SHRI VISHWAKARMA SKILL UNIVERSITY

(A State Govt Skill University Established by Govt. of Haryana)

Skill Department of Industry 4.0

(Skill Faculty of Engineering & Technology)

M. Tech Robotics & Automation

Batch 2024-25 onwards

- Advance Computer Concept for Automation(24PECE45)
- Virtual Instrumentation(24PECE46)
- Simulation, Modeling & Analysis(24PECE47)
- Process Control & Automation(24PECE48)
- Design of Mechanisms and Manipulators(24PECE49)
- Industrial Process Automation(24PECE50)
- Robotics for Industrial Automation(24PECE51)
- Embedded System Design(24PECE52)
- Artificial Intelligence in Automation(24PECE53)
- Data Driven Methods for Robotic Systems(24PECE54)
- Cyber Security in Industrial Automation(24PECE55)
- Wireless Sensor Networks(24PECE56)
- Model Based Development of Cyber - Physical Systems(24PECE57)
- Quadruped Robots(24PECE58)
- Optimization Theory(24PECE59)
- Probability and Statistics(24PECE60)
- Mathematical formulation of robotics(24PECE61)
- Nonlinear Dynamics(24PECE62)

List of Open Elective-I and Open Elective-II (Course code)

- Research Methodology (24PECE63)
- Fuzzy Sets and Artificial Neural Network(24PECE64)
- Entrepreneurship Development(24PECE65)
- Professional Ethics(24PECE66)
- Nonlinear Optimization(24PECE67)
- Vehicle Dynamics and Multi-body Systems(24PECE68)
- Application of FPGA in process control(24PECE69)
- Biological computing(24PECE70)
- Entrepreneurship(24PECE71)
- Organization Development(24PECE72)
- Energy, Environment and Society(24PECE73)
- Intellectual Property Rights(24PECE74)
- Disaster Management(24PECE75)
- Non-Conventional Power Generation(24PECE76)
- Industrial Electronics(24PECE77)
- Fundamentals of Engineering Materials(24PECE78)
- Introduction to Robotics and Material Handling(24PECE79)
- Energy Management and Conservation(24PECE80)
- Business Analytics(24PECE90)
- Analog and Digital I.C. Applications (24PECE91)
- Operations Research(24PECE92)
- Cost Management(24PECE93)
- Error control coding(24PECE94)

Proposed Scheme for Master of Technology (Robotics and Automation)

Semester I

Course Name	Course Code	L	T	P	Credits
MEMS/NEMS Technology for SMART Robotics System	24PECE01	3	1	0	4
Computer Vision and Image Processing	24PECE02	4	0	0	4
FPGA based System Design	24PECE03	3	0	2	4
Humanoid Robotics	24PECE04	4	0	0	4
Industrial Internet of Things	24PECE05	3	0	2	4
Total		17	1	04	20

Semester II

Course Name	Course Code	L	T	P	Credits
Real Time Embedded Systems for Robotics	24PECE06	3	0	2	4
Program Elective-I	24PECEXX	4	0	0	4
Open Elective-I	24PECEXX	4	0	0	4
Program Elective-II	24PECEXX	4	0	0	4
Open Elective-II	24PECEXX	4	0	0	4
Total		19	0	02	20

Semester III

Course Name	Course Code	L	T	P	Credits
Research and Publication Ethics (online Mode)	2-P---XX	2	0	0	2
Seminar-I	24PECE07	-	-	4	2
Dissertation stage-I	24PECE08	-	-	32	16
Total		2	0	36	20

Semester IV

Course Name	Course Code	L	T	P	Credits
Dissertation stage-II	24PECE09	-	-	40	20
Total		-	-	40	20

Note: Depending upon the expertise of the faculty and industry needs, the lab experiments for the respective subjects may not be included in the syllabus and be covered during the class.

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- Unmanned Aerial Vehicles(24PECE95)
- Advanced Power Electronics and Control(24PECE96)
- Artificial Intelligence and Machine Learning (24PECE97)

Depending upon the choice of the students and expertise of the faculty, courses as per the recent trends can be included in the scheme. No defined course content/syllabus is needed for such type of courses.

Green : R&D Product Interviews
Yellow: Robotics Applications Dev Interviews

Syllabus of various subjects (core subjects) and also the list of Program Elective-I, Program Elective-II and Open Elective-I and Open Elective-II M.Tech (RBA) Program

1. **Program Elective-I and Program Elective-II (Course code)**
   - Introduction to Modern Algorithm Design (24PECE10)
   - Advanced AI for Robotics(24PECE11)
   - Control System (24PECE12)
   - Robotics Based Industrial Automation (24PECE13)
   - Computer Aided Modeling and Design (24PECE14)
   - Introduction to Wireless Networks(24PECE15)
   - Digital System Design(24PECE16)
   - Digital Control System(24PECE17)
   - Medical Robotics(24PECE18)
   - Mechatronics Systems and Applications(24PECE19)
   - Machine tool control and condition monitoring(24PECE20)
   - Fluid Power System and Factory Automation(24PECE21)
   - Reliability Engineering(24PECE22)
   - Precision Engineering(24PECE23)
   - Power Electronics & Drives(24PECE24)
   - Fault Detection and Diagnosis(24PECE25)
   - Energy Auditing and Management(24PECE26)
   - Nano Technology(24PECE27)
   - Advanced Electrical and Electronics(24PECE28)
   - Embedded Sensors and System Design(24PECE29)
   - Computer Integrated Manufacturing(24PECE30)
   - Soft Computing(24PECE31)
   - Advanced Process Control(24PECE32)
   - Advanced Manufacturing Systems(24PECE33)
   - Robot Programming(24PECE34)
   - Modern Control Theory(24PECE35)
   - Mobile Robots(24PECE36)
   - Machine Dynamics and Control(24PECE37)
   - Applications of FPGA in process control(24PECE38)
   - Mechatronics Systems and Applications(24PECE39)
   - Digital Signal Processing (24PECE40)
   - Hydraulics and Pneumatics (24PECE41)
   - Optimization Techniques (24PECE42)
   - Kinematics, Dynamic Systems and Control(24PECE43)
   - Fundamentals of Robotics(24PECE44)

