Dr. Babasaheb Ambedkar Technological University
(Established as University of Technology in the State of Maharashtra)

(Under Maharashtra Act No. XXIX of 2014)
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CURRICULUM

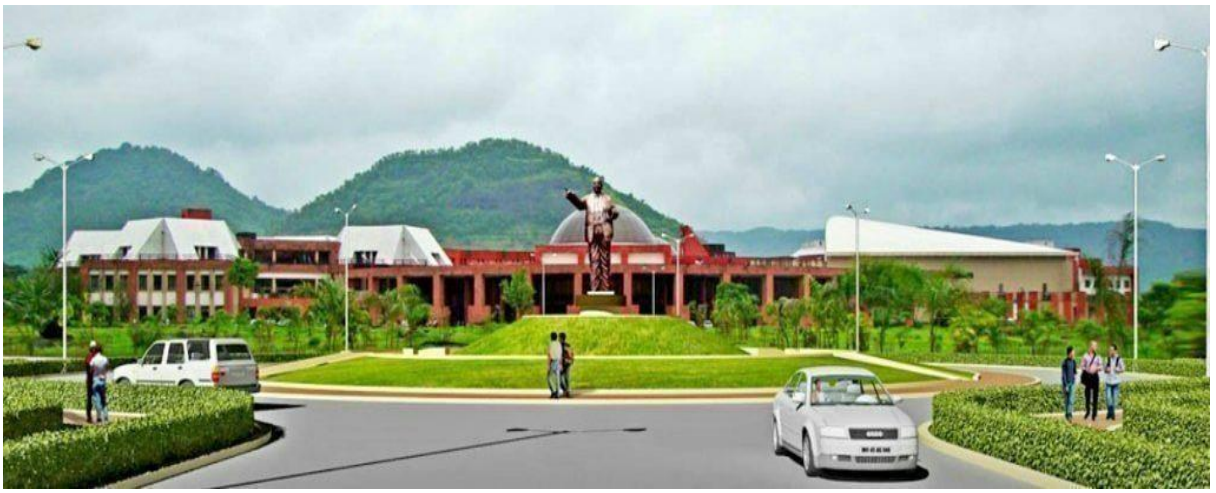
UNDER GRADUATE PROGRAMME

B. Tech

Final Year Robotics/Automation and Robotics (Affiliated Institutes)

ACADEMIC YEAR 2024-2025

(Affiliated Colleges)



Abbreviations

BSC: *Basic Science Course*

ESC: *Engineering Science Course*

PCC: *Professional Core Course*

PEC: *Professional Elective Course*

OEC: *Open Elective Course*

HSSMC: *Humanities and Social Science including Management Courses*

PROJ: *Project work, seminar and internship in industry or elsewhere*

PROGRAM OUTCOMES (PO'S)

OUTCOME IDENTIFIER	GRADUATE ATTRIBUTE	OUTCOME
PO 01	**Engineering knowledge**	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 02	**Problem analysis**	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 03	**Design/development of solutions**	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO 04	**Conduct investigations of complex problems**	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 05	**Modern tool usage**	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO 06	**The engineer and society**	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 07	**Environment and sustainability**	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 08	**Ethics**	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 09	**Individual and team work**	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication**	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance**	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-long learning**	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIPIC OUTCOMES (PSO'S)

OUTCOME IDENTIFIER	OUTCOME
PSO 01	Learn and apply modern skills, techniques, and engineering tools to automate things and simplify real world problems and human efforts
PSO 02	Understand the modern developments in Automation and Robotics systems to provide solutions by new ideas and innovations
PSO 03	Understand specialized, moral, and communal responsibilities to implement in lifelong learning

PROGRAM EDUCATIONAL OBJECTIVES (PEO'S)

OUTCOME IDENTIFIER	OUTCOME
PEO 01	To prepare students with sound knowledge of Robotics and Automation
PEO 02	To pursue higher studies and establish career in multidisciplinary domain
PEO 03	To develop and nurture entrepreneurship skills and implementation abilities

Course Structure for Semester VII
B. Tech. in Automation and Robotics (2024-25)

