – Description & Characteristics– Sensors' Swarm – Description & Characteristics– Printed Electronics –Description & Characteristics– IoT Generation Roadmap

Case studies or mini projects in some of the areas like: Home Automation, Agriculture sector, health sector, Mobility and retail sector etc.

Text Books

1. Designing the Internet of Things, Adrian McEwen and Hakim Cassimally, 1st Edition John Wiley and Sons, Ltd.
2. Internet of Things, Architecture and Design principles, Raj Kamal, 1st Edition, McGraw Hill education (India) Pvt. Ltd.

Reference Books

1. Learning of Internet of Things, Peter Waher, 1st Edition, Packt Publishing
2. Dr. Guillaume Girardin, Antoine Bonnabel, Dr. Eric Mounier, 'Technologies & Sensors for the Internet of Things Businesses & Market Trends 2014 - 2024',Yole Development Copyrights, 2014
3. Peter Waher, 'Learning Internet of Things', Packt Publishing, 2015
4. Editors OvidiuVermesan Peter Friess,'Internet of Things – From Research and Innovation to Market Deployment', River Publishers, 2014
5. N. Ida, Sensors, Actuators and Their Interfaces, Scitech Publishers, 2014.
6. Introduction to Industrial Internet of Things and Industry 4.0, SudipMisra, Chandana Roy, Anandarup Mukherjee, CRC Press

Department of Mechanical Engineering
Syllabus for Semester I, M. Tech (Robotics and Automation)

Course Code : MET 755-2 **Course : Integrated Advanced Manufacturing**

L: 3 Hrs, T: 0 Hr, P: 0 Hrs. Per week **Total Credits : 03**

Course Objective

To introduction the modern methods of additive and subtractive manufacturing.

Course Outcome

The objective of the course is to prepare the students:

1. To understand CNC technology and concepts
2. To understand the CNC turning and milling machines and working specifications
3. To generate NC part program using various codes to machine parts to specifications.
4. Awareness of the CAM modeling techniques.
5. Awareness of the methods and techniques in additive manufacturing.

Unit - I : Computer Numerical Control : Introduction of numerical control for machine tools, Components of numerical control (NC), Computer Numerical control(CNC), Direct Numerical control (DNC), applications of CNC, system devices; drives and control, ball screws, feedback devices, counting devices, interpolators.

Unit - II : Machine Controls : CNC position control: point to point, straight cut, and continuous path, open loop and closed loop NC systems, interpolation schemes, Importance of various positions like machine zero, work piece zero, program zero, home position and tool offset, ISO G and M codes for turning and milling, meaning and applications of important codes, linear interpolation and circular interpolation features, Canned cycles, cutter radius compensation.

Unit - III : CNC Part programming : NC programming format and structure of part program, part programming specification, CNC turning and milling centers features, axes nomenclature, manual part programming for CNC Lathe and CNC Mill.

Unit - IV : CAM Modeling : Solid modeling - Parametric modeling, Tool path generation for Lathe and milling operation. STL file generation; file verification & repair, STL/AMF Slicing CURA / Ultimaker, preprocessing and post processing techniques.

Unit - V : Additive Manufacturing processes : Liquid based processes, Powder based processes & Solid based processes, RP Processes overview, system classification, Stereo lithography, SL with liquid and thermal polymerization, Selective laser Sintering, Fused deposition modeling, 3D scanning, Reverse Engineering.

Text Books

1. CNC Machines: M. Adithan& B. S. Pabla, New Age International Publications New Delhi
2. Automation, production System & CIMS: M. P. Groover, Prentice Hall of India, New Delhi
3. Additive Manufacturing Technologies: Ian Gibson, Devid Rosen, Springer

Reference Books

1. Computer Control of Manufacturing Systems: YoramKoren, Mcgraw Hill, Delhi
2. CAD/CAM: E. Zimmers& M. Groover, Pearson Education, Delhi
3. Reverse Engineering- An Industrial Perspective Vinesh Raja and Kiran J Fernandes, Springer-Verlag, 2008

Department of Mechanical Engineering
Syllabus for Semester I, M. Tech (Robotics and Automation)

Course Code : MET755-3 **Course : Field and Service Robots**

L: 3 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 03**

Course Objective

The objective of the course is to familiarize the students with the various applications of robots and to make them acquainted with the various theoretical aspects associated with it. The course will generate basic knowledge of field and service robots used in indoor and outdoor environment.

Course Outcomes

At the end of this course, the students will able to

CO1 : Explain basic terminology and various applications of industrial robots

CO2 : Understand and describe the applications of underwater, aerial and space robot

CO3 : Understand and describe the applications of agriculture, construction and mining robot

CO4 : Understand and describe the applications of domestic and medical robot

CO5 : Understand and describe the applications humanoids and intelligent vehicles

Contents

Unit - I : Industrial robotics

History and evolution of robotics, laws of robotics, robots, robot subsystems, robot configurations, classification of robots, Typical applications- welding, assembly, painting, automated material transfer, machining, human-robot cooperation for handling tasks.

Introduction to parallel manipulators, structure classification of parallel manipulators, applications.

Unit - II : Underwater, Aerial and Space Robotics

Introduction to underwater robotics, historical background, sensor systems, actuating systems, applications.

Introduction to aerial robotics, historical background, unmanned aerial vehicles, quadrotors, components of autonomous flight, applications and challenges of aerial robotics.

Introduction to space robotics, historical background, orbital robotics systems, surface robotic systems, applications and examples.

Unit - III : Agriculture, Construction and Mining Robotics

Introduction to agricultural robotics, overview of the agricultural robots, typical applications, challenges of the field.

Introduction to robotics in construction, system overview, basic types of construction robots, economic aspects, applications.

Introduction to robotics in mining, historical background, applications in mining process.

Unit - IV : Domestic and Medical Robotics

Introduction to home automation, domestic robotics, cleaning robots, lawn moving robots, challenges and applications.

Introduction to medical robotics, historical background, surgical robots, rehabilitation robots, exoskeletons, issues related to safety and ethics, applications and challenges in medical robotics.

Unit - V : Humanoids and Intelligent Vehicles

Introduction to humanoids, historical background, locomotion and manipulation of humanoids, whole body activities, teaching methodologies, applications.

Concept of intelligence, need and necessity of intelligent vehicles, driver assistance systems, driver monitoring systems, road scene interpretation, automated vehicles, applications and challenges.

Reference Books

1. Industrial Robotics: Technology, Programming and Applications, by Groover M.P., Tata McGraw Hill Publication Ltd.
2. Parallel Robots: Mechanics and Control, by Taghirad H.D., CRC Press.
3. Underwater Robotics: Science, Design & Fabrication, by Moore S. W., Bohm H., and ,Jensen V., Marine Advanced Technology Education (MATE) Center, 2010.
4. Aerial Robots: Aerodynamics, Control and Application, by Mejia O. D. M., Gomez J. A. E., (eds.), In Tech Open Publications.
5. Robot Oriented Design: Design and Management Tools for the Deployment of Automation and Robotics in Construction, by Bock T., Linner T., Cmbridge University Press,
6. Robotics and Mechatronics for Agriculture, by Zhang D., Wei B., (eds.), CRC Press.
7. Medical Robotics, by Schweikard A., Ernst F., Springer Publications.
8. Household Service Robotics, by Xu Y., Qian H., and Wu X., Zhejiang University Press.
9. Springer Handbook of Robotics, by Khatib O., (ed.), Springer Publications.
10. Humanoid Robotics: A Reference, Vadakkepat P., GoswamiA., Springer Netherlands, 2017.
11. On Road Intelligent Vehicles, by Kala R., Elsevier Publications, 2017.

Department of Mechanical Engineering
Syllabus for Semester II, M. Tech (Robotics and Automation)

Course Code : MEP756 **Course : Lab Practice - I**

L: 0 Hrs., T: 0 Hrs. P: 4 Hrs. per week **Total Credits : 02**

Course objective

To introduce the concept of robotic system, its components, instrumentation and control.

Course Outcomes

Students will be able to

CO1 : Explain the fundamental of robotics, its structures and field of applications.

CO2 : Illustrate the robot kinematics and dynamics.

