SUBJECT: MANAGERIAL ECONOMICS FOR ROBOTICS		Semester	V
Course Code	**BRI501**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	**Theory**		

Course Objectives:

This course will enable students to:

- Understanding of the intersection between managerial economics and the robotics industry.
- To equip students with the skills and knowledge necessary to analyze economic principles in the context of robotics
- Understand the Fundamentals of Managerial Economics
- Analyze Economic Systems and Their Relationship with Robotics
- Conduct Cost Analysis and Production Planning in Robotics
- Perform Break-even Analysis and Capital Budgeting in Robotics Projects
- Evaluate Market Structures and Pricing Strategies in the Robotics Industry
- Explore Innovation, R&D, and Intellectual Property in Robotics
- Identify Future Trends and Challenges in Robotics

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk method for Problem Solving.
3. Flipped classroom teaching method.
4. Collaborative (Group) learning in the class.
5. Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

INTRODUCTION TO MANAGERIAL ECONOMICS IN ROBOTICS

Overview of Managerial Economics: Definition, scope, and importance of Managerial Economics in Robotics, History and evolution of robotics, Role of Managerial Economic in decision-making process in relevance to robotics and technology industries

Economic Systems and Robotics: Capitalism, socialism, and mixed economies, Role of robotics in different economic systems, Service Industries and manufacturing.

Module-2

COST ANALYSIS AND PRODUCTION IN ROBOTICS

Cost Concepts and Classification: Fixed, variable, and marginal costs, Economies of scale in robotics manufacturing, Learning curve and cost reduction, Production function in robotics, Input-output analysis, Total, average, and marginal product concepts,

Break-even Analysis: Cost-volume-profit analysis, Break-even point in robotics projects, Sensitivity analysis

Capital Budgeting and Investment Decisions: Net present value (NPV), internal rate of return (IRR), and payback period, Risk and uncertainty in robotics investment.

Module-3

MARKET STRUCTURES AND PRICING STRATEGIES IN ROBOTICS

Market Structures: Perfect competition, monopolistic competition, oligopoly, and monopoly, Market structures in the robotics industry, Strategic behaviour in oligopolistic markets.

Pricing Strategies: Cost-plus pricing, value-based pricing, and dynamic pricing, Pricing in technology-driven markets, Price discrimination in the robotics industry, Competitive strategies, Pricing wars, collusion, and cooperation.

Regulation and Antitrust Issues: Government regulations in robotics, Antitrust laws and their impact on robotics companies.

Module-4

INNOVATION, R&D, AND INTELLECTUAL PROPERTY IN ROBOTICS

Innovation and R&D in Robotics: Importance of innovation in the robotics industry process and management, Role of government and private sector in R&D funding

Intellectual Property (IP) Rights: Types of IP: Patents, trademarks, and copyrights, IP strategy in the robotics industry, Licensing and technology transfer

Economics of Innovation: Schumpeterian competition and creative destruction, Diffusion of innovation in robotics, Impact of robotics on productivity and economic growth.

Module-5

THE ECONOMIC AND SOCIAL IMPACT OF ROBOTICS

Impact on Labor Markets: Automation and job displacement, Skill requirements in the robotic era, Policies to mitigate the impact on employment

Robotics and Economic Growth: Contribution of robotics to GDP growth, Robotics in emerging vs. developed economies, Long-term economic forecasts

Ethical and Social Considerations: Ethical dilemmas in robotics and AI, Social implications of widespread automation, Policy responses to technological unemployment

Future Trends and Challenges: Future of work in a robotic economy, Robotics in sustainable development, Global competition in robotics and AI

Course Outcome (COs) (Course Skill Set)

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

- **CO1: Define** key concepts of managerial economics, including cost analysis, market structures, and innovation management, specifically within the context of the robotics industry.
- **CO2: Explain** the role of managerial economics in decision-making processes relevant to the robotics and technology industries.
- **CO3: Apply** cost-volume-profit analysis and capital budgeting techniques to evaluate the financial viability of robotics projects.
- **CO4: Analyze** the impact of different market structures on the competitive strategies and pricing behaviours of robotics companies.
- **CO5: Evaluate** the economic and social impacts of robotics on labor markets, including automation, job displacement, and the long-term growth of economies.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
2. The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
3. Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
4. For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination (SEE):

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Text Books:

- "Managerial Economics: A Problem-Solving Approach" by Luke M. Froeb, Brian T. McCann, Michael R. Ward, and Mikhael Shor
- "Cost-Benefit Analysis: Concepts and Practice" by Anthony E. Boardman, David H. Greenberg, Aidan R. Vining, and David L. Weimer
- "Industrial Organization: Contemporary Theory and Empirical Applications" by Lynne Pepall, Dan Richards, and George Norman
- "Managing Innovation: Integrating Technological, Market and Organizational Change" by Joe Tidd and John Bessant
- "The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies" by Erik Brynjolfsson and Andrew McAfee

Reference Books:

- Varian, H.R. "Intermediate Microeconomics"
- Besanko, D., & Braeutigam, R.R. "Microeconomics"
- Autor, D.H., "Why Are There Still So Many Jobs? The History and Future of Workplace Automation"
- Cemoglu, D., & Restrepo, P., "Robots and Jobs: Evidence from US Labor Markets"

Web links and Video Lectures (e-Resources):

- Introduction to Managerial Economics - MIT OpenCourseWare
- Robotics in Service and Manufacturing - NPTEL Lectures
- Pricing Strategies - Coursera (offered by University of Virginia)
- Ethics and Regulation in Robotics - Oxford Internet Institute
- Impact of Automation on Labor Markets - MIT Technology Review

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

Case Study Analysis: Evaluate real-world scenarios involving robotics and economic decision-making.

1. Economic impact of robotics in service industries
2. Investment analysis for a robotics startup
3. Antitrust issues in the tech industry

Research Project:

Analyze the economic impact of robotics in a specific industry
Successful R&D and innovation strategies in robotics

HYDRAULICS AND PNEUMATICS (IPCC)		Semester	V
Course Code	**BRI502**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 8-10 Lab slots	Total Marks	100
Credits	04	Exam Hours	03

Course Learning Objectives (CLOs)

The course will enable the students to:

CLO1. Gain knowledge of basics of hydraulic and pneumatic systems.

CLO2. Understanding the working principles of hydraulics and pneumatics components.

CLO3. Exposure to build and interpret hydraulic and pneumatic circuits related to industrial applications.

CLO4. To familiarize with logic controls and trouble shooting.

Teaching-Learning Process (General Instructions)

These are sample Strategies; that teachers can use to accelerate the attainment of the various course outcomes.These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through Power Point Presentations and Video demonstrations or Simulations.
2. Chalk and Talk method for Problem Solving.
3. Adopt collaborative (Group Learning) Learning in the class.
4. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills and develops thinking skillssuch as evaluating, generalizing, and analyzing information.
5. Conduct Laboratory Demonstrations and Practical Experiments to enhance experiential skills.

Module-1

Introduction to fluid power systems

Fluid power system: Basic components, advantages, limitations and applications. Transmission of power at static and dynamic states, Pascal's law, structure of hydraulic control system, applications, problems on Pascal's law.

Fluids for hydraulic system: types, properties, and selection. Additives, effect of temperature and pressure on hydraulic fluid. Seals, sealing materials, Types of pipes and hoses, Pressure drop in hoses/pipes. Fluid conditioning through filters, strainers; sources of contamination and contamination control.

Module-2

The source of Hydraulic Power: Pumps: Classification of pumps, Pumping theory of positive displacement pumps, construction and working of Gear pumps, Vane pumps, Piston pumps, fixed and variable displacement pumps, Pump performance characteristics, pump selection factors, problems on pumps.