Semester VII									
Course Category	**Course Code**	**Course Title**	**Teaching Scheme**			**Evaluation Scheme**			**No. of Credits**
			L	**T**	**P**	**CA**	**MSE**	**ESE**	**Total**
PCC19	BTARC 701	PLC and SCADA	3	1	-	20	20	60	100	4
PCC20	BTARC 702	Robot Operating System	3	1	-	20	20	60	100	4
PEC5	BTARPE703A-D	Elective-V	3	-	-	20	20	60	100	3
OEC3	BTAROE704A-B, BTMOE704B	Open Elective-III	3	-	-	20	20	60	100	3
OEC4	BTMOE705A-C	Open Elective-IV	3	-	-	20	20	60	100	3
PCC 21	BTARCL 706	Robot Operating System Lab	-	-	2	60	-	40	100	1
Proj 7	BTARP707	Mini Project 2			6	30		20	50	3
Proj 6	BTARI610	IT – 3 Evaluation	-	-	-	-	-	100	100	1
Total			**15**	**2**	**8**	**190**	**460**		**750**	**21**

BSC = Basic Science Course, ESC = Engineering Science Course, PCC = Professional Core Course
PEC = Professional Elective Course, OEC = Open Elective Course, LC = Laboratory Course
HSSMC = Humanities and Social Science including Management Courses

Elective V:

Sr. No	Course code	Course Name
1	BTARPE703A	Machine Vision System
2	BTARPE703B	Electronics System Design and Analysis
3	BTARPE703C	Robot System Reliability and Safety
4	BTARPE703D	VLSI Design for Robotics

Open Elective III:

Sr. No	Course code	Course Name
1	BTAROE704A	Optimization Techniques
2	BTAROE704B	Industry 4.0
3	BTMOE704B	Entrepreneurship Development (Refer Mechanical)

Open Elective IV:

Sr.No	Course code	Course Name
1	BTMOE705A	Engineering Economics (Refer Mechanical)
2	BTMOE705B	Biology for Engineers (Refer Mechanical)
3	BTMOE705C	Intellectual Properties Rights (Refer Mechanical)

Course Structure for Semester VIII

B. Tech. in Automation & Robotics Engineering (2024-25)

Semester VIII										
Course Category	**Course Code**	**Course Title**	**Teaching Scheme**			**Evaluation Scheme**				**Credit**
			L	**T**	**P**	**CA**	**MSE**	**ESE**	**Total**	
		Choose any two subjects fromANNEXURE-A#				20	20	60	100	4
						20	20	60	100	4
PROJ-8	BTAR P801/ BTAR PI801	Project Work & Internship	-	-	20	60	-	40	100	10
Total	-			**-**	**20**	**100**	**40**	**160**	**300**	**18**

SEM	I	II	III	IV	V	VI	VII	VIII	TOTAL
CREDITS	18	19	22	20	21	21	21	18	160

ANNEXURE-A# (Provisional)

Recommendations of 8th Semester Courses in Self-study Mode from NPTEL/ SWYAM Platform THE LIST MAY ALTER AND MODIFY AS PER THE AVAILABILITY OF THE SUBJECTS ON THE NPTEL/ SWYAM Platform AND USEFULNESS, EVERY YEAR

Sr No	Course Code	Course Name	Duration (Week)	Institute Offering Course	Name of Professor
1	BTARC801A	An Introduction to Artificial Intelligence	12 Weeks	IITD	Prof. Mausam
2	BTARC801B	Introduction To Industry 4.0 And Industrial Internet Of Things	12 Weeks	IITKGP	Prof. Sudip Misra
3	BTARC801C	Advanced Robotics	12 Weeks	IITK	Prof. Ashish Dutta
4	BTARC801D	Industrial Hydraulics and Automation	12 Weeks	IITKGP	Prof. Niranjan KumarProf. Ajit Kumar
5	BTARC801E	Industrial Automation And Control	12 Weeks	IITKGP	Prof. Alokkanti Deb
6	BTARC801F	Innovation in Marketingand Marketing of Innovation	12 Weeks	IITR	Prof. Vinay Sharma
7	BTARC801G	Patent Law for Engineers and Scientists	12 Weeks	IITM	Prof. Feroz Ali
8	BTARC801H	Advanced Robotics	12 Weeks	IITK	Prof. Ashish Dutta
9	BTARC801I	Operations Management	12 Weeks	IITR	Prof. Inderdeep Singh
10	BTARC801J	Marketing Analytics	12 Weeks	IITKGP	Prof. Swagato Chatterjee