CO3 : Demonstrate the knowledge of robot drives, actuators and their control.

Contents

Lab Practice-1 shall constitute of the practical related to kinematics, dynamics and control strategy of n-DOF robot of various body-arm configuration. It also constitute of various drives and actuators required to design the robot.

Department of Mechanical Engineering
Syllabus for Semester II, M. Tech (Robotics and Automation)

Course Code : MEP757 **Course : Lab Practice - II**

L: 0 Hrs., T: 0 Hrs. P: 4 Hrs. per week **Total Credits : 02**

Course objective

To design IoT architectural layers through IDEs (Arduino / Raspberry Pi) and multiple sensors based on IEEE standards and implement IoT application for some engineering domain like home automation, smart cities, Agriculture, Retails, e-mobility etc

Course Outcomes

CO1 : The students will be able to write Arduino sketch/python codes

CO2 : The students will be able to use Arduino/RPi IDEs connected with sensors.

CO3 : The students will be able to interface with Bluetooth devices/GSM Module and to communicate Sensor data with Clouds

Contents

Lab Practice-2 shall constitute of the practical related to various sensors to make intelligent and autonomous robot as well as practical related to internet of things.

Department of Mechanical Engineering
Syllabus for Semester II, M. Tech (Robotics and Automation)

Course Code : MEP758 **Course : Seminar (Project based Learning)**

L: 0 Hrs., T: 0 Hrs. P: 2 Hrs. per week **Total Credits : 01**

Course Objective

In this course the students will acquire the knowledge through active participation by solving real word problem in the domain of robotics and automation.

Course Outcome

Student will be able to:

1. Carry out the detailed literature survey and indentify the research gap to frame the problem statement.
2. Formulate the appropriate methodology to design the solution.
3. Prepare the technical reports and present the findings effectively.

Contents

The seminar topic should be latest and ahead of the scope of curriculum. The exhaustive literature review should be conducted to identify the research gap. The performance of the student will be evaluated on the basis of the contents, the presentation and discussion during the delivery of the seminar in front of the evaluation committee appointed by the Department.

Department of Mechanical Engineering
Syllabus for Semester II, M. Tech (Robotics and Automation)

Course Code : MET759 **Course : Professional Practices and Ethics - I**

L: 2 Hrs., T: 0 Hrs. P: 0 Hrs. per week **Total Credits : 00**

Course Objectives

The objectives of the course are to familiarize the students with the prevailing professional practices and to develop professional skills in them. The course also aims at imbibing ethical and moral values among the students.

Course outcomes

At the end of this course students will demonstrate the ability to

1. Develop the moral values of a good human being and a responsible citizen
2. Imbibe the professional ethics appropriate with the engineering profession
3. Become familiar with the professional practices in engineering profession

Introduction to morals, ethics and human values in professional and personal life. Ethical and moral dilemmas and challenges.

Understanding the professional practices in the industry necessary for effective working and adapting to the work culture of the corporate world. Developing professional approach towards work and developing communication and presentation skills.

Case studies related to professional practices and ethics.

Text Books

Professional Ethics and Human Values by R.S Naagarazan, New Age International Publishers

Department of Mechanical Engineering
Syllabus for Semester II, M. Tech (Robotics and Automation)

Course Code : MET761 **Course : Mobile Robotics**

L: 3 Hrs, P: 0 Hrs. Per week **Total Credits : 03**

Course Objective

This course will present various aspects of design, fabrication, motion planning, and control of intelligent mobile robotic systems.

Course Description

This course introduces the fundamentals of robotics with an emphasis on mobile robots, which are integrated mechanical, electrical and computational systems functioning in the physical world. The course aims to provide boththeoreticalandpracticalexperiencetostudentsthroughlecturesandhands-on experiments with real robots and simulation software.

Course Outcomes

At the end of this course students will able to

1. Explain about mobile robot and robot locomotion.
2. Explain and solve problems related to robot kinematics and dynamics.
3. Explain and apply the concept of mobile robot perception.
4. Use and apply any one of the localization techniques.
5. Apply path planning and navigation algorithms.

Unit - I : Introduction to mobile robots

Mobile robot, definition, types of robots, Applications of Mobile Robot.

Robot Hardware Robot locomotion, Types of locomotion, hopping robots, legged robots, wheeled robots, stability, maneuver ability, controllability

Unit - II : Robot kinematics and dynamics

Forwardandinversekinematics,holonomicandnonholonomicconstraints,kinematicmodelsof simple car and legged robots, dynamics simulation of mobile robots

Unit - III : Perception

Sensors Proprioceptive/Exteroceptive and passive/active sensors, performance measures of sensors, sensors for mobile robots like global positioning system (GPS), Doppler effect-based sensors, vision-based sensors, uncertainty in sensing, filtering

Unit - 4 : Localization

Odometricpositionestimation,beliefrepresentation,probabilisticmapping,Markov localization, Bayesian localization, Kalman localization, positioning beacon systems

Unit - V : Introduction to Path Planning and Navigation

Introduction, Path Planning, offline and online path planning, obstacle avoidance, path planning algorithms based on A-star, Dijkstra, Voronoi diagrams, probabilistic roadmaps (PRM), Potential field etc.

Advanced Topics : AI based techniques for navigation, Bio Inspired Algorithm, Multiple robot coordination. Design of intelligent robots

Text Book

1. R. Siegwart, I. R. Nourbakhsh, "Introduction to Autonomous Mobile Robots", The MIT Press, 2011

Reference Books

1. S.G. Tzafestas "Introduction to Mobile Robot Control", Elsevier Pub.
2. Selected readings from the research literature, to be distributed in class.

Department of Mechanical Engineering
Syllabus for Semester II, M. Tech (Robotics and Automation)

Course Code : MET762 **Course : Artificial Intelligence and Machine Learning on Robotics**

L: 3 Hrs, T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 03**

Course Objective

To introduce the artificial intelligence and machine learning used in the field of robotics.

Course Outcomes

The students shall able to

CO1 : Apply the basic principle of AI and its application.

CO2 : Understand apply the concept of planning.

CO3 : Illustrate the various algorithm for reasoning

CO4 : Understand apply the concept of supervised learning.

CO5 : Understand apply the concept of unsupervised learning.

Unit - I : Introduction to Artificial Intelligence

History, state of the art, Need for AI in Robotics. thinking and acting humanly, intelligent agents, structureof agents.

Solving problems by searching, informed search and exploration, constraint satisfaction problems, knowledge and reasoning, knowledge representation, first order logic.

Unit - II : Planning

Introduction, planning with forward and backward state space search, partial order planning, planning graphs, planning with propositional logic, planning and acting in real world.

Unit - III : Reasoning

Introduction, uncertainty, probabilistic reasoning, filtering and prediction, Hidden Markov models, Kalman filters, Dynamic Bayesian Networks, Speech recognition, making decisions.

Unit - IV : Supervised Learning

Introduction to machine learning, learning input- output functions, types of learning, performance evaluation, noise.

Decision trees and inductive bias, geometry and nearest neighbours, logistic regression, binary classification.

Unit - V : Unsupervised Learning

Introduction, curse of dimensionality, dimensionality Reduction, PCA, clustering, K-means, expectation maximization algorithm, hierarchical clustering, applications in robotics.

Text Books

1. Stuart Russell, Peter Norvig, "Artificial Intelligence: A modern approach", Pearson Education, India,2016.
2. Negnevitsky, M, "Artificial Intelligence: A guide to Intelligent Systems",. Harlow: AddisonWesley,2002.
3. Michalski, Carbonell, Tom Mitchell, „Machine Learning , Springer, 2014
4. Rogers, S., Girolami, M. (2016). A First Course in Machine Learning, Second Edition. United Kingdom: CRC Press.

Reference Books

1. David Jefferis, "Artificial Intelligence: Robotics and Machine Evolution", Crabtree PublishingCompany, 1992.
2. Huimin Lu, Xing Lu, "Artificial Intelligence and Robotics", Springer, 2017.
3. David MacKay, „Information Theory, Inference and Learning Algorithms , Cambridge, 2003
3. Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer Pub.