Accumulators: Types, and applications of accumulators. Types of Intensifiers, Pressure switches /sensor, Temperature switches/sensor.

Actuators: Classification cylinder and hydraulic motors, Hydraulic cylinders, single and double acting cylinder, mounting arrangements, cushioning, special types of cylinders, problems on cylinders.

Construction and working of rotary actuators such as gear, vane, piston motors. Theoretical torque, power, flow rate, and hydraulic motor performance; Symbolic representation of hydraulic actuators (cylinders and motors). Numerical problems.

Module-3

Components and hydraulic circuit design: Classification of control valves, Directional Control Valves- symbolic representation, constructional features of poppet, sliding spool, rotary type valves solenoid and pilot operated DCV, shuttle valve, and check valves. Pressure control valves - types, direct operated types and pilot operated types. Flow Control Valves -compensated and non-compensated FCV, needle valve, temperature compensated, pressure compensated, pressure and temperature compensated FCV, symbolic representation.

Hydraulic Circuit Design: Control of single and Double -acting hydraulic cylinder, regenerative circuit, pump unloading circuit, counterbalance valve application, hydraulic cylinder sequencing circuits, speed control of hydraulic cylinder- metering in, metering out and bleed off circuits. Pilot pressure operated circuits.

Module-4

Pneumatic power systems

Introduction to Pneumatic systems: Pneumatic power system, advantages, limitations, applications, Choice of working medium. Characteristics of compressed air. Structure of pneumatic control system, fluid conditioners-dryers and FRL unit.

Pneumatic Actuators: Linear cylinder – types of cylinders, working, end position cushioning, seals, mounting arrangements, and applications. Rotary cylinders- types, construction and application, symbols.

Pneumatic Control Valves: DCV such as poppet, spool, suspended seat type slide valve, pressure control valves, flow control valves, types and construction, use of memory valve, Quick exhaust valve, time delay valve, shuttle valve, twin pressure valve, symbols.

Module-5

Pneumatic control circuits

Simple Pneumatic Control: Direct and indirect actuation pneumatic cylinders, speed control of cylinders - supply air throttling and exhaust air throttling.

Signal Processing Elements: Use of Logic gates - OR and AND gates in pneumatic applications. Practical examples involving the use of logic gates.

Multi- Cylinder Application: Coordinated and sequential motion control, motion and control diagrams. Signal elimination methods, Cascading method- principle, Practical application examples (up to two cylinders) using cascading method (using reversing valves).

Electro- Pneumatic Control: Principles - signal input and output, pilot assisted solenoid control of DCV's, use of relay and contactors.

PRACTICAL COMPONENT OF IPCC *(May cover all / major modules)*

Sl.NO	Experiments
1	To study components and functioning of a hydraulic fluid power supply.
2	Design and analysis of Hydraulic circuit for speed control of single and double acting cylinders.
3	Design and analysis of Hydraulic circuit for sequencing of two hydraulic cylinders using sequence valves.
4	Design of regenerative Hydraulic circuit.
5	Design and analysis of Hydraulic circuit using counterbalance valve.
6	Design and analysis of synchronization circuit for two cylinders.
7	Design and analysis of Speed Control of hydraulic cylinders and motors using solenoid valves
8	Sequencing of two Pneumatic cylinders using sequence valves.
9	Sequencing of two Pneumatic cylinders using Proximity switches.
10	Pneumatic circuit for Speed control of Pneumatic motor.

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Course Outcomes (COs) (Course Skill Set):

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

CO1: Identify and analyse the functional requirements of a fluid power transmission system for a given application.

CO2: Visualize how a hydraulic/pneumatic circuit will work to accomplish the function.

CO3: Design an appropriate hydraulic or pneumatic circuit or combination circuit like electro-hydraulics, electro- pneumatics for a given application.

CO4: Select and size the different components of the circuit.

CO5: Develop a comprehensive circuit diagram by integrating the components selected for the given application.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. Theminimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to havesatisfied the academic requirements and earned the credits allotted to each subject/ course if the student securesa minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

CIE for the theory component of the IPCC (maximum marks 50)

- IPCC means practical portion integrated with the theory of the course.
- CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.
- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theorycomponent of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for thetest to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including
  viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers forthe course (**duration 03 hours**)

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximumof 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored by the student shall be proportionally scaled down to 50 Marks

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have aCIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

Suggested Learning Resources:

Text Books

[1] Fluid Power with Applications, Anthony Esposito, Pearson Education Inc., 6th Edition 2000.

[2] Pneumatics and Hydraulics, Andrew Parr, Jaico Publishing Co, 1993.

Reference Books/Journal

[1] Hydraulics and Pneumatics, Jagadeesha T; I. K. International Publishing House Pvt. Ltd., 2015.

[2] Industrial Hydraulics, Pippenger Hicks, McGraw Hill, New York

[3] Hydraulic & Pneumatic Power for Production, Harry L. Stewart, Industrial Press US, 1997.

[4] Pneumatic Systems, S. R. Majumdar, TATA McGraw Hill Publish, 1995.

[5] Hydraulic & Pneumatics' CMTI Data Book.

[6] Saeed B. Niku, "Introduction to Robotics – Analysis, Control, Applications", Wiley India Pvt. Ltd., 2010.

[7] R. Mittal, Nagrath, "Robotics and Control", McGraw Hill Education, 2017.

Web links and Video Lectures (e-Resources):

1. Oil Hydraulics and Pneumatics Online (https://archive.nptel.ac.in/courses/112/106/112106300/) Description: This website provides comprehensive resources related Hydraulics and Pneumatics, including basic components, Control Valves, and designing a circuit.
2. Video Lecture Series: Hydraulics and Pneumatics, University of Sheffield- (https://digitalmedia.sheffield.ac.uk/channel/MEC333+Hydraulics+and+Pneumatics/95899281) Description: This video lecture series covers various topics in Hydraulics and Pneumatics, including Valves, Actuators and fluid power circuits.

FUNDAMENTALS OF AI FOR ROBOTICS		Semester	V
Course Code	**BRI503**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	4:0:0	SEE Marks	50
Total Hours of Pedagogy	50	Total Marks	100
Credits	04	Exam Hours	
Examination nature (SEE)	THEORY		

Course objectives:

- Gain a historical perspective of AI and its foundations.
- Become familiar with basic principles of AI toward problem solving, inference, perception, knowledge representation, and learning.
- Investigate applications of AI techniques in intelligent agents, expert systems, artificial neural networks and other machine learning models.
- Experience AI development tools such as an 'AI language', expert system shell, and/or data mining tool.
- Experiment with a machine learning model for simulation and analysis.
  Explore the current scope, potential, limitations, and implications of intelligent systems.

Module-1

INTRODUCTION: History, Definition of AI, Foundations, History of AI, Emulation of human cognitive process, Intelligent agents – The concept of rationality, the nature of environments, the structure of agents.

Text book 1 : 1.1 to 1.4 & 2.1 to 2.4

Module-2

PROBLEM SOLVING: Problem – Solving AgentS, Problem Definitions, Formulating Problems, Searching for solutions –measuring Problem – Solving Performance with examples. Search Strategies: Uninformed search strategies – Breadth –first Search,

Text book 1 : 3.1 to 3.4

Module-3

HEURISTIC SEARCH METHODS: Uniform – Cost Search, depth –first search, depth – limited search, Iterative deepening depth – first search, bidirectional search, comparing uniformed search strategies. Informed search strategies – heuristic information, Hill climbing methods, best – first search, branch – and – bound search, optimal search and A* and Iterative deepening A*.