Six months of Internship in the industry

 # These subjects are to be studied on self –study mode using SWAYAM/NPTEL/Any other source

 # Student doing project in Industry will give NPTEL Examination/Examination conducted by the University i.e. CA/MSE/ESE # Students doing project in the Institute will have to appear for CA/MSE/ESE

Total Credits: 160 (Batch 2024-2025)

SEMESTER VII

PLC and SCADA

BTAR701	**PLC and SCADA**		3L-1T-0P	4 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 3 hrs/week Tutorial: 0 hr/week	Continuous Assessment: 20 MarksMid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: Analog Electronics, Digital Electronics, Switches, Motors , Sensors, Transducers

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

CO1	To learn PLC components and I/O processing in PLC
CO2	To learn programming of PLC
CO3	To study PLC interface to various circuits:.
CO4	To study SCADA and HMI.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

Course Contents:

Unit 1 : PLC and I/O processing: 7L

Programmable Logic Controller basics, overview of PLC systems – Architecture of PLC, Principle of Operation, input/output Units – power supplies and isolators, current sinking and current sourcing, types of PLC memory, fundamental PLC wiring diagram, relays, switches, transducers, sensors –seal-in circuits. Input/output units Signal conditioning. Remote connections Networks Processing inputs I/O addresses

Unit 2 : Programming of PLC: 7L

Fundamentals of logic, PLC programming languages. Ladder diagrams, Ladder Diagram Instruction, Logic functions, Latching, Multiple outputs. Timer and counter- types along with timing diagrams, shift registers, sequencer function, latch instruction; Arithmetic and logical instruction with various examples. ON/OFF switching devices, I/O analog devices, Analog PLC operation, PID control of continuous processes, simple closed loop systems, closed loop system using Proportional, Integral & Derivative (PID)

Unit 3 : PLC interface to various circuits: 7L

Encoders, transducer and advanced sensors. Measurement of temperature, flow, pressure, force, displacement, speed, level. Developing a ladder logic for Sequencing of motors, Tank level control, ON-OFF temperature control, elevator, bottle filling plant, car parking etc. Motors Controls: AC Motor starter, AC motor overload protection, DC motor controller, Variable speed (Variable Frequency) AC motor Drive.

Unit 4 : SCADA Systems: 7L

Introduction, Communication requirements, Desirable Properties of SCADA system, features, advantages, disadvantages an d applications of SCADA. SCADA Architectures (First generation - Monolithic, second generation - Distributed, Third generation – Networked Architecture), SCADA systems in operation and control of interconnected power system, Power System Automation (Automatic substation control and power distribution).

Unit 5 : HMI (Human Machine Interface) : 7L

Getting started with HMI , Creating applications, creating tags , Downloading / uploading programs , Communication with PLC Open systems interconnection (OSI) Model, Process Field bus (Profibus). Interfacing of SCADA with PLC, PLC interface, and Industrial process example

Reference books:

1. Stuart A. Boyer: “SCADA- Supervisory Control and Data Acquisition”, Instrument Society of America Publications, USA, The Instrumentation system and Automation Society, 4th Edition, 2010.
2. Gordon Clarke, Deon Reynders” Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems”, Newnes An imprint of Elsevier Publications, 1st Edition, 2004
3. Batten G. L., “Programmable Controllers”, McGraw Hill Inc., Second Edition
4. Gordan Clark, Deem Reynders, “Practical Modern SCADA Protocols”, ELSEVIER
5. P. K. Srivstava, “Programmable Logic Controllers with Applications”, BPB Publications

Robot Operating System

BTAR702	**Robot Operating System**		3L-1T-0P	4 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 3 hrs/week Tutorial: 0 hr/week	Continuous Assessment: 20 MarksMid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: Basics of Robots , Operating system, Robot Programming , Ubantu

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

CO1	Understand the fundamental concepts of robotics and automation
CO2	Describe message communication of robot operating system
CO3	Demonstrate robot operating system
CO4	Program and simulate robot applications
CO5	Interface robot with embedded system

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

Unit I: Introduction **7L**

Introduction to robot operating system (ROS), ROS- Objective and components, History of ROS, Terminologies used in ROS, Communication message system used in ROS, Build system, File system

Unit II: ROS- Tools and Commands **7L**

ROS command list and shell commands, ROS executive and information commands, ROS Package commands, ROS tool visualization, ROS GUI development, ROS installation and running tool

Unit III: ROS Programming **7L**

Introduction to ROS programming, Standard unit, Coordinate presentations, Different rules in ROS programming, Creating and running publisher, subscriber nodes

Unit IV: ROS Manipulator **7L**

Introduction to ROS manipulator, Basic structure of manipulator, Open manipulator modeling and simulator, Gazebo setting move, Move It, Move group, Setup assistant, Gazebo simulation

Unit V: ROS Embedded System **7L**

OpenCR- Introductio, characteristics, board specification, Establish development environment, rosserial, rosserial server, rosserial client, rosserial protocol, Constrain of rosserial, Installation of rosserial, TurtleBot3 Firmware.