Department of Mechanical Engineering
Syllabus for Semester II, M. Tech (Robotics and Automation)

Course Code : MET763 **Course : Industrial Automation and Flexible Manufacturing Systems**

L: 3 Hrs, T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 03**

Course Objectives

1. The students will gain knowledge of automation in manufacturing field and FMS flexibility.
2. To impart the role of programmable logic controllers in industrial automation and process development.

Course Outcomes

At the end of this course students will be able to:

1. Understanding the automation knowledge, in terms of production line analysis.
2. Understand flexible manufacturing systems to improve the manufacturing flexibility.
3. Gain knowledge of process control, PLC architecture and interfacing
4. Understand the development of PLC ladder logic for industrial applications
5. Development of SCADA/HMI for industrial processes

Unit - I

Automation and Production flow lines : Definition, automation principles and strategies, scope of automation, socio-economic consideration, Production concepts and mathematical models, Methods of workpart transport, Transfer mechanisms, Part feeding devices, analysis of transfer lines without storage, automated flow lines with storage buffers.

Unit - II

Flexible manufacturing systems : Components of FMS, Workstations and Machine centers in FMS, FMS layout configuration, FMS data files, system reports, FMS applications, planning and implementation issues, Types of material handling equipment,Conveyor systems, Automated Guided Vehicle Systems and applications, Analysis of AGVS systems, Automated Storage & Retrieval System, Analysis of AS/RS.

Unit -III

Process Control &Automation : Process control principles, Analog and Digital control, Architecture of Industrial Automation Systems, I/Os: Sensors and switches, Solenoids, Relays and Contactors.

Unit - IV

Programmable logic controller : PLC Architecture, Interfacing Input and Output devices with PLC, PLC based automated systems,High frequency inputs, PLC standards IEC-61131,latching and internal relays, Data handling,Timer & Counter Instructions, Data Handling Instructions, Sequencing Instructions, Typical PLC Programming Exercises for Industrial Applications.

Unit - V

SCADA & Distributed control system : Elements of SCADA, Features of SCADA, MTU, RTU Functions, Applications of SCADA, Communications in SCADA, Introduction to DCS, Architecture, Input and output modules, Specifications of DCS.

Text Books

1. Programmable Logic Controllers, Principles and Applications: John W. Webb, Ronold A Reis, Prentice Hall of India, New Delhi

2. Automation, production System & CIMS: M. P. Groover, Prentice Hall of India, New Delhi

3. SCADA supervisory control and data acquisition: Stuart A. Boyer, ISA Publication.

Reference Books

1. Computer Control of Manufacturing Systems: YoramKoren, Mcgraw Hill, Delhi

2. CAD/CAM: M. Groover& E. Zimmers , Pearson Education, Delhi

3. Process Control Instrumentation Technology: Curtis Johnson, 8th Edition, Pearson Education

4. Programmable Logic Controllers: Bolton, Elsevier India; Fifth edition

5. Programmable Logic Controllers: Frank D. Petruzella McGraw Hill, Delhi

Department of Mechanical Engineering
Syllabus for Semester II, M. Tech (Robotics and Automation)

Course Code : MET764 **Course : Robot Path Planning**

L: 3 Hrs, T: 0 Hrs, P: 0 Hrs. Per week **Total Credits : 03**

Objective

To introduce the concepts of path planning for fixed base and mobile robots.

Course Outcomes

CO1 : Understand and apply the concept of Joint space planning for various robotic manipulators.

CO2 : Understand and apply the concept of Cartesian space planning for various robotic manipulators.

CO3 : Recognize various path planning approaches for Mobile Robot.

CO4 : Understand and apply various graph based techniques for path planning

CO5 : Illustrate the various practical application of trajectory planning.

Unit - I : Joint Space Planning

Introduction to trajectory planning, basic terminologies, one dimensional trajectories, multi-dimensional trajectories.

Polynomial trajectories, parabolic trajectory, trajectory with asymmetric constant acceleration, cubic trajectory, polynomial of degree five, other higher order polynomials, trigonometric trajectories, exponential trajectories.

Unit - II : Cartesian Space Planning

Introduction to cartesian space planning, cartesian path, continuity of the geometric path and continuity of the trajectory, interpolation, rotational path and tool orientation, manipulator motion by end effector path.

Unit - III : Mobile Robot Path Planning

Introduction to wheeled locomotion, design space, mobile robot localization, challenges and methods of localization, planning and navigation, competences for navigation, path planning, case studies.

Unit - IV : Graph based method for motion planning

Gross and compliant motion planning, Motion planning approach, Types of motion planning scheme: Traditional and non-traditional, Visibility and reduced visibility graph, Rotational plane sweep algorithm, Voronoi diagram, Cell decomposition and tangent graph.

Unit - V : Trajectory Planning Applications

Identification and selection of the trajectories for different applications, case studies: object manipulation, machine loading, spray painting operation, welding operation, assembly operation, material handling.

Text Books

1. Jazar, R. N. (2007). Theory of Applied Robotics: Kinematics, Dynamics, and Control. Ukraine: Springer US.
2. Melchiorri, C., Biagiotti, L. (2008). Trajectory Planning for Automatic Machines and Robots. Germany: Springer Berlin Heidelberg.

Reference Books

1. Nourbakhsh, I. R., Scaramuzza, D., Siegwart, R. (2011). Introduction to Autonomous Mobile Robots. United Kingdom: MIT Press.
2. Lee, C. S. G., Gonzalez, R. C., Fu, K. S. (1987). Robotics: Control, Sensing, Vision, and Intelligence. Taiwan: McGraw-Hill.
3. Ceccarelli, M. (2012). Service Robots and Robotics: Design and Application. Ukraine: Engineering Science Reference.
4. Groover, M. P. (2012). Industrial Robotics (Special Indian Edition). India: McGraw-Hill.

Department of Mechanical Engineering
Syllabus for Semester II, M. Tech (Robotics and Automation)

Course Code : MET765-1 **Course : Multi-body Dynamic System**

L: 3 Hrs, T: 0 Hrs, P: 0 Hrs. Per week **Total Credits : 03**

Course Objectives

This course will bring together students interested in the applied field of multi body dynamics. They will extend their understanding of basic particle dynamics and 2-dimensional rigid body mechanics to 3-dimensional rigid bodies and how to analyze interconnected bodies in a multi- body system.

Course Outcomes

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

CO1 : Understand the basics of laws of motion and work energy principles

CO2 : Implement methods of formulating equations of motion for inter-connected bodies.

CO3 : Apply their mathematical background in differential equations to analyze multi-body systems.

CO4 : Derive equations of motion for rigid bodies and analyze the behaviors of the multi-body systems

CO5 : Extend learning to determine the stability of the system

Contents

Unit - I

Basic concepts : Inertial coordinate system, fundamental laws of motion, mechanics of particles and system of particles, principles of linear and angular momentum, work-energy principles.(6 hrs)

Unit - II

Lagrangian dynamics : Degrees of freedom, generalized coordinates and generalized forces, holonomic and non-holonomic constraints, Lagrange's equation from d'Alembert's principles, application of Lagrange's equation for conservative and non-conservative autonomous systems with holonomic and non-holonomic constraints, applications to systems with very small displacements and impulsive motion; Hamilton principle from d'Alembert's principle, Lagrange equation from Hamilton's principle (8 hrs)

Unit - III

Multi-body dynamics : Space and fixed body coordinate systems, coordinate transformation matrix, direction cosines, Euler angles, Euler parameters, finite and infinitesimal rotations, time derivatives of transformations matrices, angular velocity and acceleration vectors (8 hrs)

Unit - IV

Equations of motion of multi-body system, Newton-Euler equations, planer kinematic and dynamic analysis, kinematic revolute joints, joint reaction forces, simple applications of planer systems. (7 hrs)

Unit - V

Stability of motion : Fundamental concept in stability, autonomous systems and phase plane plots, Routh's criteria for stability, Liapunov's method, Liapunov's stability theorems, Liapunov's function to determine stability of the system (7 hrs)Text and

