Dr. Babasaheb Ambedkar Technological University, Lonere

(Established as a University of Technology in the State of Maharashtra)

(Under Maharashtra Act No. XXIX of 2014)
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Curriculum for Undergraduate Degree Programme

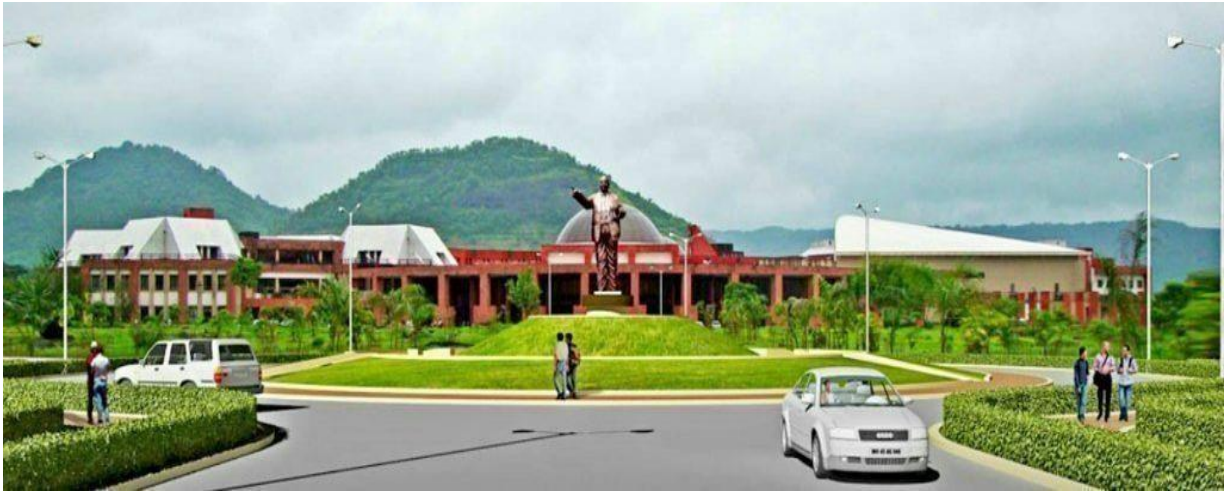
B. Tech in Automation & Robotics

and

B. Tech in Robotics

(Final Year) AY 2024-25

(For Affiliated Institutes)



Abbreviations

BSC: *Basic Science Course*

ESC: *Engineering Science Course*

PCC: *Program Core Course*

PEC: *Program 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 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	BTARC701	PLC and SCADA	3	1	-	20	20	60	100	4
PCC20	BTARC702	Robot Operating System	3	1	-	20	20	60	100	4
PEC5	BTARPE703 (A/B/C/D)	Elective-V	3	-	-	20	20	60	100	3
OEC3	BTAROE704 (A/B) /BTMOE704B	Open Elective-III	3	-	-	20	20	60	100	3
OEC4	BTMOE705A/ BTMOE705B/ BTMOE705C	Open Elective-IV	3	-	-	20	20	60	100	3
PCC 21	BTARCL706	Robot Operating SystemLab	-	-	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**	**100**	**460**	**750**	**22**

BSC = Basic Science Course, ESC = Engineering Science Course, PCC = Professional Core CoursePEC = 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

Open Elective-IV

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

Course Structure for Semester VIII

B. Tech in Automation and Robotics and Robotics (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 from ANNEXURE-A#				20	20	60	100	4
						20	20	60	100	4
PROJ-8	BTARP801/BTARPI801	Project Work or 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	22	18	161

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	Operations Management	12 Weeks	IITR	Prof. Inderdeep Singh
9	BTARC801I	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

SEMESTER VII

PLC and SCADA

BTARC701	PLC and SCADA	PCC19	3-1-0	4 Credits

Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid 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: [07 Hours]

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: [07 Hours]

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: **[07 Hours]**

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: **[07 Hours]**

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) : **[07 Hours]**

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

BTARC702	Robot Operating System	PCC20	3-1-0	4 Credits

Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid 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												
CO5												