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Course Title	MEMS/NEMS Technology for SMART Robotics System	Course No *(will be assigned)*	24PECE01			
Course Offering Department	Department of Industry 4.0	Structure (LTPC)	3	2	0	4
Offered for	PG	Status	Core ✔		Elective	
Faculty		Type	New ✔		Modification	
Pre-requisite		To take effect from				
Submission date		Date of approval by Senate				
Objectives	This aim of this course is to demonstrate the integration of sensors and actuators using MEMS/NEMS technology to enhance the Robots performance.					
Course Outcomes	Upon successful completion of this course, students will be able to: CO1: To understand the basic concepts of device technology for MEMS applications. CO2: To understand and apply the standard/advanced device integration methods for MEMS devices process sequence optimization. CO3: To apply the fundamental knowledge of sensors and actuator for Robotic application specific device designing and enhance the employability. CO4: To apply and analyze the advance concepts of MEMS/NEMS technology for smart applications. CO5: To apply and analyze the design and fabrication key considerations for MEMS/NEMS technology for enhance the employability/entrepreneurship opportunities.					
Contents of the course	**UNIT- I: Fundamental of MEMS technology for robotic applications** Introduction to MEMS principles and its importance for smart transducer systems, Application of MEMS sensors and actuators for Robotic systems. **UNIT- II: MEMS Integration Processes/Challenges and opportunities** Microsystem fabrication processes: Selection of substrate materials, Oxidation, Thin film depositions: LPCVD, Sputtering, Evaporation, Electroplating, Materials/thin film property modification using standard technologies (Ion Implantation, Diffusion)/ any advance methodology(Polymers Nano composites etc.), Etching techniques: Dry and wet etching, electrochemical etching; Micromachining: Bulk Micromachining, Surface Micromachining, High Aspect-Ratio (LIGA and LIGA-like) Technology; Packaging: Microsystems packaging, Essential packaging technologies, Selection of packaging materials. **UNIT-III: MEMS design parameter consideration for different Robotics applications** MEMS Sensors: Design of Acoustic wave sensors, resonant sensor, Vibratory gyroscope, Capacitive and Piezo Resistive Pressure sensors- engineering mechanics behind these Micro sensors. MICRO Actuators: Design of Actuators, Actuation using thermal forces, Actuation using shape memory Alloys, Actuation using piezoelectric crystals, Actuation using Electrostatic forces (Parallel plate, Torsion bar, Comb drive actuators), Micromechanical Motors and pumps. **UNIT IV: NEMS Technology for advanced applications** Atomic Structures and Quantum Mechanics, Molecular and Nanostructure Dynamics: Shrodinger Equation and Wavefunction Theory, Density Functional Theory, Nanostructures and Molecular Dynamics, Electromagnetic Fields and their quantization, Molecular Wires and Molecular Circuits. **UNIT –V: Case Study** Case Study –I(MEMS Sensor), Case Study –II(MICRO Actuator).					

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- Operations Research(24PECE92)
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- Error control coding(24PECE94)

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Textbook	1. Chang Liu, "Foundations of MEMS", Pearson education India limited, 2006. 2. Modeling MEMS and NEMS by John A. Pelesko and David H. Bernstein, Chapman & Hall/CRS, 2003. 3. "Microsystem Design" by Stephen D. Senturia, Kluwer Academic Publishers, 2001.
References	1. Introductory MEMS: Fabrication and Applications by Thomas M. Adams and Richard A. Layton, Springer, 2010. 2. NPTEL online resources- https://nptel.ac.in/courses/117105082 3. NPTEL online resources- https://nptel.ac.in/courses/108106165

- Unmanned Aerial Vehicles(24PECE95)
- Advanced Power Electronics and Control(24PECE96)
- Artificial Intelligence and Machine Learning (24PECE97)

Depending upon the choice of the students and expertise of the faculty, courses as per the recent trends can be included in the scheme. No defined course content/syllabus is needed for such type of courses.

Green : R&D Product Interviews
Yellow: Robotics Applications Dev Interviews

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Course Title	Computer Vision and Image Processing	Course No *(will be assigned)*	24PECE02			
Course Offering Department	Department of Industry 4.O	Structure (LTPC)	4	0	0	4
Offered for	PG	Status	Core ✔		Elective	
Faculty		Type	New ✔		Modification	
Pre-requisite		To take effect from				
Submission date		Date of approval by Senate				
Objectives	This course introduces the basics of computer vison and the formation of Digital images, image formation in stereo vision and camera models, transform the images and extraction of the features, machine learning techniques for computer vision to the postgraduate students.					
Course Outcomes	Upon successful completion of this course, students will be able to: CO1: To understand the basics of computer vision and image formation model CO2: To understand the techniques for camera calibration and image formation in stereo vision CO3: To apply the techniques for image transformation and features extraction. CO4: To understand the machine learning techniques to classify the patterns in a digital image. CO5: To apply and analyze the design techniques for motion and appearance from the digital images for various applications in computer vision.					
Contents of the course	**UNIT- I: Introduction to computer vision and image formation** Introduction to Computer vision, The human eye-brain system as a model for computer vision, Re-projection, Reconstruction, Registration, Recognition, Fundamentals of Image Formation, Digital Image Properties and Types, Colour Models Memory and File Storage of Images, Image Histograms, Brightness/Contrast adjustment. **UNIT- II: Image Formation in stereo vision and Camera calibration** Binocular Stereopsis: Camera, Binocular Stereopsis: Epipolar Geometry, monocular and stereo vision, projective geometry, Camera models, Camera Calibration, Pin-hole camera model, Handling Distortion in Camera Calibration, 3-D reconstruction framework; Auto calibration **UNIT-III: Image transformation** Introduction of operating systems, Fourier Transform, Affline transformations, Homography, Convolution and Filtering, Gabor Filters and DWT, Region Growing, Edge Based approaches to segmentation, Texture Segmentation; Object detection. **UNIT IV: Machine learning** Clustering: K-Means, K-Medioids, Mixture of Gaussians, Classification: Discriminant Function, Supervised, Un-supervised, Semi supervised, Classifiers: Bayes, KNN, ANN models, Using Genetic Algorithm: Map Coloring. **UNIT –V: Motion and Appearance Analysis** Optical Flow, Dynamic Stereo, Motion parameter estimation, Light at Surfaces, Phong Illumination Model, Reflectance Map, Appearance Models; Shape from Shading, Appearance from Texture, color, motion and edges.					

Course Title	MEMS/NEMS Technology for SMART Robotics System	Course No *(will be assigned)*	24PECE01			
Course Offering Department	Department of Industry 4.0	Structure (LTPC)	3	2	0	4
Offered for	PG	Status	Core ✔		Elective	
Faculty		Type	New ✔		Modification	
Pre-requisite		To take effect from				
Submission date		Date of approval by Senate				
Objectives	This aim of this course is to demonstrate the integration of sensors and actuators using MEMS/NEMS technology to enhance the Robots performance.					
Course Outcomes	Upon successful completion of this course, students will be able to: CO1: To understand the basic concepts of device technology for MEMS applications. CO2: To understand and apply the standard/advanced device integration methods for MEMS devices process sequence optimization. CO3: To apply the fundamental knowledge of sensors and actuator for Robotic application specific device designing and enhance the employability. CO4: To apply and analyze the advance concepts of MEMS/NEMS technology for smart applications. CO5: To apply and analyze the design and fabrication key considerations for MEMS/NEMS technology for enhance the employability/entrepreneurship opportunities.					
Contents of the course	**UNIT- I: Fundamental of MEMS technology for robotic applications** Introduction to MEMS principles and its importance for smart transducer systems, Application of MEMS sensors and actuators for Robotic systems. **UNIT- II: MEMS Integration Processes/Challenges and opportunities** Microsystem fabrication processes: Selection of substrate materials, Oxidation, Thin film depositions: LPCVD, Sputtering, Evaporation, Electroplating, Materials/thin film property modification using standard technologies (Ion Implantation, Diffusion)/ any advance methodology(Polymers Nano composites etc.), Etching techniques: Dry and wet etching, electrochemical etching; Micromachining: Bulk Micromachining, Surface Micromachining, High Aspect-Ratio (LIGA and LIGA-like) Technology; Packaging: Microsystems packaging, Essential packaging technologies, Selection of packaging materials. **UNIT-III: MEMS design parameter consideration for different Robotics applications** MEMS Sensors: Design of Acoustic wave sensors, resonant sensor, .Vibratory gyroscope, Capacitive and Piezo Resistive Pressure sensors- engineering mechanics behind these Micro sensors. MICRO Actuators: Design of Actuators, Actuation using thermal forces, Actuation using shape memory Alloys, Actuation using piezoelectric crystals, Actuation using Electrostatic forces (Parallel plate, Torsion bar, Comb drive actuators), Micromechanical Motors and pumps. **UNIT IV: NEMS Technology for advanced applications** Atomic Structures and Quantum Mechanics, Molecular and Nanostructure Dynamics: Shrodinger Equation and Wavefunction Theory, Density Functional Theory, Nanostructures and Molecular Dynamics, Electromagnetic Fields and their quantization, Molecular Wires and Molecular Circuits. **UNIT –V: Case Study** Case Study –I(MEMS Sensor), Case Study –II(MICRO Actuator).					