Reference Books

1. Ginsberg, J.H., "Advanced Engineering Dynamics", Harper and Row. 1988
2. Meirovitch, L., "Methods of Analytical Dynamics", McGraw Hill Inc. 1970
3. Harold Josephs and Ronald Huston, "Dynamics of Mechanical Systems", CRC Press. 2002
4. Katsuhiko Ogata, "System Dynamics",4th Ed., Prentice Hall; 2003
5. Robert L. Woods and Kent L. Lawrence, "Modeling and Simulation of Dynamic Systems", Prentice Hall. 1997
6. Ramin S. Esfandiari and Bei Lu, "Modeling and Analysis of Dynamic Systems", CRC Press. 2010
7. Dean C. Karnopp, Donald L. Margolis, and Ronald C. Rosenberg, "System Dynamics: Modeling and Simulation of Mechatronic Systems", 4th Ed., Wiley. 2006
8. Richard A. Layton, "Principles of Analytical System Dynamics" (Mechanical Engineering Series), Springer. 1998

Department of Mechanical Engineering
Syllabus for Semester II, M. Tech (Robotics and Automation)

Course Code : MET765-2 **Course : Robot Process Automation**

L: 3 Hrs, T: 0 Hrs, P: 0 Hrs. Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students to develop the processes using RPA & cognitive services of Blue Prims, UiPath, Automation Anywhere, for various automation applications.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand Robotic Process Automation (RPA) and its value proposition.
2. Understand various RPS skills.
3. Learn different RPA tools and use different component to automate process.
4. Learn and use Web, Email, Excel, Database, API etc. and Image Automation.
5. Understand RPA services and its integration with RPA Tools.

Contents

Unit - I : Robotic Process Automation (RPA) Foundation : Overview of RPA, Development of RPA, Evolution of RPA, Differentiating RPA from Automation, Assisted and unassisted automation, Defining Robotic Process Automation & its benefits, comparison to other automation technology.

Unit - II : RPA Skills : On premise Vs. the cloud, Web Technology, Programming Languages and low code, OCR, APIs, Cognitive automation, flowchart Process Methodologies: Lean, Six Sigma, Applying lean and Six Sigma to RPA.

Unit - III : Planning and BOT Development : How Robotic Process Automation works, RPA development methodology and key considerations, Robotic Process Automation Tools. Sequence flowchart and control flow, various types of loops and decision making, Introduction to UiPath platform and its components, Types of Templates, User Interface Domains in Activities Workflow, Files in UiPath.

Unit - IV : Automate login to your (web)Email account Recording mouse and keyboard actions to perform an operation Scraping data from website and writing to CSV/Excel Programming, Debugging and Logging

Unit - V : Deployment and Monitoring, Data Preparation, RPA Vendors, Blue Prism, UiPath platform etc. Open Source RPA, Future of RPA.

Text and Reference Books

1. Taulli T. Process Mining. The Robotic Process Automation Handbook 2020:A Guide to Implementing RPA System (pp. 273-292). Apress, Berkeley, CA.
2. Tripathi AM. Learning Robotic Process Automation: Create Software robots and automate business processes with the leading RPA tool–UiPath. Packt Publishing Ltd; 2018 Mar 28

Department of Mechanical Engineering
Syllabus for Semester II, M. Tech (Robotics and Automation)

Course Code : MET765-3 **Course : Bioinspired Robotics**

L: 3 Hrs, T: 0 Hrs, P: 0 Hrs. Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students:

1. To understand the biological systems with reference to robotic system
2. To develop biologically inspired robotic applications

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand the Bioinspired sensing.
2. Formulate bioinspired motion
3. Differentiate Soft and Hard Robotics
4. Analyse control architecture and behaviour with reference to kinematics
5. Evaluate collective and Biohybrid robotics/ create electromechanical robotic system

UNIT - I

Fundamentals of Traditional Robots, Biologically-inspired Robots, Introduction, Bio-inspired morphologies, Bio-inspired sensors, Vision, Audition, Touch, Smell, taste, Idiothetic sensors.

UNIT - II

Fundamentals of Biologically Inspired Robots, Bio-inspired actuators, locomotion, crawling, walking, wall climbing, jumping, swimming, flying, grasping, drilling

UNIT - III

Soft Robotics, Structural Difference between Hard and Soft Robots, Bio-inspiration in Soft Robotics, Hydrostatic Skeletons, Muscular Hydrostats, Soft Active Plant Structure, Soft Robots, Actuators, Pneumatic Artificial Muscles, Electroactive Polymers, Shape Memory Alloys

UNIT - IV

Bio-inspired control architectures, Behavior-based robotics, learning robots, Evolving robots, Developing robots, Bio-inspired Robot Design Considering Load-bearing and Kinematic Ontogeny of Sea Turtles.

UNIT - V

Energetic anatomy, Collective robotics, Biohybrid robots. Case studies and mini projects in Design and Fabrication of Biologically Inspired Robots

Text Book

1. J.J. Craig. Introduction to Robotics: Mechanics and Control. Prentice Hall; 3rd edition, 2003.Reference Books

1. G. A. Bekey. Autonomous Robots. MIT Press, 2005.
2. Karl Williams. Amphibionics: Build Your Own Biologically Inspired Reptilian Robot. McGraw-Hill/TAB Electronics, 2003.
3. David Cook. Robot Building for Beginners. Apress, 2002.
4. Handbook of Robotics, Jean-Arcady Meyer and AgnèsGuillot

Web references

http://www.youtube.com/watch?time_continue=7&v=JISayvpQH54

http://www.youtube.com/watch?time_continue=74&v=vlgpATwOpD0

http://www.youtube.com/watch?time_continue=36&v=lbXRiTbuDvY

Department of Mechanical Engineering
Syllabus for Semester II, M. Tech (Robotics and Automation)

Course Code : MET599-3 **Course : Industrial Robotics (OE)**

L: 3 Hrs, T: 0 Hrs, P: 0 Hrs. Per week **Total Credits : 03**

Course Objectives

To understand the basic concepts associated with the design, functioning and applications of Robots.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand the basic of Robotics.
2. Understand the kinematic analysis of Robotics.
3. Understand the dynamics and trajectory planning for manipulator
4. Understand the Sensing, Actuation and control issues of robot
5. Understand the Motion planning and control of mobile robot and explore the various application of robot

Unit - I : Introduction

Introduction to robots and their evolution, Anatomy and classification of robot, what is and what is not a robot, progressive advancements in robots.

Unit - II : Kinematics of serial robots

Coordinate frame, mapping and transformation, Forward & inverse kinematics, Representation of joints, link representation using D-H parameters, Examples of D-H parameters and link transforms

Unit - III : Dynamics and trajectory planning of serial robot

Linear and angular velocity of links, Manipulator Jacobians, singularity, dexterity for serial manipulators, Euler-Lagrangian formulation for equations of motion for serial manipulators, Joint and Cartesian space trajectory planning and generation.

Unit - IV : Sensing, Actuation and control

Kinds of actuators – stepper, DC servo and brushless motors, model of a DC servo motor, Types of transmissions, Purpose of sensors, internal and external sensors, common sensors – encoders, tachometers, strain gauge based force-torque sensors, proximity and distance measuring sensors, vision. Classical control concepts using the example of control of a single link, Independent joint PID control, Control of a multi-link manipulator.

Unit - V : Mobile Robotics and Robot Applications

Mobile robotics, sensing, control, navigation, path planning algorithms (holonomic, non- holonomic) Industrial application of robots: material handling, processing, assembly, inspection, welding, and painting. Non industrial applications: domestic, medical, military operations, children toys, humanoids. Robot safety.

Text Books

1. R. K. Mital, I. J. Nagrath, "Robotics and Control", McGraw Hill Education, 2017.

Reference Books

1. Mikell P Groover, Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, "Industrial Robotics, Technology programming and Applications", McGraw Hill, 2012.
2. Craig. J. J. "Introduction to Robotics- mechanics and control", Addison- Wesley, 1999.