CLASSICAL SEARCH: Local search algorithms and optimization problems, continuous spaces, Searching with Nondeterministic Actions

Text book 1 : 3.6 to 3.6 & 4.1 to 4.6

Module-4

EXPERT SYSTEM: Expert system – Introduction, Rule-Based Systems Architectures, Nonproduction Systems Architectures, Dealing with Uncertainty, Knowledge Acquisition and Validation, Knowledge System Building Tools

Text book 2 : 15.1 to 15.6

Module-5

AI IN ROBOTICS: Introduction, Robot Hardware, Robotic Perception, Planning to move, Planning Uncertain Movements, Moving, Robotic Software Architectures, Application Domains

Text book 2 : 25.1 to 25.8

Course outcome (Course Skill Set)

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

1. Demonstrate fundamental understanding of the history of artificial intelligence (AI) and its foundations.
2. Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation, and learning.
3. Demonstrate awareness and a fundamental understanding of various applications of AI techniques in intelligent agents, expert systems, artificial neural networks and other machine learning models.
4. Demonstrate proficiency developing applications in an 'AI language', expert system shell, or data mining tool.
5. Demonstrate proficiency in applying scientific method to models of machine learning.
6. Demonstrate an ability to share in discussions of AI, its current scope and limitations, and societal implications.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

TEXT BOOKS:

1. Artificial Intelligence Modern Approach : Russell Stuart, Norvig Peter , Pearson Education seRIes in AI 3rd Edition, 2010.
2. Introduction to Artificial Intelligence and Expert Systems : Dan.W.Patterson, PHI Learning 2009

REFERENCE BOOKS:

1. A guide to Expert Systems : Donald.A.Waterman, Pearson 2002

Web links and Video Lectures (e-Resources):

- https://onlinecourses.nptel.ac.in/noc24_ge47/preview
- https://elearn.nptel.ac.in/shop/nptel/fundamentals-of-artificial-intelligence/?v=c86ee0d9d7ed
- https://www.youtube.com/watch?v=Zzz4gGVFLQI

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Building a Simple Chatbot
- Creating a Recommendation System
- AI-Powered Virtual Assistant
- Facial Recognition System

ARTIFICIAL INTELLIGENCE LAB		Semester	**5**
Course Code	**BRIL504**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2:0	SEE Marks	50
Credits	01	Exam Hours	100
Examination nature (SEE)	**Practical**		

Course objectives:

- Implement and demonstrate the Depth First Search (DFS) algorithm
- Implement the A* search algorithm, which is an informed search algorithm that uses heuristics to find the shortest path to the goal.
- To equip students with the foundational knowledge and practical skills necessary to implement and understand various AI search algorithms and problem-solving strategies.

Sl.NO	**Experiments**
1	Implement and Demonstrate Depth First Search Algorithm on Water Jug
2	Implement and Demonstrate Best First Search Algorithm on Missionaries-Cannibals Problems using Python
3	Implement A* Search algorithm

4	Implement AO* Search algorithm
5	Solve 8-Queens Problem with suitable assumptions
6	Implementation of TSP using heuristic approach
7	Implementation of the problem-solving strategies: either using Forward Chaining or Backward Chaining
8	Implement resolution principle on FOPL related problems
9	Implement Tic-Tac-Toe game using Python
10	For a given set of training data examples stored in a .CSV file, implement and demonstrate the Candidate-Elimination algorithim to output a description of the set of all hypotheses consistent with training examples.

Course outcomes (Course Skill Set):

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

CO1: Understand and apply search algorithms to solve classical AI problems.
CO2: Implement heuristic and informed search strategies like A* and AO*.
CO3: Develop solutions to constraint satisfaction problems, such as the 8-Queens problem.
CO4: Understand and implement problem-solving strategies using logical reasoning techniques like forward and backward chaining.
CO5: Apply the resolution principle in logical reasoning and theorem proving.
CO6: Implement game-playing algorithms and explore decision-making processes in AI.
CO7: Understand and apply the Candidate-Elimination algorithm for concept learning in machine learning.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation (CIE):

CIE marks for the practical course are**50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment is to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments are designed by the faculty who is handling the laboratory session and are made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled down to **30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct a test of 100 marks after the completion of all the experiments listed in the syllabus.

- In a test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The marks scored shall be scaled down to **20 marks** (40% of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and marks of a test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

- SEE marks for the practical course are 50 Marks.
- SEE shall be conducted jointly by the two examiners, an internal examiner from the same institute and an external examiner from other institute, are appointed by the University.
- The examination schedule and names of examiners are informed to the university before the conduction of the examination. These practical examinations are to be conducted between the schedule mentioned in the academic calendar of the University.
- All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the questions lot prepared by the examiners jointly.
- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 15% of Marks allotted to the procedure part are to be made zero.

The minimum duration of SEE is 02 hours

Suggested Learning Resources:

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INTRODUCTION TO PLC		Semester	V
Course Code	**BRI515A**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	40 Hrs.	Total Marks	100
Credits	03	Exam Hours	03

**** Additional One hour may be considered for instructions if required***

Course objectives:

Students will be able

- Understanding of PLC architecture, components, and their role in industrial automation systems.
- Acquire proficiency in ladder logic programming, enabling them to create efficient and effective PLC control programs.
- Utilize PLC functions and instructions to solve real-world automation problems and optimize industrial processes.
- Gain expertise in data handling, shift registers, and other advanced programming concepts for complex automation tasks.
- Develop the ability to diagnose and rectify PLC system issues, ensuring optimal performance and reliability.

Teaching-Learning Process (General Instructions)

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Utilize traditional board work to guide students through problem-solving exercises and PLC programming tasks.
3. Implement a flipped classroom model where students review PLC materials independently and engage in hands-on activities during class.
4. Foster group learning activities to encourage teamwork and peer support in understanding and applying PLC systems.
5. Apply PBL techniques to help students develop critical thinking and analytical skills by solving real-world PLC-related problems.

MODULE-1

Introduction to PLC Systems: Overview of PLCs, advantages, and disadvantages, Comparison between Relay Logic Control and PLC Logic Control, PLC architecture and its components

PLC Hardware: Internal architecture of PLC, I/O modules (interfaces), Memory organization and addressing.

MODULE-2

PLC Programming Fundamentals: Programming standards, ladder logic basics, Conversion from word description to ladder diagram, Input/output instructions and examples

PLC Logic Operations: Contact and coil programming, Logical operations (AND, OR, NOT, XOR Etc) in ladder logic, Practical programming examples and exercises.

MODULE-3

PLC Arithmetic and Timer Functions: Arithmetic operations (addition, subtraction, multiplication, division), Timer functions (ON delay, OFF delay, pulse timers), Application examples in process control

PLC Counter Functions: Basic counter operations, up/down counters, Application examples in automation systems, Dual counter operation and sequencing

MODULE-4

Data Handling Functions: Skip functions, master control relay, MOVE and block MOVE functions, Application of FIFO and LIFO in automation

Shift Registers: Operation and programming of shift registers, Practical applications in real-time systems, Example scenarios like flashing arrow patterns and Morse code

MODULE 5

Advanced PLC Programming: PID control and implementation in PLCs, Integration of PLCs with SCADA systems, Distributed Control Systems (DCS)
PLC Maintenance and Troubleshooting: Selection criteria for PLCs, Maintenance strategies and best practices, Troubleshooting common PLC problems

Course outcomes (Course Skill Set):