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Textbook	1. R.C. Gonzalez and R.E. Woods, Digital Image Processing, Pearson Education; Fourth edition (30 July 2018) 2. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London Limited 2011. 3. Computer Vision: A Modern Approach, D. A. Forsyth, J. Ponce, Pearson Education, Second Edition 2012 Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, Second Edition, Cambridge University Press, March 2004.
References	1. IEEE-T-PAMI (IEEE Transactions on Pattern Analysis and Machine Intelligence). 2. IJCV (International Journal of Computer Vision) - Springer. 3. CS6350: Computer Vision, IIT M

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Course Title	FPGA based System Design	Course No *(will be assigned)*	24PECE03			
Course Offering Department	Department of Industry 4.O	Structure (LTPC)	3	0	2	4
Offered for	PG	Status	Core ✔		Elective	
Faculty		Type	New ✔		Modification	
Pre-requisite		To take effect from				
Submission date		Date of approval by Senate				
Objectives	This course introduces the understanding of Digital system design using HDL, FPGA architecture, interconnect and technologies, different FPGA's and implementation methodologies and configuring and implementing digital embedded system, microcontrollers, microprocessors, DSP algorithm on FPGA.					
Course Outcomes	After learning the course, the students should be able to: CO1: To understand the model combinational and sequential digital circuits using Verilog HDL CO2: To understand the FPGA architectural and technology. CO3: To apply the concept of designing as well as modelling of digital circuits with Verilog HDL at behavioral, structural, and RTL Levels CO4: To apply the concept of hardware designing as well as test benches for simulation after designing of combinational and sequential circuits. CO5: To apply and analyze the Design and development of a system Design using FPGA for enhance the employability/entrepreneurship opportunities for robotics applications.					
Contents of the course	**UNIT I: Verilog HDL Coding Style:** Lexical Conventions - Ports and Modules – Operators – Gate Level Modeling - System Tasks &Compiler Directives - Test Bench - Data Flow Modeling - Behavioral level Modeling -Tasks & Functions. **UNIT II: Overview of FPGA Architectures and Technologies:** FPGA Architectural options, coarse vs fine grained, vendor specific issues (emphasis on Xilinx FPGA), Antifuse, SRAM and EPROM based FPGAs, FPGA logic cells, interconnection network and I/O Pad. **UNIT III: Verilog Modelling of Combinational and Sequential Circuits:** Behavioral, Data Flow and Structural Realization – Adders – Multipliers-Comparators - Flip Flops - Realization of Shift Register - Realization of a Counter-Synchronous and Asynchronous FIFO –Single port and Dual port RAM –Pseudo Random LFSR – Cyclic Redundancy Check. **UNIT IV: Synchronous Sequential Circuit:** State diagram-state table –state assignment-choice of flip-flops – Timing diagram –One hot encoding Mealy and Moore state machines – Design of serial adder using Mealy and Moore state machines - State minimization – Sequence detection-Design examples: Sequence detector, Serial adder, vending machine using One Hot Controller. **UNIT V: Case study: System Design Examples using Xillinx FPGAs** Traffic light Controller, Real Time Clock -Interfacing using FPGA: VGA, Keyboard, LCD, Embedded Processor Hardware Design.					

Course Title	Computer Vision and Image Processing	Course No *(will be assigned)*	24PECE02			
Course Offering Department	Department of Industry 4.O	Structure (LTPC)	4	0	0	4
Offered for	PG	Status	Core ✔		Elective	
Faculty		Type	New ✔		Modification	
Pre-requisite		To take effect from				
Submission date		Date of approval by Senate				
Objectives	This course introduces the basics of computer vison and the formation of Digital images, image formation in stereo vision and camera models, transform the images and extraction of the features, machine learning techniques for computer vision to the postgraduate students.					
Course Outcomes	Upon successful completion of this course, students will be able to: CO1: To understand the basics of computer vision and image formation model CO2: To understand the techniques for camera calibration and image formation in stereo vision CO3: To apply the techniques for image transformation and features extraction. CO4: To understand the machine learning techniques to classify the patterns in a digital image. CO5: To apply and analyze the design techniques for motion and appearance from the digital images for various applications in computer vision.					
Contents of the course	**UNIT- I: Introduction to computer vision and image formation** Introduction to Computer vision, The human eye-brain system as a model for computer vision, Re-projection, Reconstruction, Registration, Recognition, Fundamentals of Image Formation, Digital Image Properties and Types, Colour Models Memory and File Storage of Images, Image Histograms, Brightness/Contrast adjustment. **UNIT- II: Image Formation in stereo vision and Camera calibration** Binocular Stereopsis: Camera, Binocular Stereopsis: Epipolar Geometry, monocular and stereo vision, projective geometry, Camera models, Camera Calibration, Pin-hole camera model, Handling Distortion in Camera Calibration, 3-D reconstruction framework; Auto calibration **UNIT-III: Image transformation** Introduction of operating systems, Fourier Transform, Affline transformations, Homography, Convolution and Filtering, Gabor Filters and DWT, Region Growing, Edge Based approaches to segmentation, Texture Segmentation; Object detection. **UNIT IV: Machine learning** Clustering: K-Means, K-Medioids, Mixture of Gaussians, Classification: Discriminant Function, Supervised, Un-supervised, Semi supervised, Classifiers: Bayes, KNN, ANN models, Using Genetic Algorithm: Map Coloring. **UNIT –V: Motion and Appearance Analysis** Optical Flow, Dynamic Stereo, Motion parameter estimation, Light at Surfaces, Phong Illumination Model, Reflectance Map, Appearance Models; Shape from Shading, Appearance from Texture, color, motion and edges.					

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Textbook	1. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis" Prentice Hall, Second Edition, 2003. 2. Wayne Wolf, "FPGA Based System Design", Prentices Hall Modern Semiconductor Design Series.
References	1. Peter Ashenden, "Digital Design using VHDL", Elsevier, 2007. 2. Peter Ashenden, "Digital Design using Verilog", Elsevier, 2007. 4. W. Wolf, "FPGA based system design", Pearson, 2004. 3. Stephen Brown &ZvonkoVranesic, "Digital Logic Design with Verilog HDL" TATA McGraw Hill Ltd. 2nd Edition 2007.