Course Contents

Unit I: Introduction **[07 Hours]**

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 **[07 Hours]**

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 **[07 Hours]**

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

Unit IV: ROS Manipulator **[07 Hours]**

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 **[07 Hours]**

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	PEC5	3-0-0	3 Credits

Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week	Continuous Assessment: 20 Marks Mid 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												

Course Contents

Unit I : Fundamentals of Image Processing **[07 Hours]**

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 **[07 Hours]**

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 [07 Hours]

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 [07 Hours]

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 [07 Hours]

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
3. 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	PEC5	3-0-0	3 Credits

Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week	Continuous Assessment: 20 Marks Mid 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												

Course Contents

UNIT 1: Introduction to EDA Tools **[07 Hours]**

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 **[07 Hours]**

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 **[07 Hours]**

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 **[07 Hours]**

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 **[07 Hours]**

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 ISBN 978-1-4842-2046-7.

ELECTIVE V

Robot System Reliability and Safety

BTARPE703C	Robot System Reliability and Safety	PEC5	3-0-0	3 Credits

Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week	Continuous Assessment: 20 Marks Mid 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												

Course Contents

Unit 1: Robot Safety **[07 Hours]**

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 **[07 Hours]**

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 **[07 Hours]**

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 **[07 Hours]**

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 **[07 Hours]**

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	PEC5	3-0-0	3 Credits

Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week	Continuous Assessment: 20 Marks Mid 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												

Course Contents

Unit I: Introduction to VHDL Modeling **[07 Hours]**

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 **[07 Hours]**

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

Unit III: System & Interconnection **[07 Hours]**

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 **[07 Hours]**

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 **[07 Hours]**

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

BTAROE704A	Optimization Techniques	OEC3	3-0-0	3 Credits

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

Pre-Requisites: None

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												

Course Contents

Unit I: Introduction to operations research: **[07 Hours]**

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

Unit II: Linear programming: **[07 Hours]**

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: **[07 Hours]**

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: [07 Hours]

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

Unit V: Evolutionary programming: [07 Hours]

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

BTAROE704B	Industry 4.0	OEC3	3-0-0	3 Credits

Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week	Continuous Assessment: 20 Marks Mid 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												

Course Contents

Unit I: Introduction **[07 Hours]**

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 **[07 Hours]**

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 **[07 Hours]**

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 **[07 Hours]**

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 **[07 Hours]**

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:

1. "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).
3. "Industry 4.0: The Industrial Internet of Things" by Alasdair Gilchrist (A press),

Entrepreneurship Development

BTMOE704B	OEC 3	Entrepreneurship Development	3-0-0	3 Credits

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

Pre-Requisites: None

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

CO1	enlarge the supply of entrepreneurs for rapid industrial development
CO2	Develop small and medium enterprises sector which is necessary for generation of
CO3	employment
CO4	Industrialize rural and backward regions
CO5	Provide gainful self-employment to educated young men and women

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									2			
CO2									2			
CO3											2	
CO4											2	3
CO5												3

Course Contents

Unit 1: Introduction to Entrepreneurship **[07 Hours]**

Evolution of the Concept of Entrepreneur Functions of Entrepreneur, Characteristics of an Entrepreneur, Types of Entrepreneur, Concept of Entrepreneurship, Growth of Entrepreneurship, Barriers of Entrepreneurship, Role of Entrepreneurship in India, Entrepreneurial Motivation, Major Entrepreneurial Competencies.

Unit 2: Small Scale Industries (SSI) **[07 Hours]**

Characteristics of Small Scale Industry, Basis for Classification of Small Scale Industry: Resource Based, Demand Based, Ancillary, Subsidiary Based or Sub-Controlled Type, Technology Based etc. Government Policy for Small Scale Industry, Growth of SSI in Developing Countries, Role of National and State Agencies Providing Assistance To SSI's, Relationship between Small and Big Industries, Ownership Structure, Registration of SSI.