Department of Mechanical Engineering
Syllabus for Semester II, M. Tech (Robotics and Automation)

Course Code : MET599-4 **Course : Mechatronics (Open Elective)**

L: 3 Hrs, T: 0 Hrs, P: 0 Hrs. Per week **Total Credits : 03**

Course Objective

To understand the key elements of Mechatronics system to design automation system.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand and recognize the synergistic combination of all related branches of engineering.
2. Apply knowledge about sensors and actuators for selection for a typical application.
3. Explain construction and working of CNC machines as Mechatronics systems.
4. Understand and apply the design process a Mechatronics system.
5. Gain the knowledge on advanced applications in Mechatronics.

Unit - I : Introduction

Introduction to Mechatronics Systems, Definition of Mechatronics, Classification and Description of Mechatronic using Graphical and Block Diagram Method, Multi-disciplinary scenario, origins. Evolution of Mechatronics, Mechatronics key elements, Mechatronics design process, Need for mechatronics in industries, Objectives, advantages and disadvantages of mechatronics.

Unit - II :Sensors, Transducers and Actuators

Introduction toSensors and Transducers: Performance Terminology Displacement, Position and Proximity-Velocity and Motion-Fluid, Classifications of different sensors used in mechatronics systems.

Classifications of Actuators, Types of stepper motors and its control circuit, Types of DC Motor, DC Geared motors, SD Servo geared Motors, Mechanical Actuation Systems,Pneumatic and Hydraulic Actuation Systems.Piezoelectric actuators Introduction to Microprocessors and Micro Controllers used for Mechatronic devices.

Unit - III : Elements of CNC Machines

Introduction to Computer Numerical Control, Features of CNC Machines, Structure, Drive Mechanism, gearbox,Main drive, feed drive, Spindle Motors, Axes motors. Timing beltsand pulleys, Spindle bearing – Arrangement and installation, Slideways, Re - circulating ball screws

– Backlash measurement andcompensation, linear motion guide ways,Retrofitting of Conventional Machine Tools, Description of a simple CNC control system.Types of measuring systems in CNC machines.

Unit - IV : Design of Mechatronics System

Stages in designing Mechatronics Systems–Traditional and Mechatronic Design-Possible Design Solutions, Intelligent techniques in mechatronics – algorithmsman machine interface- case studies

Unit - V : Applied Mechatronics

Principle of working of automatic camera, engine management system, and automatic washing machine. Pick and Place robot, Mechatronics design in Automated car parking system, Automated Washing Machine System, Automated Traffic signal Method,. Case studies in: Mechatronics in Home appliances, Medical Devices, Defense, Automobiles and office automation, Industrial Automation, Future of Mechatronics.

Text Books

1. W. Bolton,"Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering"– 4thEdition.Pearson Education; 4 edition (2010)
2. Principles, Concepts and applications - Mechatronics –- Nitaigour and PremchandMahilik – Tata McGraw Hill – 2003

Reference Books

1. Devdas Shetty and Richard A. Kolk "Mechatronics System design"2nd Edition Cengage learning, (2012)
2. David G. Alciatore and Michael B.Histand, Introduction to Mechatronics and Measurement systems, 2nd edition Tata McGraw-Hill, 2003.

Department of Mechanical Engineering
Syllabus for Semester II, M. Tech (Robotics and Automation)

Course Code : MET599-5 **Course : Automobile Engineering**

L: 3 Hrs, T: 0 Hrs, P: 0 Hrs. Per week **Total Credits : 03**

Course Objective

To make the student conversant with fundamentals of automobile systems

Course Outcomes:

1. Recognize and illustrate the working of various power train and transmission components.
2. Identify and explain the working of different types of steering, suspension, and braking system in the automobile.
3. Express the need and functioning of Mechatronics, passenger safety devices and recent trends in automobiles.
4. Identify the cause of automotive pollution and demonstrate the various after treatment devices for pollution control.
5. Justify the need of e-mobility and appraise the basics of electric vehicles along with the policy, technology and business perspective.

Unit - I : Powertrain & Transmission Components : Engine types, Electronic Fuel Injection system, CRDI, Clutch, Gearbox, driveline components, Differential

Unit - II : Running Gear and Controls : Tyres its types and application, Suspension system, Independent suspensions, shock absorbers, steering mechanism, power Steering brakes, drum and disc brakes, hydraulic and pneumatic brakes.

Unit - III : Electricals, Auto-Mechatronics and Vehicle Safety : Starter Motor, Ignition system, Alternator, Active and Passive Safety, Airbags, Crumple Zone, Collision Avoidance, Adaptive Cruise Control, Intelligent Lighting etc

Unit - IV : Vehicle Emissions and Control Strategies : Causes and Methods to reduce vehicular pollution, after treatment devices, Catalytic Converter, EGR, SCR etc.

Unit - V : Introduction to Electric Vehicle : Need of EV and its types, EV configurations, factors affecting electric vehicle adoption. Policy, Business and Technology perspective of EV. Electric vehicle infrastructure, fast and slow charging.

Electric Car Technology: Battery for EVs- types, chemistry, suitability. Motors for EVs, Fuel Cells, Chargers, Converters.

Text Book/ Reference Book

1. Automobile Engineering Vol. 1 & Vol. 2 by Kirpal Singh, Standard Publishers.
2. Automobile Engineering by G.B.S. Narang, Khanna publisher
3. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, MehrdadEhsani, Yimin Gao, Stefano Longo, CRC Press.

Department of Mechanical Engineering
Syllabus for Semester II, M. Tech (Robotics and Automation)

Course Code : MEP767 | **Course : ROS and Robot Programming**

L: 0 Hrs, P: 4 Hrs. Per week | **Total Credits : 02**

Course Objective

To provide knowledge on ROS and robot programming languages.

Course Outcome: The students will be able to,

CO1: Describe the need of ROS and programming languages.

CO2: Summaries the commands used in ROS for robot programming

CO3: Demonstrate the applications of ROS and robot programming languages.

Introduction : Installation of Ubuntu and ROS, Linux Basics, Command line tools, Need for ROS, ROS architecture, ROS Workspace (catkin tools, catkin workspace), ROS Messages, ROS Topics, ROS Services, ROS Clients

ROS tools and utility : ROS Computation Graph, ROS Tools and Utilities - RQT Plots, Launch Files, ROS Nodes, ROS Master, Subscribers and Publishers (both in c++ and python), ROS Actions, ROS Bag files, ROS Package structure

Application of ROS : Experimentation with TurtleSim Package - Teleoperation Node, Go to Goal Behavior, Simple PID, Spiral/Square Path, Contour tracing(optional), Gazebo Simulator Basics - Understanding gazebo, different types of formats like URDF, SDF, xacro, building a world in Gazebo, Sensor Plugins and Simulations, Connecting ROS with Gazebo, building a robot in Gazebo, launching the robot in a custom world, Teleoperation of the robot with the help of ros-controls, Simulating a camera in Gazebo and receiving the image in ROS (cv-bridge)

Introduction to Robot Programming : Robot programming-Introduction-Types- Flex Pendant- Lead through programming, Coordinate systems of Robot, Robot controller- major components, functions-Wrist Mechanism- Interpolation-Interlock commands-Operating mode of robot, Jogging-Types, Robot specifications- Motion commands, end effectors and sensors commands.

VAL Language : Robot Languages-Classifications, Structures- VAL language commands motion control, hand control, program control, pick and place applications, palletizing applications using VAL, Robot welding application using VAL program-WAIT, SIGNAL and DELAY command for communications using simple applications. VAL-II programming-basic commands, applications-Simple problem using conditional statements-Simple pick and place applications-Production rate calculations using robot.

Text Books

1. Lentin Joseph, "Robot Operating Systems (ROS) for Absolute Beginners, Apress, 2018
2. Aaron Martinez, Enrique Fernández, "Learning ROS for Robotics Programming", Packt Publishing Ltd, 2013.
3. S. R.Deb, "Robotics technology and flexible automation", Tata McGraw Hill publishing company limited.
4. Mikell. P. Groover, "Industrial Robotics Technology", Programming and Applications, McGraw Hill Co.

Department of Mechanical Engineering

Syllabus for Semester II, M. Tech (Robotics and Automation)

Course Code : MEP768 **Course : Lab Practice - III**

L: 0 Hrs, T: 0 Hrs, P: 4 Hrs. Per week **Total Credits : 02**

Course Objectives

To impart the practical knowledge of motion planning and automation system used in industrial applications.