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

- Understand the fundamental concepts of simulation modelling and the role of system variables in representing real-world processes.
- Apply dimensional analysis and physical modelling techniques to accurately represent and analyze engineering systems.
- Develop and solve deterministic and state-space models for both static and dynamic systems using mathematical tools.
- Implement traditional and non-traditional optimization techniques, including genetic algorithms and simulated annealing, to enhance system performance.
- Utilize advanced simulation tools, including MATLAB and Simulink, to model, analyze, and optimize continuous and discrete engineering systems.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment. **Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

Semester-End Examination (SEE):

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students must answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Textbooks

1. "Programmable Logic Controllers: Principles and Applications" by John W. Webb and Ronald A. Reis
2. "Programmable Logic Controllers" by Frank D. Petruzella
3. "Industrial Automation and Process Control" by Jon Stenerson
4. "Programmable Logic Controllers and Industrial Automation" by Madhuchhanda Mitra and Samarjit Sen Gupta
5. "Programmable Logic Controllers: Industrial Control" by Khaled Kamel and Eman Kamel

Reference books

1. "Programmable Logic Controllers" by W. Bolton
2. "Introduction to PLCs" by Gary Dunning
3. "Automation, Production Systems, and Computer-Integrated Manufacturing" by Mikell P. Groover
4. "Industrial Control Electronics: Devices, Systems, and Applications" by Terry L.M. Bartelt
5. "Industrial Process Automation Systems: Design and Implementation" by B.R. Mehta and Y.J. Reddy

Web links and Video Lectures (e-Resources):

1. **NPTEL : PLC Programming:** https://www.youtube.com/watch?v=IbafU1NvxOE&list=PLbLIF1odr7VxEBquNDn5lcd57vKb1bq5B&index=1
2. **PLC Training Series** https://www.youtube.com/watch?v=d6sSKfCx1A0&list=PLDJvwEGpPRLZzgOEj-RmY41Ju-ER9tWID
3. **PLC Tutorials:** https://www.realpars.com/courses/plc-programming-made-easy-level-1
4. https://www.solisplc.com/tutorials/plc-programming-tutorial-allen-bradley-training-in-rslogix-5000-ladder-logic-basics-for-beginners
5. https://www.linkedin.com/pulse/real-world-case-studies-successful-applications-plc-programming-81ivc/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- **Course seminar**
- **Term project**

FINITE ELEMENT ANALYSIS		Semester	V
Course Code	**BRI515B**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	40 Hrs.	Total Marks	100
Credits	03	Exam Hours	03

**** Additional One hour may be considered for instructions if required***

Course objectives:

Students will be able

- To learn the basic principles of finite element analysis procedure
- To understand heat transfer problems with application of FEM.
- Solve 1 D, 2 D and dynamic problems using Finite Element Analysis approach.
- To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses.

Teaching-Learning Process (General Instructions)

These are sample strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk method for Problem Solving.
3. Adopt flipped classroom teaching method.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analyzing information.

MODULE-1

Introduction to Finite Element Method: General steps of the finite element method. Engineering applications of finite element method. Advantages of the Finite Element Method. (L 1.4,1.5,1.6) Potential energy method, Displacement method of finite element formulation. Convergence criteria, Discretization process, ***Rayleigh Ritz method, Galerkin's method (for study purpose only)***

Types of elements: 1D, 2D and 3D, Node numbering, Location of nodes. Strain- displacement relations, Stress-strain relations, Plain stress and Plain strain conditions, temperature effects.

Interpolation models: Simplex, complex and multiplex elements, linear interpolation polynomials in

terms of global coordinates 1D, 2D, 3D Simplex Elements.

MODULE-2

Introduction to the stiffness (Displacement) method: Introduction, One-Dimensional Elements- Analysis of Bars and Trusses, Linear interpolation polynomials in terms of local coordinate's for1D, 2D elements. Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates, Constant strain triangle, Four-Noded Tetrahedral Element (TET 4), Eight-Noded Hexahedral Element (HEXA 3 8), 2D iso-parametric element,

Numerical Problems: Solution for displacement, stress and strain in 1D straight bars, stepped bars and tapered bars using elimination approach and penalty approach

MODULE-3

Beams and Shafts: Boundary conditions, Load vector, Hermite shape functions, Beam stiffness matrix based on Euler- Bernoulli beam theory, Numerical problems on simply supported, fixed straight and cantilever beams, propped cantilever beams with concentrated and uniformly distributed load.

Torsion of Shafts: Finite element formulation of shafts, determination of stress and twists in circular shafts.

MODULE-4

Heat Transfer: Basic equations of heat transfer: Energy balance equation, Rate equation: conduction, convection, radiation, 1D finite element formulation using variational method, Problems with temperature gradient and heat fluxes, heat transfer in composite sections, straight fins.

Fluid Flow: Flow through a porous medium, Flow through pipes of uniform and stepped sections, Flow through hydraulic networks.

MODULE 5

Axi-symmetric Solid Elements: Derivation of stiffness matrix of axisymmetric bodies with triangular elements, Numerical solution of axisymmetric triangular element(s) subjected to surface forces, point loads, angular velocity, pressure vessels. **Dynamic Considerations**: Formulation for point mass and distributed masses, Consistent element mass matrix of one- d i m e n s i o n a l bar element, truss element, triangular element, beam element. Lumped mass matrix of bar element, truss element, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.

Course outcomes (Course Skill Set):

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

- Identify the application and characteristics of FEA elements such as bars, beams, plane and isoperimetric elements.
- Develop element characteristic equation and generation of global equation.
- Formulate and solve Axi-symmetric and heat transfer problems.
- Apply suitable boundary conditions to a global equation for bars, trusses, beams, circular shafts, heat transfer, fluid flow, axi-symmetric and dynamic problems.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then

only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.

- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment. **Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

Semester-End Examination (SEE):

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students must answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Textbooks

1. A first course in the Finite Element Method, Logan, D. L, Cengage Learning, 6th Edition 2016.
2. Finite Element Method in Engineering, Rao S. S, Pergamon Int. Library of Science 5th Edition 2010.
3. Finite Elements in Engineering Chandrupatla T. R PHI 2nd Edition 2013

Reference books

1. Finite Element Method, J.N.Reddy, McGraw -Hill International Edition.
2. Finite Elements Procedures Bathe K. J PHI

Web links and Video Lectures (e-Resources):

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Course seminar
- Term project

DATA ANALYTICS		Semester	V
Course Code	**BRI515C**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3 Hours
Examination type (SEE)	**Theory**		

Course objectives:

- To explain introductory concepts, a brief methodological description and some descriptive statistics of data
- To explain multivariate descriptive statistics methods of data analytics, methods used in the data preparation phase of the CRISP-DM methodology, concerning data quality issues, converting data to different scales or scale types and reducing data dimensionality.
- To explain methods involving clustering, frequent pattern mining, capturing the most frequent patterns
- To explain cheat sheet and project on descriptive analytics and generalization, performance measures for regression and the bias–variance trade-off.
- To explain the binary classification problem, performance measures for classification, methods based on probabilities and distance measures and more advanced and state-of-the-art methods of prediction of data.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Show Video/animation films to explain functioning of various concepts.
3. Encourage collaborative (Group Learning) Learning in the class.
4. Ask at least three HOT (Higher order Thinking) questions in the class, which promotes critical thinking.
5. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it.
6. Topics will be introduced in a multiple representation.
7. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
8. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.

Module-1

Data Analysis &Probability Theory: Data Representation. Average. Spread, Experiments. Outcome. Events, Probability, Permutation & Combinations, Random Variables. Probability Distributions, Mean and Variance of Distributions, Binomial. Poisson and Hypergeometric Distributions, Normal Distributions, Distribution of Several Random Variables

Module-2

Introduction to Data: Big Data and Data Science, Big Data Architectures, Small Data, what is Data, A Short Taxonomy of Data Analytics, Examples of Data Use.