References:

1. “ROS robotics by example” by C. Fairchild and L. T. Harman (Pakt Publications), ISBN: 9781785286704
2. “Programming Robots by ROS” by M. Quigley, B. Gerkey and W. D. Smart (O Reilly Media Inc.), ISBN: 9781449325503
3. “A Gentle Introduction to ROS” by J. M. OKane (Independently Published) ISBN:9781492143239

ELECTIVE V

Machine Vision System

BTARPE703A	**Machine Vision System**		3L-0T-0P	3 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 3 hrs/week Tutorial: 0 hr/week	Continuous Assessment: 20 MarksMid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: Image Processing, Sensors Technology, Basic of Robot, Artificial Intelligence for Robotics

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

CO1	Understand digital image using various algorithms with the help of computer programming.
CO2	Understand the role of image processing in different fields such as medical, engineering, space, biotechnology, ocean, agriculture, food industry, etc.
CO3	Realize the significance of digital image processing in automation.
CO4	Understand models for image degradation/restoration.
CO5	Know the mathematical calculations of basic filters used in digital image enhancement.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

Machine Vision System

Unit I : Fundamentals of Image Processing 7L

Definition of image, basics of image processing, Human visual system, Sampling & quantization, Representing digital images, Spatial & gray-level resolution, Image file formats, Basic relationships between pixels, Distance Measures. Basic operations on images-image addition, subtraction, logical operations, scaling, translation, rotation. Image Histogram. Color fundamentals & models – RGB.

Unit II: Image Enhancement and Restoration 7L

Spatial domain enhancement: Point operations-Log transformation, Power-law transformation, Piecewise linear transformations, Histogram equalization. Filtering operations- Image smoothing, Image sharpening. Frequency domain enhancement: 2D DFT, Smoothing and Sharpening in frequency domain. Homomorphic filtering. Restoration: Noise models, Restoration using Inverse filtering and Wiener filtering

Unit III: Image Compression Techniques 7L

Types of redundancy, Fidelity criteria, Lossless compression – Run length coding, Huffman coding, Bit-plane coding, Arithmetic coding. Introduction to DCT, Wavelet transform. Lossy compression – DCT based compression, Wavelet based compression. Image and Video Compression Standards – JPEG, MPEG.

Unit IV: Image Segmentation and Morphological Operations 7L

Image Segmentation: Point Detections, Line detection, Edge Detection-First order derivative – Prewitt and Sobel. Second order derivative – LoG, DoG, Canny. Edge linking, Hough Transform, Thresholding – Global, Adaptive. Otsu's Method. Region Growing, Region Splitting and Merging. Morphological Operations: Dilation, Erosion, Opening, Closing, Hit-or-Miss transform, Boundary Detection, Thinning, Thickening, Skeleton.

Unit V: Object Recognition and Applications 7L

Feature extraction, Patterns and Pattern Classes, Representation of Pattern classes, Types of classification algorithms, Minimum distance classifier, Correlation based classifier, Bayes classifier. Applications: Biometric Authentication, Character Recognition, Content based Image Retrieval, Remote Sensing, Medical application of Image processing

Text Books

1. Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing", Third Edition, - Pearson Education
2. S Sridhar, "Digital Image Processing", Oxford University Press.