Course Outcomes

Students will be able to

CO1 : Plan the trajectory to perform specific task.

CO2 : Implement path planning algorithms for navigation of robot.

CO3 : Develop automation systems using PLC

Contents

Lab Practice-3 shall constitute of the practical related to trajectory planning, motion control and automation systems using PLC.

Department of Mechanical Engineering
Syllabus for Semester II, M. Tech (Robotics and Automation)

Course Code : MET769 **Course : Professional Practices and Ethics - II**

L: 2 Hrs, T: 0 Hrs, P: 0 Hrs. Per week **Total Credits : 00**

Course Objectives

The objectives of the course are to provide knowledge and understanding about the professional practices and acquaint them with the professional tools for effective working. The course also aims at developing ethical values expected in the field of business and research among the students.

Course Outcomes

At the end of this course students will demonstrate the ability to

1. Learn the professional practices and tools for better performance
2. Understand the ethical dimensions of the business, research etc
3. Realize the importance of corporate social responsibility and how they can contribute towards it in the capacity of an employee or an entrepreneur

Professional tools and soft skills related to business and research for improving productivity and performance. Introduction to safety and responsibility of safety.

Relevance and importance of following ethical approach in business and research.

Role of engineers in serving the society. Awareness about corporate social responsibility meaning, scope etc.

Case studies related to professional practices, ethics or corporate social responsibility.

Reference Book

Professional Ethics and Human Values by R. S. Naagarazan, New Age International Publishers

Department of Mechanical Engineering

Syllabus for Semester III, M. Tech (Robotics and Automation)

Course Code : MET851 **Course : Research Methodology**

L: 3 Hrs, P: 0 Hrs. Per week **Total Credits : 03**

Course Objective

At the end of the course the student will be able to:

1. Get an overview of the research methodology and become familiar with various steps in a scientific research.
2. Plan, execute the research work and present it.

Course Outcomes

At the end of the course the student will be able to:

CO1 : Understand the concept and process of Research and its Methodology.

CO2 : Formulating a research problem and frame the hypothesis.

CO3 : Demonstrate the details of sampling designs and different methods of data collections.

CO4 : Apply various tools and soft computing methods in research.

CO5 : Write research articles and understand various forms of the intellectual property.

Unit - I : Introduction

Meaning & Objectives of Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Importance of Knowing How Research is done, Research Process, Steps in research, Criteria of good Research.

Unit - II : Literature Review and Formulating a Research Problem

Significance of Literature Review, Procedure for reviewing the literature, Analysis of Literature Review – Primary and Secondary Sources, Web sources –critical Literature Review, Sources of a Research Problem, Selecting the Problem, Necessity of Defining the Problem, Techniques involved in defining a Problem.

Unit - III : Data Collection and Analysis

Sources of Data – Primary, Secondary and Tertiary – Types of Data – Categorical, nominal Collection of Primary Data, Various Methods of Data Collection, Data Analysis, Sampling methods – Need for Sampling, Sampling Distributions, Sample Size Determination Data Processing and Analysis strategies- Graphical representation Descriptive Analysis Inferential Analysis- Correlation analysis Least square method - Data Analysis using statistical package Hypothesis testing Generalization and Interpretation Modeling.

Unit - IV : Computing Tools and Techniques in Research

Introduction to spreadsheet application, features and functions, using formulae and functions, Data storing, Statistical data analysis, generating charts/ graph and other features, Use of statistical Analysis software. Introduction to soft computing techniques. Case study on the research problems related to Robotics and automation.Unit 5: Technical Writing and IPR:

Planning of Report Writing, Thesis writing, Formats of report writing, Types of research report: Dissertation and Thesis, research manuscript, review article, short communication, conference presentation etc., Referencing and referencing styles, Research Journals, Indexing and citation of Journals, Intellectual property, Plagiarism Unscientific practices in thesis work, Ethics in research.

Text Books

1. Research Methodology: Methods and Techniques, Kothari C.K. (2004), 2/e, New Age International, New Delhi.
2. Research Methodology: A Step by Step Guide for Beginners, 2nd ed.: Ranjit Kumar: Pearson

Reference Books

1. Design and Analysis of Experiments: Angela Dean and Daniel Voss, Springer-Verlag New York.
2. Theories of Engineering Experimentation, 1st ed.: H. Schenck Jr., Mc-Graw Hill.
3. Simulation Modeling and Analysis, 2nd ed.: Law, A. M, W. D. Kelton, 1991, McGraw Hill
4. Applied Statistics & Probability for Engineers: Montgomery, Douglas C. &Runger, George C. (2007), 3/e, (Wiley India)

Department of Mechanical Engineering

Syllabus for Semester III, M. Tech (Robotics and Automation)

Course Code : MET852-1 **Course : Embedded System Design**

L: 4 Hrs, T: 0 Hrs, P: 0 Hrs. Per week **Total Credits : 04**

Course Objective

This course will introduce the conceptual understanding of Embedded System and its components.

Course outcome

The students will able to

CO1 : Summarize the concept of embedded system, microcontroller, different components of microcontroller and their interactions.

CO2 : Understand the architecture and organization of 8085 microprocessor

CO3 : Explain the architecture and organization of microcontroller

CO4 : Construct the software and hardware component to interface the peripherals with microcontroller

CO5 : Design real world application using microcontroller and explain the concepts of Embedded Operating System

Unit - I : Introduction to Embedded Systems and microcomputers

Introduction to Embedded Systems, Embedded System Applications, Block diagram of embedded systems, Trends in Embedded Industry, Basic Embedded system Models, Embedded System development cycle, Challenges for Embedded system Design, Evolution of computing systems and applications. Basic Computer architecture: VonNeumann and Harvard Architecture, RISC and CISC architecture. Basics on Computer organizations. Computing performance, Throughput and Latency, Basic high performance CPU architectures, Microcomputer applications to Embedded systems and Mechatronics.

Unit - II : Microprocessor

8085 Microprocessor and its Internal Architecture, Pin Configuration and their functions, Mode of Operation, Introduction to I/O and Memory, Timing Diagrams, Introduction to Interrupts. Microprocessor Programming: Introduction to assembly language, Instruction format, Assembly language programming format, Addressing mode, Instruction Sets. Introduction to DMA.

Unit - III : Microcontroller

Introduction to Microcontroller and its families, Criteria for Choosing Microcontroller. Microcontroller Architecture, Programming model, Addressing modes, Instruction sets, programming for Microcontroller, I/O programming using C language, Interrupt Controller, I/O interfacing, Timers, Real Time Clock, Serial and parallel Communication protocols, SPI Controllers. LCD Controller41.

Unit - IV : Microcontroller Interfacing

Introduction to Microcontroller Interfacing and applications: case studies: Display Devices, controllers and Drivers for DC, Servo and Stepper Motor.

Unit - V : Introduction to Software

Embedded C, Embedded OS, Real Time Operating System (RTOS), Linux.

Text Book

1. Embedded Systems: Raj Kamal, TATA McGRAW Hill Publications
2. Microprocessor: Architecture, Programming & applications with 8085; Ramesh S. Gaonkar; Penramth International, 5 Edition.
3. Arduino Cookbook by Michael Margolis, O'Reilly Media, Inc., 1st edition
4. An embedded software primer: David E Simon, Pearson education Asia, 2000

Reference Book

1. Introduction to Embedded Systems: Shibu K V, McGRAW Hill Publications.
2. The 8051 Microcontroller and Embedded Systems Using Assembly and C; Muhammad Ali Mazidi, 2nd Edition, Pearson
3. The 8051 Microcontroller and Embedded Systems Using Assembly and C; Muhammad Ali Mazidi, 2nd Edition, Pearson
4. Beginning C for Arduino By Jack Purdum (ebook) Arduino for Beginners: Essential Skills Every
5. Maker Needs, John Baichtal, Pearson Education, Inc., 1st edition
6. Micro C/OS II The Real Time Kernel: Jean J. Labrosse, CMPBooks,(2/E) 2002
7. Embedded LinuxPrimer: christopherHallinan, Pearson (1/E) 2007

Department of Mechanical Engineering

Syllabus for Semester III, M. Tech (Robotics and Automation)

Course Code : MET852-2 **Course : Machine Vision**

L: 4 Hrs, T: 0 Hrs, P: 0 Hrs. Per week **Total Credits : 04**

Course Objective

To introduce students the fundamentals of image formation, the major ideas, methods, and techniques of computer vision and pattern recognition.