Unit 3: Project Identification and Project Formulation **[07 Hours]**

Meaning of Project, Project Identification and Selection, Elements of Project Formulation, Concept and Significance of Project Formulation, Meaning, Significance and Contents of Project Report. Accounting for Small Enterprises: Objective of Accounting, Accounting Process, Journal, Ledger, Preparation of Balance Sheet and Assessment of Economic Viability

Unit 4: Project Appraisal **[07 Hours]**

Concept of Project Appraisal, Project Appraisal Methods, Cash Flows as Costs and Benefits, Payback Period, Average Rate of Return. Discounted Cash Flow Techniques, Working Capital Management, Cost of Capital, Financing of Enterprises, Project Sickness & Corrective Measures.

Unit 5: Marketing Management **[07 Hours]**

Market Segmentation, Marketing Mix, and Packaging, Pricing Policy, Distribution Channels, and Govt. Purchases from SSIS.

Laws Concerning Entrepreneur: Income Tax Laws, Excise Duty ,The Central Sales Tax Act, Professional Tax, Value Added Tax (VAT), Service Tax, The Workmen Compensation Act, The Minimum Wages Act, The Maternity Benefit Act, The Payment of Bonus Act

Institutional Support

Government Policies for Small Scale Entrepreneurs, Institutional Setup, District Industries Centers, Industrial Estates , SIDCO, NSIC, Directorate of Industries, Commercial Banks, New Entrepreneurial Development Agencies.

Women Entrepreneurship: Growth, Problems, Recent Trends.

References:

1. S. S. Khanka, "Entrepreneurial Development", S. Chand and Company Ltd.
2. C. B. Gupta, N. P. Srinivasan, "Entrepreneurship Development in India", S. Chand and Sons.
3. B. Badhai, "Entrepreneurship Development Programme", Mansell Publishing Ltd.
4. V. Desai, "Dynamics of Entrepreneurial Development and Management", Hindustan Publishing House.
5. David H. Holt, "Entrepreneurship", PHI Learning.
6. Roy Rajeev, "Entrepreneurship", Oxford University Press.

Engineering Economics

BTMOE705A	Engineering Economics	OEC4	3-0-0	3 Credits

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

Pre-Requisites: None

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

CO1	Apply the appropriate engineering economics analysis method(s) for problem solving: present worth, annual cost, rate-of-return, payback, break-even, Benefit-cost ratio.
CO2	Evaluate the cost effectiveness of individual engineering projects using the methods learned and draw inferences for the investment decisions.
CO3	Compare the life cycle cost of multiple projects using the methods learned, and make a quantitative decision between alternate facilities and/or systems.
CO4	Compute the depreciation of an asset using standard Depreciation techniques to assess its impact on present or future value.
CO5	Apply all mathematical approach models covered in solving engineering economics problems: mathematical formulas, interest factors from tables, Excel functions and graphs. Estimate reasonableness of the results.
CO6	Examine and evaluate probabilistic risk assessment methods.
CO7	Compare the differences in economic analysis between the private and public sectors. Recognize the limits of mathematical models for factors hard to quantify.
CO8	Develop and demonstrate teamwork, project management, and professional communications skills

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1											3	
CO2											3	
CO3											3	
CO4											3	
CO5					3						3	
CO6											3	
CO7											3	
CO8									2		3	

Course Contents

Unit 1: Introduction to Economics **[07 Hours]**

Introduction to Economics: Flow in an economy, Law of supply and demand, Concept of Engineering Economics: Engineering efficiency, Economic efficiency, Scope of engineering economics - Element of costs, Marginal cost, Marginal Revenue, Sunk cost, Opportunity cost, Break-even analysis: V ratio, Elementary economic Analysis: Material selection for product Design selection for a product, Process planning.

Unit 2: Value Engineering **[07 Hours]**

Make or buy decision, Value engineering: Function, aims, and Value engineering procedure. Interest formulae and their applications: Time value of money, Single payment compound amount factor, Single payment present worth factor, Equal payment series sinking fund factor, Equal payment series payment Present worth factor: equal payment series capital recovery factor:
Uniform gradient series annual equivalent factor, Effective interest rate, Examples in all the methods.