Textbook	1. R.C. Gonzalez and R.E. Woods, Digital Image Processing, Pearson Education; Fourth edition (30 July 2018) 2. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London Limited 2011. 3. Computer Vision: A Modern Approach, D. A. Forsyth, J. Ponce, Pearson Education, Second Edition 2012 Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, Second Edition, Cambridge University Press, March 2004.
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<table>
<tr><td>Course Title</td><td>Humanoid Robotics</td><td>Course No
(will be assigned)</td><td colspan="4">24PECE04</td></tr>
<tr><td>Specialization</td><td>Department of Industry 4.O</td><td>Structure (LTPC)</td><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td>Offered for</td><td>PG</td><td>Status</td><td colspan="2">Core ✔</td><td colspan="2">Elective</td></tr>
<tr><td>Faculty</td><td></td><td>Type</td><td colspan="2">New ✔</td><td colspan="2">Modification</td></tr>
<tr><td>Pre-requisite</td><td></td><td>To take effect from</td><td colspan="4"></td></tr>
<tr><td>Submission date</td><td></td><td>Date of approval by Senate</td><td colspan="4"></td></tr>
<tr><td>Objectives</td><td colspan="6">On successful completion of this course, the student will be able to describe about the evolution of Humanoid robots, expose the basic knowledge in kinematics of humanoids, calculate the Humanoid Robot Motion and Ground Reaction Force, identify Two-Dimensional Walking pattern on different terrain, Create the Walking Pattern models</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">Upon successful completion of this course, students will be able to:
CO1: To understand the basic knowledge about Humanoid robots.
CO2: To apply the knowledge related to kinematics of humanoids.
CO3: To learn about the dynamics in humanoid robots.
CO4: To understand the basic in biped walking.
CO5: To apply and analyze the different walking patterns for the enhancement of employability/entrepreneurship opportunities for robotics applications.</td></tr>
<tr><td>Contents of the course</td><td colspan="6">UNIT- I: INTRODUCTION
Historical development of Humanoids, Human Likeness of a Humanoid Robot, Trade-Offs in Humanoid Robot Design, Human-Friendly Humanoid Robot Design, characteristics of humanoid robots.
UNIT- II: KINEMATICS
Kinematic structure, forward and inverse kinematic problems, differential kinematics, Twist, Spatial Velocity, and Spatial Transform, Inverse Differential Kinematic Relations. Differential kinematics at singular configurations- Gait Analysis.
UNIT-III: ZMP AND DYNAMICS
ZMP Overview, 2D Analysis, 3D Analysis, Measurement of ZMP, General Discussion- ZMP of Each Foot, ZMP for Both Feet Contact, Dynamics of Humanoid Robots, Humanoid Robot Motion and Ground Reaction Force, Momentum, Angular Momentum, Angular Momentum and Inertia Tensor of Rigid Body, Calculation of Robot's Center of Mass, Link Speed and Angular Velocity, Calculation of Robot's Momentum and Angular Momentum.
UNIT IV: BIPED WALKING
Two Dimensional Walking Pattern Generation, Two Dimensional Inverted Pendulum, Behavior of Linear Inverted Pendulum, Orbital Energy, Support Leg Exchange, Planning a Simple Biped Gait, Extension to a Walk on Uneven Terrain.
UNIT –V: CASE STUDY: WALKING PATTERN GENERATION
ZMP Based Walking Pattern Generation, Cart-Table Model, Off-Line Walking Pattern Generation, Stabilizer, Principles of Stabilizing Control, Stabilizing Control of Honda Humanoid Robot, Advanced Stabilizers.</td></tr>
</table>

Course Title	FPGA based System Design	Course No *(will be assigned)*	24PECE03			
Course Offering Department	Department of Industry 4.O	Structure (LTPC)	3	0	2	4
Offered for	PG	Status	Core ✔		Elective	
Faculty		Type	New ✔		Modification	
Pre-requisite		To take effect from				
Submission date		Date of approval by Senate				

Objectives	This course introduces the understanding of Digital system design using HDL, FPGA architecture, interconnect and technologies, different FPGA's and implementation methodologies and configuring and implementing digital embedded system, microcontrollers, microprocessors, DSP algorithm on FPGA.
Course Outcomes	After learning the course, the students should be able to: CO1: To understand the model combinational and sequential digital circuits using Verilog HDL CO2: To understand the FPGA architectural and technology. CO3: To apply the concept of designing as well as modelling of digital circuits with Verilog HDL at behavioral, structural, and RTL Levels CO4: To apply the concept of hardware designing as well as test benches for simulation after designing of combinational and sequential circuits. CO5: To apply and analyze the Design and development of a system Design using FPGA for enhance the employability/entrepreneurship opportunities for robotics applications.
Contents of the course	**UNIT I: Verilog HDL Coding Style:** Lexical Conventions - Ports and Modules – Operators – Gate Level Modeling - System Tasks &Compiler Directives - Test Bench - Data Flow Modeling - Behavioral level Modeling -Tasks & Functions. **UNIT II: Overview of FPGA Architectures and Technologies:** FPGA Architectural options, coarse vs fine grained, vendor specific issues (emphasis on Xilinx FPGA), Antifuse, SRAM and EPROM based FPGAs, FPGA logic cells, interconnection network and I/O Pad. **UNIT III: Verilog Modelling of Combinational and Sequential Circuits:** Behavioral, Data Flow and Structural Realization – Adders – Multipliers-Comparators - Flip Flops - Realization of Shift Register - Realization of a Counter-Synchronous and Asynchronous FIFO –Single port and Dual port RAM –Pseudo Random LFSR – Cyclic Redundancy Check. **UNIT IV: Synchronous Sequential Circuit:** State diagram-state table –state assignment-choice of flip-flops – Timing diagram –One hot encoding Mealy and Moore state machines – Design of serial adder using Mealy and Moore state machines - State minimization – Sequence detection-Design examples: Sequence detector, Serial adder, vending machine using One Hot Controller. **UNIT V: Case study: System Design Examples using Xillinx FPGAs** Traffic light Controller, Real Time Clock -Interfacing using FPGA: VGA, Keyboard, LCD, Embedded Processor Hardware Design.

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Textbook	1. Dragomir N. Nenchev, Atsushi Konno, "Humanoid Robots Modeling and Control", Butterworth Heinemann, 2019 2. Shuuji K, Hirohisa H, Kensuke H, Kazuhito, Springer-Verlag GmbH "Introduction to Humanoid Robotics", Springer, London, 2014. 3. Goswami Ambarish, Vadakkepat Prahlad, "Humanoid Robotics: A Reference", Springer, 2019.
References	1. J. Craig, "Introduction to Robotics: Mechanics and Control", Fourth Edition, Pearson, 2022 2. J K. Harada, E. Yoshida, K. Yokoi (Eds.), "Motion Planning for Humanoid Robots",Springer, London, 2010. 3. Lorenzo Sciavicco and Bruno Siciliano, "Modelling and Control of Robot Manipulators", second edition, Springer, 2000. 4. Jean-Claude Latombe, "Robot Motion Planning", Kluwer Academy Publishers, 2004.

Textbook	1. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis" Prentice Hall, Second Edition, 2003. 2. Wayne Wolf, "FPGA Based System Design", Prentices Hall Modern Semiconductor Design Series.
References	1. Peter Ashenden, "Digital Design using VHDL", Elsevier, 2007. 2. Peter Ashenden, "Digital Design using Verilog", Elsevier, 2007. 4. W. Wolf, "FPGA based system design", Pearson, 2004. 3. Stephen Brown &ZvonkoVranesic, "Digital Logic Design with Verilog HDL" TATA McGraw Hill Ltd. 2nd Edition 2007.