Reference Books

1. Rafael C. Gonzalez, Richard E. Woods, and Steven L. Eddins, "Digital Image Processing Using MATLAB", Second Edition, - Tata McGraw Hill Publication

2. S Jayaraman, S Esakkirajan, T Veerakumar, "Digital Image Processing", Tata McGraw Hill Publication

2. Scott E Umbaugh, Digital Image Processing and Analysis: Applications with MATLAB and CVIP tools , Taylor and Francis, ISBN: 1498766072

4. Scott EUmbaugh, Computer Vision and Image Processing Prentice-Hall International, ISBN: 9781439802052

5. A.K. Jain, Fundamentals of Digital Image Processing, Prentice-Hall of India, ISBN-100133361659

ELECTIVE V

Electronics System Design and Analysis

BTARPE703B	**Electronics System Design and Analysis**		3L-0T-0P	3 Credits

Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week Tutorial: 0 hr/week	Continuous Assessment: 20 MarksMid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: Analog Electronics, Electronics Components, Circuit Analysis, Network Theorems

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

CO1	Understand the relevance of this course to the existing technology through demonstrations, case studies, simulations.
CO2	Understand the different electronics design tools .
CO3	Understand the design of various combinational digital circuits using logic gates.
CO4	Design various circuits using analog and digital electronics
CO5	Design digital circuits using logic gates

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

UNIT 1: Introduction to EDA Tools 7L

PCB and its types, Rules of PCB design , Active and Passive Components , Filters and its types , Switches and its types, Need of Simulation, Brief introduction of various simulators, Description to simulator tool, components, wiring and schematic designing,

UNIT 2: Electronics Designing using Simulators 7L

Introduction to Simulator: Brief History, New Versions, Representing Components, Understanding the simulation Environment, Using Model Editor, designing a Circuit and drawing a schematic, Preparation for Simulation

Preparing schematic for simulation, Understand the sources for simulation, Use of different markers. DC, AC, Transient and Fourier analysis of circuit, Digital circuit Simulation.

UNIT 3: MSI Circuits 7L

Problem formulation and design of combinational circuits - Code-Converters, Half and Full Adders, Binary Parallel Adder – Carry lookahead Adder, BCD Adder, Magnitude Comparator, Decoder, Encoder, Priority Encoder, Mux/Demux, Case study: Digital transreciver / 8 bit Arithmetic and logic unit

UNIT 4 : Synchronous Sequential Circuits **7L**

Analysis and design of clocked sequential circuits – Design - Moore/Mealy models, state minimization, state assignment, circuit implementation - Counters, Ripple Counters, Ring Counters, Model Development: Designing of rolling display/real time clock

UNIT 5 : LOGIC FAMILIES AND PROGRAMMABLE LOGIC DEVICES **7L**

Logic families- TTL, MOS, CMOS, BiCMOS - Comparison of Logic families - Implementation of combinational logic/sequential logic design using standard ICs, ROM, PLA and PAL.

TEXT BOOKS:

1. M. Morris Mano and Michael D. Ciletti, "Digital Design", 5th Edition, Pearson, 2013.
2. Charles H. Roth, Jr, "Fundamentals of Logic Design", Fourth edition, Jaico Books, 2002.

REFERENCES:

1. William I. Fletcher, "An Engineering Approach to Digital Design", Prentice- Hall of India, 1980.
2. Floyd T.L., "Digital Fundamentals", Charles E. Merril publishing company,1982.
3. John. F. Wakerly, "Digital Design principles and practices", Pearson Education, Fourth Edition, 2007

3. ISBN 978-1-4842-2046-7.

ELECTIVE V

Robot System Reliability and Safety

BTARPE703C	**Robot System Reliability and Safety**		3L-0T-0P	3 Credits

Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week Tutorial: 0 hr/week	Continuous Assessment: 20 MarksMid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: Robot System, Operation of Robot , Applications of Robots

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

CO1	Understand safety and hazards in industrial robots.
CO2	Understand different reliability methods in robots.
CO3	To explore how to behave and survive in robot environment.

CO4	Understand different standards of industrial robots.
CO5	Understand different testing methods of industrial robots.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

Unit I: Robot Safety (7)

Introduction to robot safety, different features in robot safety, need for safety in robotics, methods for performing safety analysis, role of robot manufacturers and users in robot safety, robot safeguard approaches , Interrelationship of safety, quality, Electrical Hazards- Crane Safety Toxic gas Release. Preliminary Hazard Analysis

Unit 2 : Robot System Reliability (7)

Basics of Reliability, methods for performing Reliability analysis , classification of robot failures and their causes, corrective measures to avoid robot failure, robot effectiveness, reliability life characteristic phases

Unit 3 : Robot Ethics (7)

Robot ethics and level of robot morality, ethics and fundamental elements in robots , top down and bottom up robot ethics approach , ethics in human robot symbiosis, robot rights, specialized robot ethics, ethical issues of socialized robot, case studies on robot ethics.