Unit 3: Cash Flow **[07 Hours]**

Methods of comparison of alternatives: present worth method (Revenue dominated cash flow diagram), Future worth method (Revenue dominated cash flow diagram, cost dominated cash flow diagram), Annual equivalent method (Revenue dominated cash flow diagram, cost dominated cash flow diagram), rate of return method, Examples in all the methods.

Unit 4: Replacement and Maintenance Analysis **[07 Hours]**

Replacement and Maintenance analysis: Types of maintenance, types of replacement problem, determination of economic life of an asset, Replacement of an asset with a new asset: capital recovery with return and concept of challenger and defender, Simple probabilistic model for items which fail completely.

Unit 5: Depreciation and Evaluation of Public Alternatives **[07 Hours]**

Depreciation: Introduction, Straight line method of depreciation, declining balance method of depreciation, sum of the years digits method of depreciation, sinking fund method of depreciation/annuity method of depreciation, service output method of depreciation-
Evaluation of Public Alternatives
Introduction, Examples, Inflation adjusted decisions: procedure to adjust inflation, Examples on comparison of alternatives and determination of economic life of asset.

Texts:

1. PanneerSelvam R, “Engineering Economics”, Prentice Hall of India Ltd, New Delhi, 2001.

References:

1. Chan S. Park, “Contemporary Engineering Economics”, Prentice Hall of India, 2011.
2. Donald G. Newman, Jerome P. Lavelle, “Engineering Economics and analysis”, Engineering Press, Texas, 2010.
3. E. P. Degarmo, W. G. Sullivan and J. R. Canada, “Engineering Economy”, Macmillan, New York, 2011.
4. Zahid A. Khan, "Engineering Economy", Dorling Kindersley, 2012

Biology for Engineers

BTMOE705B	Biology for Engineers	OEC4	3-0-0	3 Credits

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

Pre-Requisites: None

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

CO1	Explain origin of life and Evolution, Cells, Biomolecules-Lipids
CO2	Understand Biomolecules
CO3	Understand Cell structure and function and cell cycle
CO4	Explain Mendelian genetics
CO5	Understand and Explain DNA structure, DNA replication, Transcription, Translation

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	3		1		1			1		1
CO2	1	2	3		1		1			1		1
CO3	1	2	3		1		1			1		1
CO4	1	2	3		1		1			1		1
CO5	1	2	3		1		1			1		1

Course Contents

Unit 1: Introduction **[07 Hours]**

Origin of life and Evolution, Cells, Biomolecules-Lipids

Unit 2: Biomolecules **[07 Hours]**

Carbohydrates, water, Amino acids and proteins, Enzymes, Nucleotides

Unit 3: Cell structure **[07 Hours]**

Cell structure and function, Prokaryotes, Eukaryotes

Unit 4: Cell cycle **[07 Hours]**

Cell division, mitosis, meiosis, culture growth,

Unit 5: Genetics and DNA **[07 Hours]**

Mendelian genetics, genetic disorders, Mendelian inheritance principle, pedigree analysis, Non- Mendelian inheritance DNA Chromatin, DNA structure, DNA replication, Transcription, Translation.

Texts:

1. Arthur T. Johnson, “Biology for Engineers”, CRC Press.

References:

1. N. A. Campbell, J. B. Reece, “Biology”, International edition, Benjamin Cummings, New York, 7th edition or later, 2007 or later.
2. G. Karp, “Cell and Molecular Biology: Concepts and Experiments”, Wiley, New York, 7th edition, 2013.