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Course Title	Industrial Internet of Things	Course No *(will be assigned)*	24PECE05				
Specialization	Department of Industry 4.O	Structure (LTPC)	4	0	0	4	
Offered for	PG	Status	Core ✔		Elective		
Faculty		Type	New ✔		Modification		
Pre-requisite		To take effect from					
Submission date		Date of approval by Senate					

Objectives	This course introduces : IoT technologies, architectures, standards, and regulations, data flow, hardware components and software used in implementation of IIoT technology, collecting, communicating, coordinating, and leveraging the data from connected devices, system maintenance and fault diagnosis techniques in IIoT technology, to the postgraduate students.
Course Outcomes	Upon successful completion of this course, students will be able to: CO1: To understand the IoT technologies, architectures, standards, and regulations CO2: To apply the concepts of data flow, hardware components and software used in implementation of IIoT technology CO3: To apply the value created by collecting, communicating, coordinating, and leveraging the data from connected devices. CO4: To understand system maintenance and fault diagnosis techniques in IIoT technology. CO5: To apply and analyze Design and implement developed IIoT technological solutions to different applications and Adapt technological developments that will help the students to know the current & future trends.
Contents of the course	**UNIT- I: Overview** Overview of IoT and Industry 4.0, Introduction to Industrial IoT, Key difference between IoT and IIoT, IIoT Analytics & AI, IoT architecture and layers, Challenges in IIOT, Industrial manufacturing, Predictive maintenance, Types of industrial processes, CIM Pyramid architecture, RTUs SCADA & PLC functional overview, Overview of the ERP System, Cyber Physical systems (CPS), IOT data flow in cloud, Industrial data flow in cloud. **UNIT- II: Industrial IoT data flow** Industrial data flow architecture, OPC classic, OPC UA information model, Data exchange and security model, Edge gateway, Edge architecture, IoT edge vs IIoT edge, Edge tools and computing, Edge gateway, Edge Internet protocols, Industrial networking, Communication protocols, IEEE Network standards, Field bus architecture, Edge on field bus setup, Merits and demerits, IIoT data sources, IIoT data collection. **UNIT-III: Implementation framework** Overview of cloud server solutions, AZURE, Google cloud and AWS, Types of client server architecture, Registering on IoT core & client, Installation prerequisites, configuration practices, Configuring authentication, Configuring security, Communication channel, Modes of communication, Server to client data transfer, Deployment of application, First Data collection, Dataset creation techniques, Dataset processing techniques, Data presentation tools and Data analytics tools.

Course Title	Humanoid Robotics	Course No *(will be assigned)*	24PECE04				
Specialization	Department of Industry 4.O	Structure (LTPC)	4	0	0	4	
Offered for	PG	Status	Core ✔		Elective		
Faculty		Type	New ✔		Modification		
Pre-requisite		To take effect from					
Submission date		Date of approval by Senate					
Objectives	On successful completion of this course, the student will be able to describe about the evolution of Humanoid robots, expose the basic knowledge in kinematics of humanoids, calculate the Humanoid Robot Motion and Ground Reaction Force, identify Two-Dimensional Walking pattern on different terrain, Create the Walking Pattern models						
Course Outcomes	Upon successful completion of this course, students will be able to: CO1: To understand the basic knowledge about Humanoid robots. CO2: To apply the knowledge related to kinematics of humanoids. CO3: To learn about the dynamics in humanoid robots. CO4: To understand the basic in biped walking. CO5: To apply and analyze the different walking patterns for the enhancement of employability/entrepreneurship opportunities for robotics applications.						
Contents of the course	**UNIT- I: INTRODUCTION** Historical development of Humanoids, Human Likeness of a Humanoid Robot, Trade-Offs in Humanoid Robot Design, Human-Friendly Humanoid Robot Design, characteristics of humanoid robots. **UNIT- II: KINEMATICS** Kinematic structure, forward and inverse kinematic problems, differential kinematics, Twist, Spatial Velocity, and Spatial Transform, Inverse Differential Kinematic Relations. Differential kinematics at singular configurations- Gait Analysis. **UNIT-III: ZMP AND DYNAMICS** ZMP Overview, 2D Analysis, 3D Analysis, Measurement of ZMP, General Discussion- ZMP of Each Foot, ZMP for Both Feet Contact, Dynamics of Humanoid Robots, Humanoid Robot Motion and Ground Reaction Force, Momentum, Angular Momentum, Angular Momentum and Inertia Tensor of Rigid Body, Calculation of Robot's Center of Mass, Link Speed and Angular Velocity, Calculation of Robot's Momentum and Angular Momentum. **UNIT IV: BIPED WALKING** Two Dimensional Walking Pattern Generation, Two Dimensional Inverted Pendulum, Behavior of Linear Inverted Pendulum, Orbital Energy, Support Leg Exchange, Planning a Simple Biped Gait, Extension to a Walk on Uneven Terrain. **UNIT –V: CASE STUDY: WALKING PATTERN GENERATION** ZMP Based Walking Pattern Generation, Cart-Table Model, Off-Line Walking Pattern Generation, Stabilizer, Principles of Stabilizing Control, Stabilizing Control of Honda Humanoid Robot, Advanced Stabilizers.						

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	UNIT IV: Preventive Maintenance Overview of preventive maintenance, Preventive maintenance procedures, Predictive maintenance, Predictive maintenance procedures, Condition monitoring, Fault diagnostics, Analytics on cloud, Analytics on edge, Analytics on controller, Analytics on server & clients, Types of data driven techniques, Types of physics based techniques, Advanced modeling, Digital Twin approach, ML based approach, DL based approach. **UNIT –V: Applications** Deployment of IIoT based applications, System design & challenges, Sustainable Development Goals, Relevance of SDGs to IIoT, Smart Process Automation, Smart sensor based control using IoT, Wearable antennas (WA), Smart Aviation (SA), Architecture design using IoT, Smart Water Management (SWM), SWM Measurement & storage using IoT and linking medical data using IoT.
Textbook	1. Giacomo Veneri, and Antonio Capasso, Hands On Industrial Internet of Things Create a powerful Industry 4.0, Packt publishing Ltd, First edition, 2018 2. R. Anandan, Suseendran, Souvik Pal and NoorZaman, Industrial Internet of Things, John Wiley & Sons, First edition, 2022 3. Anand Tamboli, Build your own IoT platform ,Apress Publisher, 2019
References	1. Sudhip Mishra, Chandana Roy, A.Mukherjee, Introduction to Internet of Things & Industry 4.0, CRC Press, First edition, 2021 2. NPTEL online resources- https://onlinecourses.nptel.ac.in/noc22_cs95

Textbook	1. Dragomir N. Nenchev, Atsushi Konno, "Humanoid Robots Modeling and Control", Butterworth Heinemann, 2019 2. Shuuji K, Hirohisa H, Kensuke H, Kazuhito, Springer-Verlag GmbH "Introduction to Humanoid Robotics", Springer, London, 2014. 3. Goswami Ambarish, Vadakkepat Prahlad, "Humanoid Robotics: A Reference", Springer, 2019.
References	1. J. Craig, "Introduction to Robotics: Mechanics and Control", Fourth Edition, Pearson, 2022 2. J K. Harada, E. Yoshida, K. Yokoi (Eds.), "Motion Planning for Humanoid Robots",Springer, London, 2010. 3. Lorenzo Sciavicco and Bruno Siciliano, "Modelling and Control of Robot Manipulators", second edition, Springer, 2000. 4. Jean-Claude Latombe, "Robot Motion Planning", Kluwer Academy Publishers, 2004.