Mathematical Statistics: Introduction. Random sampling, Point Estimation of Parameters, confidence Interval, Testing Hypotheses. Decisions, Quality Control, Acceptance Sampling, Goodness of Fit. X^2-Test, Nonparametric Tests, Regression. Fitting Straight lines. Correlation.

Module-3

Descriptive Statistics: Scale Types, Descriptive Univariate Analysis, Descriptive Bivariate Analysis
Multivariate Analysis: Multivariate Frequencies, Multivariate Data Visualization, Multivariate Statistics, Infographics and Word Clouds.
Data Quality and Pre-processing: Data Quality, Converting to a Different Scale Type, Converting to a Different Scale, Data Transformation, Dimensionality Reduction.

Module-4

Clustering: Distance Measures, Clustering Validation, Clustering Techniques.
Frequent Pattern Mining: Frequent Item sets, Association Rules, Behind Support and Confidence, Other Types of Pattern.
Cheat Sheet and Project on Descriptive Analytics: Cheat Sheet of Descriptive Analytics, Project on Descriptive Analytics.

Module-5

Regression: Predictive Performance Estimation, Finding the Parameters of the Model, Technique and Model Selection.
Classification: Binary Classification, Predictive Performance Measures for Classification, Distance-based Learning Algorithms, Probabilistic Classification Algorithms.

Course outcome (Course Skill Set)
At the end of the course, the student will be able to :

1. Define data, its architecture and examples of data use.
2. Explain methods of descriptive analytics of data.
3. Explain methods for multivariate analysis, data preparation and data transformation and reducing.
4. Explain techniques for clustering the data and pattern mining
5. Explain the methods of predictive analytics, performance measures for regression and algorithms for regression.
6. Explain performance measures for classification of data and methods of prediction

Assessment Details (both CIE and SEE)
The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks(18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions(for 100 marks), selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Text Books

1. Advanced Engineering Mathematics, Erwin Kreyszig, 9th Edition, Wiley India Edition
2. A General Introduction to Data Analytics, *João Mendes Moreira*, Wiley 2019

Reference Books :

1. Introduction to Data Science, Jeffrey M. Stanton, 2013
2. The Elements of Data Analytic Style, Jeff Leek, 2015
3. Business intelligence & Data Mining, Dr. Anil Maheswari, 2015
4. Mathematics IV, Dr. KS Chandrashekar
5. Mathematical Statistics and Data Analysis, John A. Rice, Third Edition

Web links and Video Lectures (e-Resources):

- https://bcs.wiley.com/he-bcs/Books?action=index&bcsId=11277&itemId=1119296242
- https://onlinecourses-archive.nptel.ac.in/noc17_mg24
- *http://meity.gov.in/writereaddata/files/Guidelines%20for%20Use%20of%20IT%20Devices%20on%20Government%20Network%20_0.pdf*

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

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SIMULATION, MODELLING AND ANALYSIS		Semester	V
Course Code	**BRI515D**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	40 Hrs.	Total Marks	100
Credits	03	Exam Hours	03

**** Additional One hour may be considered for instructions if required***

Course objectives:

Students will be able

- To master the fundamental concepts and methodologies of simulation.
- To develop and apply various modelling techniques to real-world engineering and industrial systems.
- To utilize optimization techniques to enhance system performance.
- To employ simulation tools effectively for model development and analysis.
- To integrate simulation into the decision-making process for complex systems.

Teaching-Learning Process (General Instructions)

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Utilize traditional board work to guide students through problem-solving exercises and PLC programming tasks.
3. Implement a flipped classroom model where students review PLC materials independently and engage in hands-on activities during class.
4. Foster group learning activities to encourage teamwork and peer support in understanding and

applying PLC systems.

5. Apply PBL techniques to help students develop critical thinking and analytical skills by solving real-world PLC-related problems.

MODULE-1

Introduction to Simulation Modelling

Fundamentals of Simulation: Definitions: System, environment, input and output variables, state variables, Types of systems: Static vs. dynamic systems, Modelling strategies and hierarchy of knowledge about systems

Basics of Simulation Tools: Overview of MATLAB and its applications in simulation, Introduction to Simulink for dynamic system modelling

MODULE-2

Physical and Mathematical Modelling

Dimensional Analysis and Physical Modelling: Dimensionless groups, similarity criteria, Application of dimensional analysis in physical models,

Mathematical Modelling of Systems: Review of conservation laws, deterministic models (distributed and lumped parameter models), State-space models, transfer functions, and block diagrams

MODULE-3

Optimization Techniques

Traditional Optimization Techniques: Gradient-based techniques for optimization, Application examples using MATLAB,

Non-Traditional Optimization Techniques: Genetic Algorithms (GA) and Simulated Annealing, Implementation of GA and Simulated Annealing in MATLAB

MODULE-4

Neural Networks and Fuzzy Logic in Modelling

Neural Network Modelling: Architecture of neural networks, learning algorithms, Application of neural networks in engineering systems

Fuzzy Logic and Expert Systems: Fuzzy sets, membership functions, fuzzy inference systems, Design and implementation of fuzzy controllers

MODULE 5

Simulation of Engineering Systems

Monte Carlo Simulation: Overview of Monte Carlo methods, applications in engineering problems, Implementation of Monte Carlo simulation using MATLAB

Simulation of Continuous and Discrete Systems: Techniques for simulating continuous and discrete processes, Case studies and practical examples using MATLAB and Simulink

Course outcomes (Course Skill Set):

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

- Demonstrate a comprehensive understanding of simulation concepts, including system definition, model development, and validation.
- Apply dimensional analysis and physical modelling techniques to create accurate representations of engineering systems.
- Develop and solve deterministic and stochastic models using appropriate mathematical and computational methods.
- Implement optimization algorithms to improve system performance and identify optimal design parameters.
- Utilize simulation software to build, analyse, and interpret simulation models for complex engineering systems.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum of the CIE (Continuous Internal

Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment. **Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

Semester-End Examination (SEE):

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students must answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Textbooks

1. Simulation Modeling and Analysis by Averill M. Law and W. David Kelton
2. Discrete-Event System Simulation by Jerry Banks, John S. Carson II, Barry L. Nelson, and David M. Nicol
3. Introduction to Simulation and Modeling by James R. Clymer
4. Simulation Modeling with Python by Vincent Knight
5. "Theory of Modelling and Simulation" by B.P. Zeigler, H. Praehofer, and I.G. Kim.

Reference books

1. The Art of Modelling with Any Logic by Michael Tolkmitt
2. System Dynamics: Modeling for Policy Decisions by Jay W. Forrester
3. Optimization Modeling with Excel Solver by Winston L. Winston
4. "Getting Started with MATLAB" by Rudra Pratap, Oxford University Press, 2009.
5. "Modern Control Engineering" by Katsuhiko Ogata.
6. "Neuro-Fuzzy and Soft Computing" by J.S.R. Jang, C.T. Sun, and E. Mizutani.
7. "System Simulation: The Art and Science" by R.E. Shannon

Web links and Video Lectures (e-Resources):

NPTEL: Modeling and Simulation of Discrete Event Systems:

1. **https://www.youtube.com/watch?v=Ej26SZrcPAg&list=PLOcdvqD25x4P4XpSdILrQ9mKP9cAMQjBV&index=1**

Tutorials :

2. **https://ctms.engin.umich.edu/CTMS/index.php?example=Introduction&section=SimulinkModeling**
3. **https://www.geeksforgeeks.org/introduction-to-simulation-modeling-in-python/**
4. **https://www.datacamp.com/tutorial/monte-carlo-simulation-in-excel**

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- **Course seminar**
- **Term project**

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ROBOT OPERATING SYSTEM		Semester	VI
Course Code	**BRI601**	CIE Marks	50
Teaching Hours/Week (L: T:P)	(4:0:0)	SEE Marks	50
Total Hours of Pedagogy	50	Total Marks	100
Credits	04	Exam Hours	03

Course objectives:

Students will be able

Understanding ROS framework elements.