Course Outcome

The students will able

CO1 : To give an overview of the various image processing techniques used in machine vision

CO2 : To give knowledge on geometric transformation and its techniques

CO3 : To develop various image algorithms

CO4 : understand various techniques of Image Filtering and EDGE Detection

CO5 : Understand the techniques for Object Detection.

Unit - I : Image capture and digitization

Image transforms; digital Fourier transform, fast Fourier transform, other transforms, convolution, correlation; image enhancement; spatial methods, frequency domain methods; image restoration.

Unit - II : Geometric transformation

Image compression; error free and lossy compression; edge detection; hough transform, region based segmentation; image feature/region representation and descriptors; morphological operators.

Unit - III : Features based matching

Baye's classification; Low level vision: Introduction to stereopsis, shape from shading, optical flow; Rule based picture segmentation. Development and evaluation of image algorithms.

Unit - IV : Image Filtering and EDGE Detection

Histogram Modification, Linear Systems, Linear Filters, Median Filter, Gaussian Smoothing.

Gradient, Steps in Edge Detection, Roberts Operator, Sobel Operator, Prewitt Operator, Comparison, Second Derivative Operators, Laplacian of Gaussian, Image Approximation, Gaussian Edge Detection, Canny Edge Detector, Subpixel Location Estimation, Edge Detector Performance, Sequential Methods, Line Detection

Unit - V : Object Detection

System Components, Complexity of Object Recognition, Object Representation, Observer- Centered Representations, Object-Centered Representations, Feature Detection, Recognition Strategies, Verification.

Text Books / References

1. Milan Sanka, Vaclav Halavac, Roger Boyle "Image Processing, analysis and machine vision" Vikas Publishing.
2. Kenneth &Castleman "Digital Image Processing (PHI)
3. Conzalez RC & P Wint "Digital Image Processing" Addison Wesely
4. Chanda&Mazumdar " Digital Image Processing & Analysis" (PHI)
5. Anil K. Jain, "Digital Image Processing", Prentice Hall, 1989

Department of Mechanical Engineering

Syllabus for Semester III, M. Tech (Robotics and Automation)

Course Code : MET852-3 **Course : Industry 4.0**

L: 4 Hrs, T: 0 Hrs, P: 0 Hrs. Per week **Total Credits : 04**

Course Objectives

This course is designed to offer learners an introduction to Industry 4.0 (or the Industrial Internet), its applications in the business world. Learners will gain deep insights into how smartness is being harnessed from data and appreciate what needs to be done in order to overcome some of the challenges.

Course Outcomes

The students will able to

CO1 : Understand the drivers and enablers of Industry 4.0

CO2 : Appreciate the smartness in Smart Factories, Smart cities, smart products and smart services

CO3 : Able to outline the various systems used in a manufacturing plant and their role in an Industry 4.0 world

CO4 : Appreciate the power of Cloud Computing in a networked economy

CO5 : Understand the opportunities, challenges brought about by Industry 4.0 and how organizations and individuals should prepare to reap the benefits

Unit - I : Introduction to Industry 4.0

1.1 The Various Industrial Revolutions, 1.2 Digitalisation and the Networked Economy, 1.3 Drivers, Enablers, Compelling Forces and Challenges for Industry 4.0, 1.4 The Journey so far: Developments in USA, Europe, China and other countries, 1.5 Comparison of Industry 4.0 Factory and Today's Factory, 1.6 Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation

Unit - II : Road to Industry 4.0

2.1 Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services, 2.2 Smart Manufacturing, 2.3 Smart Devices and Products, 2.4 Smart Logistics, 2.5 Smart Cities, 2.6 Predictive Analytics

Unit - III : Related Disciplines, System, Technologies for enabling Industry 4.0

3.1 Cyber physical Systems, 3.2 Robotic Automation and Collaborative Robots, 3.3 Support System for Industry 4.0, 3.4 Mobile Computing, 3.5 Related Disciplines, 3.6 Cyber Security

Unit - IV : Role of data, information, knowledge and collaboration in future organizations

4.1 Resource-based view of a firm, 4.2 Data as a new resource for organizations, 4.3 Harnessing and sharing knowledge in organizations, 4.4 Cloud Computing Basics, 4.5 Cloud Computing and Industry 4.0

Unit - V : Other Applications and Case Studies

5.1 Industry 4.0 laboratories, 5.2 IIoT case studies, 5.3 Case studies from HKPolyU studentsBusiness issues in Industry 4.0: Opportunities and Challenges, Future of Works and Skills for Workers in the Industry 4.0 Era, Strategies for competing in an Industry 4.0 world.

Text books

1. Industry 4.0: The Industrial Internet of Things by Alasdair Gilchrist
2. The Fourth Industrial Revolution by Klaus Schwab
3. Sustainability in Manufacturing Enterprises: Concepts, Analyses and Assessments for Industry 4.0 by Ibrahim Garbie

Department of Mechanical Engineering
Syllabus for Semester III, M. Tech (Robotics and Automation)

Course Code : MET853-1 **Course : Automation in Supply Chain**

L: 4 Hrs, T: 0 Hrs, P: 0 Hrs. Per week **Total Credits : 04**

Course Objective

To provide an insight on the fundamentals of Automated supply chain networks, tools and techniques.

Course Outcome

The student would understand the framework and scope of Automatedsupply chain networks and functions.

Contains

Supply Chain Network Design, Role of Distribution in Supply Chain – Factors influencing Distribution network design – Design options for Distribution Network Distribution Network in Practice-Role of network Design in Supply Chain – Framework for network Decisions.

Logistics in Supply Chain, Role of transportation in supply chain – factors affecting transportations decision – Design option for transportation network – Tailored transportation – Routing and scheduling in transportation.

Supply Chain and Information Technology, The role IT in supply chain- The supply chain IT frame work Customer Relationship Management -Internal supply chain management – supplier relationship management – future of IT in supply chain -E-Business in supply chain.

Warehouse Automation India, Automated storage &Retrieval,Cloud-Based Supply Chain Mgmt, Warehouse Robotics, Automated Guided Vehicles, Autonomous Mobile Robots, Aerial Drones, Automated Storage and Retrieval Systems

Text Books

1. Sunil Chopra, Peter Meindl and Kalra, Supply Chain Management, Strategy, Planning, and operation, Pearson Education, 2010.
2. Warehouse Management: Automation and Organisation of Warehouse and Order Picking Systems, By Michael Hompel, Thorsten Schmidt · 2006, Springer

References Books

1. David J.Bloomberg, Stephen Lemay and Joe B.Hanna, Logistics, PHI 2002.
2. James B.Ayers, Handbook of Supply chain management, St.Lucle press, 2000.
3. Jeremy F.Shapiro, Modeling the supply chain, Thomson Duxbury, 2002.
4. Srinivasan G.S, Quantitative models in Operations and Supply Chain Management, PHI, 2010.

Department of Mechanical Engineering
Syllabus for Semester III, M. Tech (Robotics and Automation)

Course Code : MET853-2 **Course : MEMS and Microsystems**

L: 4 Hrs, T: 0 Hrs, P: 0 Hrs. Per week **Total Credits : 04**

Course Objective

To understand and explain MEMS Technology, micro sensors, micro- actuators, their types and applications.

Course Outcomes

Upon the completion of this course, students will demonstrate the ability to

1. Apply the principles behind the operation of MEMS devices
2. Choose a micromachining technique for a specific MEMS fabrication process
3. Design and fabricate MEMS devices or Microsystems
4. Understand recent advancements in the field of MEMS and devices.
5. Explore successful miniaturization of Mechanical Systems.