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<table>
<tr><td>Course Title</td><td>Real Time Embedded Systems for Robotics</td><td>Course No
(will be assigned)</td><td colspan="4">24PECE06</td></tr>
<tr><td>Course Offering Department</td><td>Department of Industry 4.O</td><td>Structure (LTPC)</td><td>3</td><td>0</td><td>2</td><td>4</td></tr>
<tr><td>Offered for</td><td>PG</td><td>Status</td><td colspan="2">Core ✔</td><td colspan="2">Elective</td></tr>
<tr><td>Faculty</td><td></td><td>Type</td><td colspan="2">New ✔</td><td colspan="2">Modification</td></tr>
<tr><td>Pre-requisite</td><td></td><td>To take effect from</td><td colspan="4"></td></tr>
<tr><td>Submission date</td><td></td><td>Date of approval by Senate</td><td colspan="4"></td></tr>
<tr><td>Objectives</td><td colspan="6">This course introduces the fundamental concepts, principles and application of Real Time Embedded Systems and design for Robotics to the postgraduate students.</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">Upon successful completion of this course, students will be able to:
CO1: To understand the basic concepts of Embedded systems and ARM processor.
CO2: To apply the concept of Embedded Computing Platform Design in various applications.
CO3: To analyze various program logics to optimize the program size.
CO4: To apply the design techniques and networks methodology for Robotics applications.
CO5: To apply and analyze Design and development of an Embedded system for enhance the employability/entrepreneurship opportunities for robotics applications.</td></tr>
<tr><td>Contents of the course</td><td colspan="6">UNIT- I: Introduction to Embedded Computing And Arm Processors
Purpose of Embedded Systems, History of Embedded Systems, Classification of Embedded systems, Major Application Areas, Characteristics and Quality Attributes of Embedded Systems, Design example of Embedded systems, Model train controller, Instruction sets preliminaries, ARM Processor, CPU, Memory system mechanisms.
UNIT- II: Embedded Computing Platform Design
The CPU Bus, Memory devices and systems, designing with computing platforms, Consumer electronics architecture platform, Level performance analysis, Components for embedded programs, Models of programs, Assembly, linking and loading Compilation techniques.
UNIT-III: Processes And Operating Systems
Introduction of operating systems, Multiple tasks and multiple processes, Multirate systems, Preemptive real-time operating systems, Priority based scheduling, Mailbox, Interprocess, Communication mechanisms, Evaluating operating system performance.
UNIT IV: Design Techniques And Networks
Design methodologies, Design flows, Requirement Analysis, Specifications-System analysis and architecture design, Lab:10Interfacing stepper motor and temperature sensor, Distributed embedded system, Wireless based Embedded Systems, MPSoC's.
UNIT –V: Case Study
Data compressor Techniques, Applications-Design of Alarm Clock, Applications-Design of Audio player, Case Study –I, Case Study –II.</td></tr>
</table>

Course Title	Industrial Internet of Things	Course No *(will be assigned)*	24PECE05			
Specialization	Department of Industry 4.O	Structure (LTPC)	4	0	0	4
Offered for	PG	Status	Core ✔		Elective	
Faculty		Type	New ✔		Modification	
Pre-requisite		To take effect from				
Submission date		Date of approval by Senate				
Objectives	This course introduces : IoT technologies, architectures, standards, and regulations, data flow, hardware components and software used in implementation of IIoT technology, collecting, communicating, coordinating, and leveraging the data from connected devices, system maintenance and fault diagnosis techniques in IIoT technology, to the postgraduate students.					
Course Outcomes	Upon successful completion of this course, students will be able to: CO1: To understand the IoT technologies, architectures, standards, and regulations CO2: To apply the concepts of data flow, hardware components and software used in implementation of IIoT technology CO3: To apply the value created by collecting, communicating, coordinating, and leveraging the data from connected devices. CO4: To understand system maintenance and fault diagnosis techniques in IIoT technology. CO5: To apply and analyze Design and implement developed IIoT technological solutions to different applications and Adapt technological developments that will help the students to know the current & future trends.					
Contents of the course	**UNIT- I: Overview** Overview of IoT and Industry 4.0, Introduction to Industrial IoT, Key difference between IoT and IIoT, IIoT Analytics & AI, IoT architecture and layers, Challenges in IIOT, Industrial manufacturing, Predictive maintenance, Types of industrial processes, CIM Pyramid architecture, RTUs SCADA & PLC functional overview, Overview of the ERP System, Cyber Physical systems (CPS), IOT data flow in cloud, Industrial data flow in cloud. **UNIT- II: Industrial IoT data flow** Industrial data flow architecture, OPC classic, OPC UA information model, Data exchange and security model, Edge gateway, Edge architecture, IoT edge vs IIoT edge, Edge tools and computing, Edge gateway, Edge Internet protocols, Industrial networking, Communication protocols, IEEE Network standards, Field bus architecture, Edge on field bus setup, Merits and demerits, IIoT data sources, IIoT data collection. **UNIT-III: Implementation framework** Overview of cloud server solutions, AZURE, Google cloud and AWS, Types of client server architecture, Registering on IoT core & client, Installation prerequisites, configuration practices, Configuring authentication, Configuring security, Communication channel, Modes of communication, Server to client data transfer, Deployment of application, First Data collection, Dataset creation techniques, Dataset processing techniques, Data presentation tools and Data analytics tools.					

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Textbock	1. Jonathan W. Valvano, Embedded Microcomputer Systems: Real-Time Interfacing, Brookes/Cole, Pacific Grove, 2000. 2. F. Vahid & T. Givargis, Embedded System Design, Wiley. 3. Wolf, W., Computers as Components: Principles of Embedded Computing System Design, Morgan Kaufmann, San Francisco, 2001.
References	1. Furber, S., ARM: system-on-chip architecture, 2nd Edition, Addison-Wesley, London, 2000. 2. Hayes, J. P., Computer Architecture and Organization, 3rd Edition,, McGraw-Hill,1998.

	UNIT IV: Preventive Maintenance Overview of preventive maintenance, Preventive maintenance procedures, Predictive maintenance, Predictive maintenance procedures, Condition monitoring, Fault diagnostics, Analytics on cloud, Analytics on edge, Analytics on controller, Analytics on server & clients, Types of data driven techniques, Types of physics based techniques, Advanced modeling, Digital Twin approach, ML based approach, DL based approach. **UNIT –V: Applications** Deployment of IIoT based applications, System design & challenges, Sustainable Development Goals, Relevance of SDGs to IIoT, Smart Process Automation, Smart sensor based control using IoT, Wearable antennas (WA), Smart Aviation (SA), Architecture design using IoT, Smart Water Management (SWM), SWM Measurement & storage using IoT and linking medical data using IoT.
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References	1. Sudhip Mishra, Chandana Roy, A.Mukherjee, Introduction to Internet of Things & Industry 4.0, CRC Press, First edition, 2021 2. NPTEL online resources- https://onlinecourses.nptel.ac.in/noc22_cs95

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Course Title	Real Time Embedded Systems for Robotics	Course No *(will be assigned)*	24PECE06			
Course Offering Department	Department of Industry 4.O	Structure (LTPC)	3	0	2	4
Offered for	PG	Status	Core ✔		Elective	
Faculty		Type	New ✔		Modification	
Pre-requisite		To take effect from				
Submission date		Date of approval by Senate				
Objectives	This course introduces the fundamental concepts, principles and application of Real Time Embedded Systems and design for Robotics to the postgraduate students.					
Course Outcomes	Upon successful completion of this course, students will be able to: CO1: To understand the basic concepts of Embedded systems and ARM processor. CO2: To apply the concept of Embedded Computing Platform Design in various applications. CO3: To a nalyze various program logics to optimize the program size. CO4: To apply the design techniques and networks methodology for Robotics applications. CO5: To apply and analyze Design and development of an Embedded system for enhance the employability/entrepreneurship opportunities for robotics applications.					
Contents of the course	**UNIT- I: Introduction to Embedded Computing And Arm Processors** Purpose of Embedded Systems, History of Embedded Systems, Classification of Embedded systems, Major Application Areas, Characteristics and Quality Attributes of Embedded Systems, Design example of Embedded systems, Model train controller, Instruction sets preliminaries, ARM Processor, CPU, Memory system mechanisms. **UNIT- II: Embedded Computing Platform Design** The CPU Bus, Memory devices and systems, designing with computing platforms, Consumer electronics architecture platform, Level performance analysis, Components for embedded programs, Models of programs, Assembly, linking and loading Compilation techniques. **UNIT-III: Processes And Operating Systems** Introduction of operating systems, Multiple tasks and multiple processes, Multirate systems, Preemptive real-time operating systems, Priority based scheduling, Mailbox, Interprocess, Communication mechanisms, Evaluating operating system performance. **UNIT IV: Design Techniques And Networks** Design methodologies, Design flows, Requirement Analysis, Specifications-System analysis and architecture design, Lab:10Interfacing stepper motor and temperature sensor, Distributed embedded system, Wireless based Embedded Systems, MPSoC's. **UNIT –V: Case Study** Data compressor Techniques, Applications-Design of Alarm Clock, Applications-Design of Audio player, Case Study –I, Case Study –II.					