Understand and Navigate the ROS Ecosystem
Engage with the ROS Community and Ecosystem

Teaching-Learning Process (General Instructions)

These are sample strategies teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk method for Problem Solving.
3. Adopt the flipped classroom teaching method.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem-Based Learning (PBL), which fosters analytical skills and develops thinking skills such as evaluating, generalizing, and analyzing information.

MODULE-1 INTRODUCTION TO ROS

Introduction to ROS, ROS filesystem, ROS Packages, ROS Meta Packages, ROS Services, ROS Nodes, ROS Messages, ROS Topics, ROS bags, ROS Master, ROS Parameter, ROS community level.

MODULE-2 Getting Started with ROS Programming

Creating a ROS package, Working with ROS topics, Creating ROS nodes, Building the nodes, adding custom msg and srv files, Working with ROS services, Working with ROS actionlib, Creating the ROS action server, Creating the ROS action client, Building the ROS action server and client, creating launch files, Applications of topics, services, and actionlib, Maintaining the ROS package, Releasing ROS package

MODULE-3 Robot Programming Using ROS

Introduction to Robot Programming, ROS equation, History of ROS, Robots and Sensor support for ROS, ROS Architecture, ROS File System.
ROS packages for robot modeling, robot modeling using URDF, ROS package for the robot description.

MODULE-4 ROS Tools and Utilities

Visualization tools: RViz, rqt_graph, rqt_plot, Simulation tools: Gazebo, Stage, Debugging tools: rqt_console, rqt_logger_level, Package creation and structure, Dependency management with rospack and rosdep

MODULE- 5 ROS for Industrial Robots

ROS-Industrial packages, Goals of ROS-Industrial, ROS-Industrial – a brief history, Benefits of ROS-Industrial, Installing ROS-Industrial packages, Block diagram of ROS-Industrial packages, creating a URDF for an industrial robot, Creating, Updating and Testing the Move It configuration

Course outcome (Course Skill Set)

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

1. Demonstrate Proficiency in ROS Architecture
2. Manage and Utilize ROS Packages and Filesystems
3. Implement and Test ROS Communication Mechanisms:
4. Engage with and Contribute to the ROS Community

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50) in the semester-end examination (SEE), and a minimum of 40% (40 marks out of 100) in the total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.

- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.
- The Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination (SEE):

- Theory SEE will be conducted by the University as per the scheduled timetable, with common question papers for the course (duration 03 hours).
- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a
- maximum of 3 sub-questions), should have a mix of topics under that module.
- The students have to answer 5 full questions, selecting one full question from each module.
- Marks scored shall be proportionally reduced to 50 marks

DIGITAL IMAGE PROCESSING (IPCC)		Semester	VI
Course Code	**BRI602**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 8-10 Lab slots	Total Marks	100
Credits	04	Exam Hours	03

Course Learning Objectives (CLOs)

The course will enable the students to:

- Define the fundamental concepts in image processing.
- Evaluate techniques followed in image enhancements.
- Understand the Morphological Operations and Image Processing.
- Understand the image restoration techniques and methods used in digital image processing
- Illustrate image compression algorithms.

Teaching-Learning Process (General Instructions)

These are sample Strategies; that teachers can use to accelerate the attainment of the various course outcomes.These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through Power Point Presentations and Video demonstrations or Simulations.
2. Chalk and Talk method for Problem Solving.
3. Adopt collaborative (Group Learning) Learning in the class.
4. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills and develops thinking skillssuch as evaluating, generalizing, and analyzing information.
5. Conduct Laboratory Demonstrations and Practical Experiments to enhance experiential skills.

Module-1

Introduction: Fundamental Steps in Digital Image Processing, Components of an Image Processing System, Sampling and Quantization, Representing Digital Images (Data structure), Some Basic Relationships Between Pixels- Neighbors and Connectivity of pixels in image, Applications of Image Processing: Medical imaging, Robot vision, Character recognition, Remote Sensing.

Module-2

Image Enhancement In The Spatial Domain: Some Basic Gray Level Transformations, Histogram Processing, Enhancement Using Arithmetic/Logic Operations, Basics of Spatial Filtering, Smoothing Spatial Filters, Sharpening Spatial Filters, Combining Spatial Enhancement Methods.

Module-3

Morphological Image Processing:
Preliminaries, Erosion and Dilation, Opening and Closing.
Image Processing:
Color Fundamentals, Color Models, Pseudo color Image Processing.

Module-4

Restoration: Noise models, Restoration in the Presence of Noise Only using Spatial Filtering and Frequency Domain Filtering, Linear, Position-Invariant degradations Estimating the Degradation Function, Inverse Filtering, Minimum Mean Square Error (Wiener) Filtering, Constrained Least Squares Filtering.

Module-5

Image Compression: Introduction, coding Redundancy , Inter-pixel redundancy, image compression model, Lossy and Lossless compression, Huffman Coding, Arithmetic Coding, LZW coding, Transform Coding, Sub-image size selection, blocking, DCT implementation using FFT, Run length coding.

PRACTICAL COMPONENT OF IPCC *(May cover all / major modules)*

Sl.NO	Experiments
1	Write a Program to read a digital image. Split and display image into 4 quadrants, up, down, right andleft
2	Write a program to show rotation, scaling, and translation of an image.
3	Read an image, first apply erosion to the image and then subtract the result from the original.
4	Demonstrate the difference in the edge image if you use dilation instead of erosion.
5	Demonstrate enhancing and segmenting low contrast 2D images.
6	Read an image and extract and display low-level features such as edges, textures using filtering techniques.
7	Write a Program to convert RGB image into Gray image and Binary image.
8	Implementation of image restoring techniques.
9	Write a program for image compression.
10	Implementation of Image Intensity slicing technique for image enhancement.

Course Outcomes (COs) (Course Skill Set):

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

CO1: Understand, Ascertain and describe the basics of image processing concepts through mathematical interpretation.

CO2: Apply image processing techniques in both the spatial and frequency (Fourier) domains.

CO3: Design image analysis techniques in the form of Morphological Image Processing

CO4: Demonstrate image restoration process and its respective filters required.

CO5: Conduct independent study and analysis of Image Compression techniques.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. Theminimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to havesatisfied the academic requirements and earned the credits allotted to each subject/ course if the student securesa minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

CIE for the theory component of the IPCC (maximum marks 50)

- IPCC means practical portion integrated with the theory of the course.
- CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.
- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theorycomponent of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

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CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for thetest to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including
  Viva-voce and marks shall be awarded on the same day.

- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers forthe course (**duration 03 hours**)

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximumof 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored by the student shall be proportionally scaled down to 50 Marks

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have aCIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

Suggested Learning Resources:

Text Books:

[1] Digital Image Processing, Rafael C G., Woods R E. and Eddins S L, Prentice Hall, 3rd edition,2008.

Reference Books/Journal

[2] Image Processing, analysis and Machine Vision, Milan Sonka, Thomson Press India Ltd, Fourth Edition.
[3] Fundamentals of Digital Image Processing, Anil K. Jain, Prentice Hall of India, 2nd Edition.
[4] Digital Image Processing, S. Sridhar, Oxford University Press, 2nd Ed, 2016.
[5] Digital Image Processing - S.Jayaraman, S.Esakkirajan, T.Veerakumar, Tata McGraw Hill 2014.