Unit 4 : Robot Standards (7)

Different standards in robots, characteristics and benefits of standardization, standardization bodies, standard setting, robot standards : electrical interferences on robots for industrial environments, end effectors in industrial robots, safety requirements for robotics in industrial environments, safety design for industrial robot system, performance criteria and related test methods for service robots.

Unit 5 : Robot Testing (7)

Different robots performance testing methods , tests – robot program method, ford method, IPA – Stuttgart method, national bureau of standards methods , testing equipments and procedures, test reports , Hazard Identification and Risk Assessment

Reference Books:

1. Dhillon, B.S., 'Robot System Reliability and Safety: A Modern Approach', CRC Press, Boca Raton, Florida, 2015.
2. Kapur Reliability in engineering Design‖, Wiley india
3. Chandrupatla, ― Quality and Reliability in Engineering‖ Cambridge Uni. Press, India
4. S S. Rao, Reliability Based Design, McGraw Hill Inc. 1992

ELECTIVE V

VLSI Design for Robotics

BTARPE703D	**VLSI for Robotics**		3L-0T-0P	3 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 3 hrs/week Tutorial: 0 hr/week	Continuous Assessment: 20 MarksMid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: Digital Electronics , Microprocessor, Microcontroller, DSP, Embedded System

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

CO1	Model digital circuit with HDL, simulate, synthesis and prototype.
CO2	Understand chip level issues and need of test ability.
CO3	Design analog & digital CMOS circuits for specified applications.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												

Unit I: Introduction to VHDL Modeling 7L

Data objects, Data types, Entity, Architecture & types of modeling, Sequential statements, Concurrent statements, Packages, Sub programs, Attributes, VHDL Test bench, Test benches using text files. VHDL modeling of Combinational, Sequential logics & FSM, Meta-stability.

Unit II: PLD Architectures 7L

PROM, PLA, PAL: Architectures and applications. Software Design Flow. CPLD Architecture, Features, Specifications, Applications. FPGA Architecture, Features, Specifications, Applications.

Unit III: System & Interconnection 7L

Clock skew, Clock distribution techniques, Supply and ground bounce, power distribution techniques. Power optimization. Interconnect routing techniques; wire parasitic, Signal integrity issues. I/O architecture, pad design. Architectures for low power.

Unit IV: Digital CMOS Circuits 7L

MOS Capacitor, MOS Transistor theory, C-V characteristics, Non ideal I-V effects, Technology Scaling. CMOS inverters, DC transfer characteristics, Power components, Power delay product. Transmission gate. CMOS combo logic design.

Delays: RC delay model, Effective resistance

Unit V: Analog CMOS Design 7L

Current sink and source, Current mirror. Active load, Current source and Push-pull inverters. Common source, Common drain, Common gate amplifiers. Cascode amplifier, Differential amplifier, Operational amplifier.

Text Books

1. Charles H. Roth, "Digital systems design using VHDL", PWS.
2. Wyane Wolf, "Modern VLSI Design (System on Chip)", PHI Publication.

Reference Books

1. Allen Holberg, "Analog CMOS Design", Oxford University Press.
2. Neil H. E. Weste, David Money Harris, "CMOS VLSI Design: A Circuit & System Perspective", Pearson Publication

OPEN ELECTIVE III

Optimization Techniques

BTAROE 704A	**Optimization Techniques**		3L-0T-0P	3 Credits

Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week Tutorial: 0 hr/week	Continuous Assessment: 20 MarksMid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites:

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

CO1	Understand the Knowledge on the concept in operation research
CO2	Understand and Recognize about the linear programing
CO3	Analyze the various methods in one dimensional and multi-dimensional
CO4	Understand the Knowledge in constrained and unconstrained problems
CO5	Apply the various methods in evolutionary programming

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												

CO2												
CO3												
CO4												
CO5												

UNIT – I : INTRODUCTION TO OPERATIONS RESEARCH: 7L

Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

UNIT – II : LINEAR PROGRAMMING: 7L

Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis - Computer programming linear methods

UNIT – III : ONE DIMENSIONAL AND MULTI-DIMENSIONAL: **7L**

Introduction to descent methods – global convergence of decent algorithms – speed convergence –Fibonacci method – golden section search method – steepest descent – newton's method –polynomial approximation method- computer programming in one dimensional and multi-dimensional methods