Intellectual Property Rights

BTMOE705C	Intellectual Property Rights	OEC4	3-0-0	3 Credits

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

Pre-requisites: None

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

CO1	State the basic fundamental terms such as copyrights, Patents, Trademarks etc.,
CO2	Interpret Laws of copy-rights, Patents, Trademarks and various IP registration Processes.
CO3	Exhibit the enhance capability to do economic analysis of IP rights, technology and innovation related policy issues and firms commercial strategies.
CO4	Create awareness at all levels (research and innovation) to develop patentable technologies.
CO5	Apply trade mark law, copy right law, patent law and also carry out intellectual property audits.
CO6	Manage and safeguard the intellectual property and protect it against unauthorized use.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1											
CO2								1				
CO3		1						1				
CO4										1		
CO5	1							1				
CO6								2				

Course Contents

Unit 1: Introduction to Intellectual Property **[07 Hours]**

Introduction, types of intellectual property, international organizations, agencies and treaties, importance of intellectual property rights.

Unit 2: Trade Marks **[07 Hours]**

Purpose and function of trademarks, acquisition of trade mark rights, protectable matter, selecting and evaluating trade mark, trade mark registration processes.

Unit 3: Law of Copy Rights **[07 Hours]**

Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration, notice of copy right, international copy right law.

Unit 4: Law of Patents and Trade Secrets **[07 Hours]**

Foundation of patent law, patent searching process, ownership rights and transfer.

Trade Secrets

Trade secretes law, determination of trade secretes status, liability for misappropriations of trade secrets, protection for submission, trade secrete litigation.

Unfair competition: Misappropriation right of publicity, false advertising.

Unit 5: New Development of Intellectual Property **[07 Hours]**

New developments in trade mark law; copy right law, patent law, intellectual property audits.

International overview on intellectual property, international trade mark law, copy right law, international patent law, and international development in trade secrets law.

Texts:

1. Deborah, E. Bouchoux, "Intellectual Property Right", Cengage learning.
2. Prabuddha Ganguli, "Intellectual property right: Unleashing the knowledge economy", Tata McGraw Hill Publishing Company Ltd.

References:

1. Ajit Parulekar, Sarita D'Souza, "Indian Patents Law-Legal and Business implications", Macmillan India Ltd., 2006.
2. B. L. Wadhera, "Law related to patents, Trademarks, Copyrights, Designs and Geographical indications", Universal law Publishing Pvt. Ltd., India, 2000.
3. P. Narayanan, "Law of copyright and Industrial Designs", Eastern Law house, Delhi, 2010.

Robot Operating System Lab

BTARCL706	Robot Operating System Lab	PCC 21	0-0-2	1 Credit

Teaching Scheme:	Examination Scheme:
Practical: 2 hrs/week	Continuous Assessment: 60 Marks End Semester Exam: 40 Marks

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

CO1	
CO2	
CO3	
CO4	

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

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

Mini Project 2

BTARP707	Mini Project 2	PROJ-7	0-0-6	3 Credits

Teaching Scheme:	Examination Scheme:
Practical: 6 hrs/week	Continuous Assessment: 30 Marks Mid Semester Exam: -- End Semester Exam: 20 Marks

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

CO1	
CO2	
CO3	
CO4	

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												

Industrial Training – 3 Evaluation

BTMI608 (IT – 3)	Industrial Training – 3 Evaluation	PROJ-6	0-0-0	1 Credit

Teaching Scheme:	**Examination Scheme:**
Practical: --	Continuous Assessment: -- Mid Semester Exam: -- End Semester Exam (PR/OR) : 100 Marks

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

CO1	
CO2	
CO3	
CO4	

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												

SEMESTER VIII
Project Work or Internship

BTARP801/ BTARPI801	**Project Work or Internship**	**PROJ-8**	**0-0-20**	**10 Credits**

Teaching Scheme:	**Examination Scheme:**
Practical: 20 hrs/week	Continuous Assessment: 60 Marks End Semester Exam: 40 Marks

- BTARP707 Mini Project 2 and BTARP801/ BTARPI801 Project /Internship are independent and allotment will also be done independently in respective semester.
- BTMP707 Mini Project 2 will be done in-house only.
- Evaluation of both will be done independently as per the time schedule in AC.
- In case student(s) choose in-house project, it may be an extension of the Mini Project, however, Mini Project should be completed in all respect in semester VII itself.