Web links and Video Lectures (e-Resources):

INDUSTRY 4.0 & IIOT		Semester	VI
Course Code	**BRI613A**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	
Examination nature (SEE)	THEORY		

Course objectives:

- To understand the basic concepts of Industry 4.0
- To understand the Technologies & Framework for Industry 4.0.
- To understand the basic concepts in Industrial IOT
- To understand IOT technologies and key opportunities in the industry
- To understand IOT architecture and protocols

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and
- Video demonstrations or Simulations.
- Chalk and Talk method for Problem Solving.
- Adopt flipped classroom teaching method.
- Adopt collaborative (Group Learning) learning in the class.
- Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information

Module-1

Introduction to Industry 4.0: Introduction, core idea of Industry 4.0, origin concept of industry 4.0,Industry 4.0 production system, current state of industry 4.0, Technologies, How is India preparing for Industry 4.0

A Conceptual Framework for Industry 4.0: Introduction, Main Concepts and Components of Industry 4.0, State of Art, Supportive Technologies, Proposed Framework for Industry 4.0.

Module-2

Industrial Internet – Key IIOT technologies – Innovation and the IIOT – Key opportunities and Benefits – The Digital and Human Workforce – Logistics and the Industrial Internet – IOT Innovations in Retail.

Cyber Physical Systems (CPS) – IP Mobility – Network Virtualization – SDN (software Defined Networks) – The cloud and Fog – Role of Big Data in IIOT – Role of Machine learning and AI in IIOT.

Module-3

Industrial Internet Architecture Framework (IIAF) - Industrial Internet Viewpoints – Architectural Topology: The Three – tier Topology – Key System Characteristics – Data Management – Advanced data Analytics.

Module-4

Legacy Industrial Protocols – Modern Communication Protocols – Proximity Network Communication Protocols –Wireless Communication Technologies – Gateways: Industrial gateways – CoAP (Constrained Application Protocol) – NFC

Module-5

Publish / Subscribe Pattern: MQTT, XMPP, AMQP, DDS – Middleware Architecture – SigFox – LoRa WAN – Augmented reality – Real World Smart Factories

Course outcome (Course Skill Set)

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

7. Explain the basic concepts on industry 4.0
8. Understand the various technologies of industry 4.0
9. Discuss the various technologies of IOT
10. Implement Industrial application using sensors
11. Identify the IOT related opportunities in industry.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

1. Alp Ustundag and EmreCevikcan,"Industry 4.0: Managing the Digital Transformation".
2. Bartodziej, ChristophJan,"The Concept Industry 4.0". "Control systems Principles and Design", M.Gopal, 3rd Edition, TMH, 2000.

REFERENCE BOOKS:

1. Gilchrist, Alasdair. Industry 4.0 The Industrial Internet of Things. Apress, 2017.
2. Sabina Jeschke, Christian Brecher, Houbling Song,Danda B. Rawat. Industrial Internet Of Things: Cyber
3. Manufacturing Systems. Springer 2017
4. Zaigham MahmoodThe Internet of Things in the Industrial Sector: Security and Device connectivity, smart environments and Industry 4.Springer 2019

Web links and Video Lectures (e-Resources):

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- https://onlinecourses.nptel.ac.in/noc20_cs69/preview
- https://archive.nptel.ac.in/courses/106/105/106105195/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- To create a program to display grayscale image using read and write operation
- To create a vision program to convert a 2D array into a grayscale image.
- To create a vision program to convert gray images into an array of numbers.
- To create a program to rotate an image.
- To create a vision program to find histogram value and display histograph of a grayscale and color image
- To create a vision program for Non-Linear Filtering technique using edge detection.

INTELLIGENT MANUFACTURING		Semester	VI
Course Code	**BRI613B**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40 hours	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	Theory		

Course objectives:

The objectives of this course are to:

1. Explain the basic concepts and principles of intelligent manufacturing, including smart factories
2. valuate traditional manufacturing processes and systems and compare them with intelligent manufacturing systems.
3. Assess the economic benefits and challenges of implementing intelligent manufacturing systems.
4. Discuss the ethical considerations, legal regulations, and social implications related to the adoption of intelligent manufacturing technologies.
5. Explore the impact of intelligent manufacturing on the workforce, including changes in skill requirements and job displacement.
6. Stay informed about emerging trends and future developments in intelligent manufacturing.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. The lecturer's approach (L) does not have to be limited to traditional methods of teaching. It is possible to incorporate alternative and effective teaching methods to achieve the desired outcomes.
2. Utilize videos and animations to illustrate the functioning of different techniques used in the manufacturing of smart materials.
3. Foster collaborative learning exercises within the classroom to encourage group participation and engagement.
4. Pose a minimum of three Higher Order Thinking (HOT) questions during class discussions to stimulate critical thinking among students.
5. Implement Problem-Based Learning (PBL) as an approach that enhances students' analytical skills and nurtures their ability to design, evaluate, generalize, and analyse information, rather than solely relying on repetition.

MODULE-1

Computer Integrated Manufacturing Systems: - Structure and functional areas of CIM system, - CAD, CAPP, CAM, CAQC, ASRS. Advantages of CIM. Manufacturing, Communication Systems - MAP/TOP, OSI Model, Data Redundancy, Top- down and Bottom-up Approach, Volume of Information. Intelligent Manufacturing System Components, System Architecture and Data Flow, System Operation.

MODULE-2

Basic Components of Knowledge Based Systems: Knowledge Representation, Comparison of Knowledge Representation Schemes, Interference Engine, Knowledge Acquisition. Automated Process Planning - Variant Approach, Generative Approach, Expert Systems for Process Planning, Feature Recognition, Phases of Process planning. Knowledge Based System for Equipment Selection (KBSES) - Manufacturing system design. Equipment Selection Problem, Modeling the Manufacturing Equipment Selection Problem, Problem Solving approach in KBSES, Structure of the KRSES.

MODULE-3

Group Technology: Models and Algorithms Visual Method, Coding Method, Cluster Analysis Method, Matrix Formation - Similarity Coefficient Method, Sorting-based Algorithms, Bond Energy Algorithm, Cost Based method, Cluster Identification Method, Extended CI Method. Knowledge Based Group Technology - Group Technology in Automated Manufacturing System. Structure of Knowledge based system for group technology (KBSC IT) — Data Base, Knowledge Base, Clustering Algorithm.

MODULE-4

Flexible Manufacturing Systems: FMS and its Components, Layout considerations in FMS, Material Handling in FMS. Reverse Engineering – Principles and Technology, Rapid Prototyping – Principles and Classification, Steps in Additive Manufacturing, Benefits and Applications.

MODULE-5

Cloud Based Design & Manufacturing: Internet of Things, Data Storage and Analytics, Cloud computing, Cyber-Physical Systems

Course Outcomes:

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

1. Summarize the concepts of computer integrated manufacturing systems and manufacturing communication systems.
2. Identify various components of knowledge-based systems.
3. Select the manufacturing equipment using knowledge-based system for equipment selection.
4. Apply various methods to solve group technology problems and demonstrate the structure for knowledge-based system for group technology.
5. Understand the various stages of product development from design to manufacturing including the interconnections in smart manufacturing.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
2. The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
3. Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
4. For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination (SEE):

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
- The students have to answer 5 full questions, selecting one full question from each module.
- Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Text Books

1. Andrew Kusiak, "Intelligent Manufacturing Systems", Prentice Hall, 1990.
2. Pat Langley, "Computational Intelligence and Intelligent Systems", 2006.
3. Groover M. P. and Zimmers E. W., "CAD/CAM: Computer Aided Design and Manufacturing", Pearson Education, New Delhi, 2003.