UNIT – IV : UNCONSTRAINED OPTIMIZATION FOR CONSTRAINED PROBLEMS 7L

Lagrange method – inequality constraints – KKT conditions – quadratic programming – geometric programming – separable linear programming – sequential linear programming – feasible direction method

UNIT – V : EVOLUTIONARY PROGRAMMING 7L

Genetic Engineering – Genetic Operators – Reproduction – Crossover – Mutation – Selection – Genetic Local Search – Simulated Annealing – Ant Colony Optimization – Particle Swarm Optimization

TEXTBOOKS:

1. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010
2. Hitler Libermann, Operations Research: McGraw Hill Pub. 2009
3. Pant J C, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008

REFERENCES:

1. Pannerselvam, Operations Research: Prentice Hall of India 2010.
2. Taha H A, Operations Research, An Introduction, PHI, 2008
3. Singiresu S Rao, "Engineering Optimization: Theory and Practice", Wiley, 4th Edition, 2013.
4. David G.Luenberger, "Linear and Nonlinear Programming", Springer Publications, 3rd Edition, 2008. 5. Hamdy A Taha, "Operations Research – An Introduction", Pearson, 10th Edition, 2018.
6. Stephen Boyd, LievenVandenberghe, "Convex Optimization", Cambridge, 2016.
7. Bertsekas, Dimitri P. "Nonlinear Programming". 3rd Edition. Athena Scientific Press, Belmont, Massachusetts 2016

OPEN ELECTIVE III

Industry 4.0

	Industry 4.0		3L-0T-0P	3 Credits

Teaching Scheme:	**Examination Scheme:**
Lecture: 3 hrs/week Tutorial: 0 hr/week	Continuous Assessment: 20 MarksMid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-requisites: Industrial Automation and Control, Smart Manufacturing System

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

CO1	Remember the challenges for Automation in industry
CO2	Understand opportunities and new technology required for Industry 4.0
CO3	Understand proposed action required for implementation of an Industry 4.0
CO4	Use various technology applications in Industry 4.0
CO5	Apply Internet of Things (IoT) and data security issues in industries

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

Unit I:

Introduction **7L**

Introduction to industry 4.0, Sensor technology used in industry 4.0, Sensing & actuation, Revolution in industry for industry 4.0 aspects, Different Industrial Revolutions. Industry 5.0: An overview, difference between industry 4.0 and 5.0

Unit II:

Smart Manufacturing **7L**

Introduction to smart manufacturing, Role of smart manufacturing in industry 4.0, Internet of Things (IoT) & Industrial Internet of Things (IIoT), Internet of Services

Unit III:

Technologies for enabling Industry 4.0 **7L**

Role of robotics and automation in industry 4.0, Cybersecuirity, Collaborative Robots, Support System for Industry 4.0, Computing, Related Disciplines, Cyber Security.

Unit IV:

Industry 4.0 data **7L**

Industry data, Resource-based view of a firm, Data as a new resource for organizations, Harnessing and sharing knowledge inorganizations, Cloud Computing Basics, Cloud Computing and Industry 4.0.

Unit V:

Applications of industry 4.0 **7L**

Artificial Intelligence- An introduction , Industry practices in AI, Industry 4.0 laboratories, IIoT case studies, Case studies from, Opportunities and Challenges, Future of Works and Skills for Workers in the Industry 4.0 Era, Strategies forcompeting in an Industry 4.0 world

References:

4. “Industry 4.0 Paradoxes and Conflicts” by Jean Cloude Andre (Wiley ISTE), ISBN 9781786304827.
2. “The Concept Industry 4.0” by Christoph Jan Bartodziej (Springer).
“Industry 4.0: The Industrial Internet of Things” by Alasdair Gilchrist (A press),

Dr. Babasaheb Ambedkar Technological University, Lonere

Robot Operating System LAB, BTARCL 706

Scheme Practical: 2 hours / week

List of experiments:

1. ROS Essentials: Introduction to ROS Topics, Services, Actions and Nodes. Simple interaction with the course simulationn environment.

2. Building robot environment: Software representation of a Robot using Unified Robot Description Format (URDF), ROS parameter server and adding real-world object representations to the simulation environment.

3. Autonomous Navigation: Map creation with GMapping package, autonomously navigate aknown map with ROS navigation.

4. Manipulation: Motion planning, pick and place behaviors using industrial robots with ROS MoveIt

5. Robot Vision: Object detection, pose estimation.

6. Mini Project: Building production line application with industrial robot