UNIT - I : Micro-fabrication and Micromachining

Scaling laws, Materials for microstructures, Clean room practices, Success Stories: Ink-Jet printer heads, LED Projector, Accelerometer, Lithography techniques

UNIT - II : Bulk Micromachining

Isotropic Etching and Anisotropic Etching, Wafer Bonding, High Aspect-Ratio Processes (LIGA), Design problems and case studies

UNIT - III : Surface Micromachining

Sacrificial layer processes, Surface micromachining requirements, Polysilicon surface micro-machining, Silicon Dioxide, Silicon Nitride, Piezoelectric materials, Surface Micro machined Systems: Success Stories, Micro motors, Gear trains, Mechanisms

UNIT - IV : Micro-sensors

Classification of physical sensors, Integrated, Smart sensors, Sensor Principles and Examples: Thermal sensors, Mechanical Sensors, Sensors for robotic applications

Micro-actuators : Electromagnetic and Thermal micro-actuation, Mechanical design of micro-actuators, Micro-actuator examples, micro-valves, micro-pumps, micro-motors-Micro-actuator systems

UNIT - V : Application Areas

All-mechanical miniature devices, 3-D actuators and sensors, Navigation solution for Robotics, Need for MEMS components in robotics, biomedical and defense applications.

Text Books

1. Micro and Smart Systems, Ananthasuresh, G. K., Vinoy, K. J. Gopala Krishnan, S., Bhat, K. N., Aatre, V. K., Wiley-India, New Delhi, 2010. 1st Edition
2. RF MEMS and Their Applications: Vijay. Varadan, K. J. Vinoy, K. A. Jose, Wiley, 2002, 1st Edition.

Reference Books

1. Microsensors, MEMS and Smart Devices, Julian W. Gardner, Vinay K. Varadan, Osama O. Awadel karim, Wiley, 2001, 1st Edition
2. MEMS : Introduction and Fundamentals Vol. 1, Mohamed Gad-el-Hak, CRC Press
3. MEMS : Design and Fabrication Vol. 2, Mohamed Gad-el-Hak, CRC Press
4. MEMS : Application Vol. 3, Mohamed Gad-el-Hak, CRC Press

Department of Mechanical Engineering
Syllabus for Semester III, M. Tech (Robotics and Automation)

Course Code : MET853-3 **Course : Wireless Sensor Networks for Robotics**

L: 4 Hrs, T: 0 Hrs, P: 0 Hrs. Per week **Total Credits : 04**

Course Objective

To know the basic knowledge about wireless sensor networks and its implementation.

Course Outcomes

At the end of this course students will demonstrate the ability to

1. Understand the WSN node architecture and network architect
2. Identify wireless sensor network platforms
3. Demonstrate knowledge of MAC routing protocols developed for WSN
4. To design and Develop wireless sensor node
5. Understand and explain mobile data-centric networking principles

UNIT - I

Overview : Introduction, Challenges for Wireless Sensor Networks, Enabling Technologies for Wireless Sensor Networks.

Architectures: Single-Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes, Operating Systems and Execution Environments, Network Architecture, Sensor Network Scenarios, Optimization Goals and Figures of Merit, Gateway Concepts.

UNIT - II

Networking : Physical Layer and Transceiver Design Considerations, MAC Protocols for Wireless Sensor Networks, Low Duty Cycle Protocols and Wakeup Concepts, S-MAC, The Mediation Device Protocol, Wakeup Radio Concepts, Address and Name Management, Assignment of MAC Addresses, Routing Protocols- Energy-Efficient Routing, Geographic Routing and Major Routing Protocols.

UNIT - III

Infrastructure Establishment : Topology Control, Clustering, Time Synchronization, Localization and Positioning, Sensor Tasking and Control.

UNIT - 4

Sensor Network Platforms And Tools : Sensor Node Hardware – Berkeley Motes, Deployment, Programming Challenges, Node-level software platforms, Embedded Operating System, Node level Simulators, State-centric programming.

Text Books

1. Holger Karl & Andreas Willig, “Protocols And Architectures for Wireless Sensor Networks", John Wiley2005.
2. Feng Zhao & Leonidas J. Guibas, “Wireless Sensor Networks- An Information Processing Approach”, TMH, 2004.

References Books

1. Elsevier B.W. Anderson, “The Analysis and Design of Pneumatic Systems”, Wiley, 1995.
2. KazemSohraby, Daniel Minoli, &TaiebZnati, “Wireless Sensor Networks-Technology, Protocols, And Applications”, John Wiley, 2007.
3. Anna Hac, “Wireless Sensor Network Designs”, John Wiley, 2003.
4. Feng Zhao and Leonidas Guibas, “Wireless Sensor Networks”, Morgan Kaufman Publishers, 2007.

Department of Mechanical Engineering
Syllabus for Semester III, M. Tech (Robotics and Automation)

Course Code : MEP854 **Course : Project Phase - I**

L: 0 Hrs, P: 3 Hrs. Per week **Total Credits : 06**

Course Objective

To inbuilt the skills in the areas like project management, concept development, planning, implementation, testing and validation while developing robotics and automation applications.

Course Outcomes

The students will able

1. To carry out exhaustive literature review to define the problem.
2. To understand the concept and scope of project work
3. To identify the appropriate Methodology to carry out the project work.

Students can select the appropriate problem in the field of robotics and automation.

Department of Mechanical Engineering
Syllabus for Semester III, M. Tech (Robotics and Automation)

Course Code : MEP855 **Course : Research Methodology (MOOC/Any online platform)**

L: 0 Hrs, P: 3 Hrs. Per week **Total Credits : 03**

Course Objective

At the end of the course the student will be able to:

1. Get an overview of the research methodology and become familiar with various steps in a scientific research.
2. Plan, execute the research work and present it.

Course Outcomes

At the end of the course the student will be able to:

1. Understand the concept and process of Research and its Methodology.
2. Formulating a research problem and frame the hypothesis.
3. Demonstrate the details of sampling designs and different methods of data collections.
4. Apply various tools and soft computing methods in research.
5. Write research articles and understand various forms of the intellectual property

Content

Content of the course should cover following points:

- Introduction to research methodology
- Literature Review and Formulating a Research Problem
- Data Collection and Analysis
- Computing Tools and Techniques in Research
- Technical Writing and IPR

Department of Mechanical Engineering
Syllabus for Semester III, M. Tech (Robotics and Automation)

Course Code : MEP856 **Course : Industry Internship - Phase-I or Research Internship-Phase - I or TBI Internship - Phase - I**

L: 0 Hrs, P: 0 Hrs. Per week

Total Credits : 06

Course Objective

To inbuilt the skills in the areas like project management, concept development, planning, implementation, testing and validation while developing robotics and automation applications.

Course Outcomes

The students will able

1. To carry out exhaustive literature review to define the problem.
2. To understand the concept and scope of project work
3. To identify the appropriate Methodology to carry out the project work.

Students opted Industry Internship-Phase-I or Research Internship-Phase-I or TBI Internship-Phase-I can select the appropriate problem in the field of robotics and automation.

Department of Mechanical Engineering
Syllabus for Semester IV, M. Tech (Robotics and Automation)

Course Code : MEP861 **Course : Project Phase - II or Industry Internship - Phase - II/**

L: 0 Hrs, P: 7 Hrs. Per week **Research Internship - Phase - II / TBI Internship-Phase-II**

Total Credits : 12

Course Objective

To inbuilt the skills in the areas like project management, concept development, planning, implementation, testing and validation while developing robotics and automation applications.

Course Outcomes

The students will able

1. To perform kinematics and dynamic analysis of defined problem and to select the suitable drives, actuator and sensors based on application.
2. To decide the appropriate control strategy to perform the task
3. To apply the tools like ANN, AI to make the system intelligent and autonomous along with to get the proficiency in mathematical and programming tools like MATLAB, ROS.

The M. Tech. Project is aimed to train the students to identify and analyze the research topic independently based on the subject knowledge gained in the previous semesters. The projects should include the problem in the field of robotics and automation applications. The project may be a purely analytical piece of work, a completely experimental or a combination of both. The students should validate the approach used in the project work through testing and experimentation. It is expected to submit the final project report which includes detailed literature review, objective, problem definition, methodology, experimentation, testing, result and conclusion.

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