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Textbook	1. Jonathan W. Valvano, Embedded Microcomputer Systems: Real-Time Interfacing, Brookes/Cole, Pacific Grove, 2000. 2. F. Vahid & T. Givargis, Embedded System Design, Wiley. 3. Wolf, W., Computers as Components: Principles of Embedded Computing System Design, Morgan Kaufmann, San Francisco, 2001.
References	1. Furber, S., ARM: system-on-chip architecture, 2nd Edition, Addison-Wesley, London, 2000. 2. Hayes, J. P., Computer Architecture and Organization, 3rd Edition,, McGraw-Hill,1998.

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Course Title	Medical Robotics	Course No *(will be assigned)*	24PECE18			
Course Offering Department	Department of Industry 4.O	Structure (LTPC)	4	0	0	4
Offered for	PG	Status	Core		Elective ✔	
Faculty		Type	New ✔		Modification	
Pre-requisite		To take effectfrom				
Submissio ndate		Date of approvalby Senate				

Objectives	The objective of this course is to equip students with a comprehensive understanding of robotic systems and their applications in healthcare, focusing on surgical, rehabilitation, and diagnostic technologies, while addressing challenges and future trends in the field.
Course Outcomes	Upon successful completion of this course, students will be able to: CO1: Understand and analyze the fundamentals of medical robotics, including key systems, components, and technologies used in healthcare applications. CO2: Design and apply robotic systems for specific medical applications, analyzing challenges in robotic surgery and rehabilitation. CO3: Analyze and evaluate the role of AI and advanced technologies in transforming healthcare systems. CO4: Apply their understanding of robotic components to develop or enhance solutions for specific medical use cases, demonstrating employability skills. CO5: Critically evaluate future trends in medical robotics and propose innovative solutions to address opportunities and challenges posed by emerging technologies.
Contents ofthe course	**UNIT-I** **Fundamentals of Medical Robotics**: Asimov's three laws of robotics, overview of medical robotics, Terminology, History and evolution, need of robotics system in medical sector, Role of medical robotics in healthcare, Types of medical and healthcare robotic system, Applications of robotics in healthcare, Challenges and opportunities in medical robotics, Growth drives of medical robotics industry, key barriers in medical robotics industry. **UNIT-II** **Components of Healthcare Robotic System**: Manipulators, Pedestal, Controller, End effectors, Power Source, Sensors, Imaging System, Communication system, Medical support structures. Robot characteristics- Payload, Reach, Precision, repeatability. Design framework for medical/surgical robots. **UNIT-III** **Surgical Robotics**: Fundamentals of robotic-assisted surgery (RAS), Key components of robotic surgery systems, Robot-Assisted Minimally Invasive Surgery (MIS), Degree of Autonomy of Surgical Equipment, levels of autonomy in a surgical robot- no autonomy, robot assistance, task autonomy, conditional autonomy, high autonomy, and full autonomy, granularity levels of

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	surgery, Case studies- da Vinci Surgical System and MAKO Robotic-Arm. **UNIT-IV** **Rehabilitation Robotics**: Introduction to Rehabilitation Robotics, Robotic assistive devices for rehabilitation, Classifications of rehabilitation robots, Principles of robotic exoskeletons and their medical applications, Robotics for stroke, spinal cord injury, and neurorehabilitation, Case studies in the rehabilitation of patients **UNIT-V** **Future Trends in Medical Robotics**: Artificial Intelligence and Robotics in Healthcare- Need for AI and robotics in transformed health ecosystems, classification of AI and robotic systems in medicine based on Type of System, Degree of Autonomy, Application Area, Degree of Intrusion into a Patient and Care Setting, adoption challenges to AI and robotics in healthcare, Opportunities involved in AI Applications in healthcare. Micro/Nanorobots in Medicine-Applications of micro/nanorobots in drug delivery and diagnostics, Design and control challenges at micro/nano scales.

Textbook	1. Achim Schweikard, Floris Ernst, "Medical Robotics", Springer, 2016. 2. Paula Gomes, "Medical robotics Minimally invasive surgery", Woodhead, 3. Jocelyne Troccaz, "Medical Robotics", John Wiley & Sons Incorporated, 2013.
References	1. Farid Gharagozloo "Robotic Surgery", Springer, 2022. 2. Jaydev P Desai, Rajni V Patel, Antoine Ferreira; Sunil Kumar Agrawal, "The Encyclopedia of Medical Robotics", World Scientific Publishing Co. Pvt. Ltd, 2019.

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Course Title	Simulation, Modelling & Analysis	Course No *(will be assigned)*	24PECE47				
Course Offering Department	Department of Industry 4.O	Structure (LTPC)	4	0	0	4	
Offered for	PG	Status	Core		Elective ✔		
Faculty		Type	New ✔		Modification		
Pre-requisite		To take effectfrom					
Submission date		Date of approvalby Senate					
Objectives	This course provides a comprehensive understanding of simulation and modeling techniques in robotics and automation, covering discrete event simulation, FEM, material optimization, and control systems. Students will use advanced simulation tools to analyze robotic kinematics, sensor integration, and automation, gaining practical skills through hands-on applications and real-world case studies.						
Course Outcomes	Upon successful completion of this course, students will be able to: CO1: Understand and analyze the fundamental principles of simulation, modelling, and system analysis. CO2: Design and apply finite element methods and computational techniques for material and system simulations for robotics. CO3: Simulate and analyze various sensor systems used in robotics for performance optimization, demonstrating employability skills. CO4: Apply their understanding of robotic components to optimize material selection for robotic applications to enhance efficiency and durability. CO5: Perform output analysis apply optimization techniques for improving system performance, and address opportunities and challenges posed by emerging technologies.						
Contents of the course	**UNIT-I** **Introduction to Simulation**: Overview, Advantages, Limitations of Simulation, Areas of Application. System environment, system components, System model, model classifications, phases of a simulation study. Random Numbers: Properties, Generation Methods Examinations for Random Numbers - Frequency test, stationary test. **UNIT-II** **Engineering Materials and Selection for Robotics**: The role of engineering materials in simulation and their significance in robotics. Material selection criteria and how material properties impact simulation accuracy. Different material behaviours in computational modelling and the importance of selecting appropriate materials for optimized performance in robotics and other engineering applications. **UNIT-III** **Mesh Generation & Finite Element Methods (FEM)**: Mesh generation through computer graphics and meshless methods. FEM for Orthotropic materials & composite materials. Special design problems using FEM in Static/Dynamic: Isotropic materials, Composite materials, Manufacturing						

	applications, Biomedical applications, and robotic applications. **UNIT-IV** **Output Analysis and Optimization in Simulation**: simulation of various sensor systems used in robotics, Modelling and analysing sensor performance in different environments. optimization of materials for robotic systems, focusing on selecting suitable materials to enhance durability, efficiency, and performance. **UNIT-V** **FEM and simulation tools**: Tools are applied to solve practical engineering problems across multiple domains, and simulation of real-world systems with different material selections. Case studies of the various robotics simulations.

Textbook	1. Jerry Banks, John S Carson, II, Berry L Nelson, David M Nicol -Discrete Event system Simulation, III Edition, Pearson Education, Asia, ISBN – 81- 7808 – 505 – 4. 2. Narsingh Deo -Systems Simulation with Digital Computer; PHI Publication (EEE), ISBN – 0-87692-028-8.
References	1. Averill M Law, W David Kelton -Simulation Modeling & Analysis, McGraw Hill International Editions – Industrial Engineering series, ISBN – 0-07-100803-9. 2. Ryan, D L. 1993. *Robotic Simulation.* Taylor & Francis. https://books.google.co.in/books?id=8pptR6w3jgAC.

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Course Title	Entrepreneurship Development	Course No (will be assigned)	24PECE65			
Course Offering Department	Department of Industry 4.O	Structure (LTPC)	4	0	0	4
Offered for	PG	Status	Open		Elective ✔	
Faculty		Type	New ✔		Modification	
Pre-requisite		To take effectfrom				
Submissio ndate		Date of approvalby Senate				
Objectives	This subject aims to equip students with the knowledge and skills required to transform innovative ideas into successful technology-driven ventures. This course explores the fundamentals of entrepreneurship, emphasizing the role of robotics and automation in shaping future industries. Students will learn about business models, market analysis, financial planning, and intellectual property rights, with a special focus on startup ecosystems and funding opportunities. Through case studies, design thinking exercises, and business pitch presentations, this course fosters an entrepreneurial mindset, enabling students to develop, validate, and scale robotics-based business solutions.					
Course Outcome	Upon successful completion of this course, students will be able to: CO1: Understand entrepreneurship fundamentals CO2: Apply innovative thinking for robotics startups. CO3: Develop business models and analyse the market CO4: Learn government policies, IPR, and funding. CO5: Create and pitch a business plan for robotics start-ups.					

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Contents of the course	**UNIT-I** **Introduction to Entrepreneurship**: Definition, Importance, and Evolution of Entrepreneurship, types of Entrepreneurs: Technology, Social, Serial, and Corporate Entrepreneurs, role of Entrepreneurship in Robotics and AI, Challenges and Opportunities in Robotics Startups. **UNIT-II** **Innovation and Design Thinking in Robotics:** Innovation Process and Role in Robotics, Design Thinking: Empathy, Ideation, and Prototyping, Industry 4.0 and Entrepreneurship, Case Studies of Successful Robotics Startups. **UNIT-III** **Business Models and Market Analysis: Business** Model Canvas for Robotics Ventures, Market Research and Competitive Analysis, Revenue Streams, Value Proposition, and Go-to-Market Strategy, Lean Startup and Agile Development. . **UNIT-IV** **Financial Planning and Investment for Startups:** Cost Estimation and Break-even Analysis, Sources of Funding: Angel Investors, Venture Capitalists, and Crowdfunding, Government Schemes, Incubators, and Accelerators in India Risk Analysis and Financial Sustainability. **UNIT-V** **Intellectual Property Rights and Business Plan Development:** Patents, Trademarks, and Copyrights in Robotics, Technology Licensing and Commercialization, Ethical Considerations and Regulatory Framework, Case Study on Robotics Patents and Startup Legal Battles, writing a Business Plan for a Robotics Startup, Pitching and Presentation Techniques, Role of Networking and Strategic Alliances, Final Project: Developing and Presenting a Robotics Startup Idea.

Textbook	1. Hisrich, Robert D., Michael P. Peters, and Dean A. Shepherd, "Entrepreneurship", McGraw-Hill Education, January 1, 2020. 2. Drucker, Peter F., "Innovation and Entrepreneurship", HarperBusiness, May 8, 2006. 3. Blank, Steve, and Bob Dorf, "The Startup Owner's Manual: The Step-By-Step Guide for Building a Great Company", Wiley, March 1, 2020.
References	1. Ries, Eric, "The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses", Crown Business, September 13, 2011. 2. Mullins, John W., "The New Business Road Test: What Entrepreneurs and Investors Should Do Before Launching a Lean Startup", Pearson, August 2, 2017

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Course Title	Advance power electronics and control	Course No *(will be assigned)*	24PECE96				
Course Offering Department	Department of Industry 4.O	Structure (LTPC)	4	0	0	4	
Offered for	PG	Status	Core		Elective ✔		
Faculty		Type	New ✔		Modification		
Pre-requisite		To take effectfrom					
Submissio ndate		Date of approvalby Senate					
Objectives	This course aims to equip students with in-depth knowledge of power electronics and control techniques essential for modern robotic and automation systems. It covers advanced power semiconductor devices, converters, and their applications in robotics while also focusing on efficient power conversion techniques for autonomous systems, renewable energy integration, and energy management.						
Course Outcomes	Upon successful completion of this course, students will be able to: CO1: Understand the semiconductor devices and principle of power electronics used in robotic and automation systems. CO2: Apply power conversion techniques for autonomous robotic systems and renewable energy applications. CO3: Analyse different control strategies for power electronic circuits and their impact on system performance. CO4: Design and implement efficient power electronic converters. CO5: Innovate and develop new power electronics solutions for emerging applications for employability and entrepreneurship.						

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Contents of the course	**UNIT-I** **Semiconductor devices**: History and evaluation, Role and importance of power electronics in different applications. power semiconductor devices power diode, TRIAC, MOSFET, GTO etc. V- I characteristics of SCR, Recent advancement, challenges and opportunities, importance of Energy efficient systems. **UNIT-II** **Controlled Rectifier**: Overview of converters, controlled and uncontrolled rectifiers, Single phase half-controlled rectifiers with R, L, RL load, Single phase full controlled rectifier with load. **UNIT-III** **Converters**: Introduction to Inverters and its classification, comparison of VSI and CSI, step up and step-down chopper, Buck converter, Boost Converter and Buck boost Converter, Design and implement converters for different applications. **UNIT-IV** **Advance control system**: Control system and its types, Linear and nonlinear system, concept of stability, Routh Hurwitz stability, Root Locus, controllability and observability, PID controllers, State space technique. **UNIT-V** **Electric Drives**: Introduction to drives, Basic Elements of Drive, Load characteristics, Selection of Drive, Basic characteristics of DC motor, Operating modes, and its application, Case study in robotics field.

Textbook	1. P. S. Bimbhra, *"Power Electronics"*, Khanna Publishers, 2023. 2. Daniel W. Hart, *"Power Electronics"*, McGraw-Hill Education, 2023. 3. Joseph Vithayathil, *"Power Electronics: Principles and Applications"*, McGraw-Hill, 2023.
References	1. Muhammad H. Rashid, "Power Electronics Handbook", Butterworth-Heinemann, January 8, 2024. 2. John G. Kassakian, Martin F. Schlecht, and George C. Verghese, "Principles of Power Electronics", Cambridge University Press, August 3, 2023. 3. Robert W. Erickson and Dragan Maksimović, "Fundamentals of Power Electronics", Springer, 2023.

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