Reference Books

1. Mohammad Jamshidi, "Design and Implementation of Intelligent Manufacturing Systems: From Expert Systems, Neural Networks to Fuzzy Logic", 1st Edition, 1995.
2. Lucia Knapčíková, Michal Balog, "Industry 4.0: Trends in Management of Intelligent Manufacturing Systems", Springer, 2019.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=xB9Do07XJWI
2. https://www.youtube.com/watch?v=tG6TByMsiaA
3. https://www.spotfire.com/glossary/what-is-intelligent-manufacturing
4. https://www.youtube.com/watch?v=e69JBNgowIw

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Team Projects
- Seminar
- Flipped Classroom

AUTONOMOUS ROBOTS		Semester	VI
Course Code	**BRI613C**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2:2:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To learn the principles of working of autonomous robots
- To learn the holistic design of autonomous robots - from the mechatronic design to sensors and intelligence.
- To demonstrate the sensing, perception, and cognition of autonomous robots
- To understand the anatomy of autonomous robots

Teaching-Learning Process (General Instructions)

These are sample strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk method for Problem Solving.
3. Adopt the flipped classroom teaching method.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analyzing information.

Module-1

Introduction to Autonomous Robots

Introduction, Challenges of Mobile Autonomous Robots, Challenges of Manipulation, Locomotion and Manipulation: - Static and Dynamic Stability, Degrees of Freedom (example)

Locomotion: Introduction, Key issues for locomotion, Legged mobile robots, Leg configurations and stability, one leg, two legs, four legs, six legs, wheeled mobile robots, Wheeled locomotion: the design space, Wheel geometry: Stability, Manoeuvrability, Controllability

Module-2

Planning and Navigation: Map Representations, Path Planning Algorithms, Sampling-based Path Planning, Path Smoothing, and Planning at different length scales.

Navigation Architectures: Modularity for code reuse and sharing, control localization, Techniques for decomposition

Module-3

Mobile Robot Localization: The Challenge of Localization: Noise and Aliasing, Map Representation, current challenges in map representation, Probabilistic Map based Localization.

Markov Localization**,** Kalman filter localization, Landmark-based navigation, globally unique localization, Positioning beacon systems, Route-based localization, Autonomous Map Building, The stochastic map technique

Module-4

Sensors for Robots: Classification, characterizing sensors performance, Motor sensors, Heading Sensors, Ground-based beacons, Active ranging, Motion/Speed Sensors, and Vision-based sensors.

Planning and Navigation: Competences for Navigation: Planning and Reacting, Path planning, Configuration space, Path-planning overview. Road map path planning, Off-line planning

Module-5

Mobile Robot Kinematics: Kinematic Models and Constraints, Mobile robot Maneuverability, Mobile robot workspace, Beyond basic kinematics, Motion control

Course Outcomes (Course Skill Set)

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

1. Demonstrate the sensing, perception, and cognition of autonomous robots
2. Understand the anatomy of autonomous robots
3. Understand the operation of the Humanoid robot
4. Understand the principles of operation of Telecheric robots

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment

- Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the
- second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.
- The Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination (SEE):

- Theory SEE will be conducted by the University as per the scheduled timetable, with common question papers for the course (duration 03 hours).
- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a
- maximum of 3 sub-questions), should have a mix of topics under that module.
- The students have to answer 5 full questions, selecting one full question from each module.
- Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Text Books:

1. Introduction to Autonomous Mobile Robots, Roland Siegwart, Illah R. Nourbakhsh,2004, The MIT Press,
2. Introduction to Autonomous Robots, Nikolaus Correll, 2016.
3. Nikolaus Correll - Introduction to Autonomous Robots. Kinematics, Perception, Localization and Planning, 2016, Magellan Scientific

TOTAL QUALITY MANAGEMENT		Semester	VI
Course Code	**BRI613D**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40 hours	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	Theory		

Course objectives:

The objectives of this course are to:

1. Explain the basic concepts and principles of intelligent manufacturing, including smart factories
2. valuate traditional manufacturing processes and systems and compare them with intelligent manufacturing systems.
3. Assess the economic benefits and challenges of implementing intelligent manufacturing systems.
4. Discuss the ethical considerations, legal regulations, and social implications related to the adoption of intelligent manufacturing technologies.
5. Explore the impact of intelligent manufacturing on the workforce, including changes in skill requirements and job displacement.
6. Stay informed about emerging trends and future developments in intelligent manufacturing.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. The lecturer's approach (L) does not have to be limited to traditional methods of teaching. It is possible to incorporate alternative and effective teaching methods to achieve the desired outcomes.
2. Utilize videos and animations to illustrate the functioning of different techniques used in the manufacturing of smart materials.
3. Foster collaborative learning exercises within the classroom to encourage group participation and engagement.
4. Pose a minimum of three Higher Order Thinking (HOT) questions during class discussions to stimulate critical thinking among students.
5. Implement Problem-Based Learning (PBL) as an approach that enhances students' analytical skills and nurtures their ability to design, evaluate, generalize, and analyse information, rather than solely relying on repetition.

MODULE-1

TQM Principles: Quality Concepts – Definition of Quality, Dimensions of Quality, Cost of Quality and Quality Gurus.

TQM Philosophy – Principles of TQM, Deming's Philosophy, Juran's Philosophy & Crosby's Philosophy. Quality Management System – ISO. Customer Focus, Supplier partnership and Employee Involvement.

MODULE-2

Design for Quality: Detailed Design – Product Development & Quality Function Deployment (QFD), Target and Tolerance Design, Taguchi Loss Function for Tolerance Design.

Design for Reliability – Mathematics of Reliability & System Reliability. Design Optimization – Fault Tree Analysis, Design for manufacturability, environment responsibility and excellence. Total Productive Maintenance (TPM) – Concept & Improvement Needs.

MODULE-3

Measuring & Controlling the Quality: Statistical Fundamentals – Sampling Distributions, Confidence Intervals, Measures of Central Tendency and Dispersion, Population and Sample, Normal Curve.

Measuring the Quality – Measurement of Quality control, system evaluation and process capability measurement. Controlling the Quality – Statistical Process Control for Variables & Attributes.

MODULE-4

Analysis & Improve the Quality: Seven QC Tools – Stratification, Check Sheets, Control Chart, Histogram, Pareto Chart, Cause- and-effect diagram & Scatter diagram.

New Management and planning tools – 5 Why Analysis, Affinity Diagram, Interrelationship Digraph & Tree Diagram, Matrix Diagram, Matrix Data Analysis, Process Decision Program Chart and Arrow Diagram.

MODULE-5

Improve for Quality Excellence: Continuous Process Improvements – Benchmarking, PDCA Cycle, 6S, Kaizen, Lean and Six- Sigma principles.

Leadership – **Characteristics** of Quality Leaders, The 7 Habits of Highly Effective People, Ethics & The Deming Philosophy.

Course Outcomes:

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

1. Evaluate the principles of Quality Management and explain how these principles can be applied
2. Use appropriate tools and techniques to design the quality system
3. Measure and control the quality of a business through appropriate tools and techniques
4. Analysis of the quality of the business process through appropriate tools and techniques
5. Continuously Improve the business to achieve business excellence

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
2. The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
3. Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
4. For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination (SEE):

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
- The students have to answer 5 full questions, selecting one full question from each module.
- Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Text Books

1. Total Quality Management Dale H. Besterfield Pearson Education India, Edition 03. ISBN: 8129702606
2. Total Quality Management for Engineers M. Zairi Wood head Publishing, ISBN:1855730243.

Reference Books

1. Managing for Quality and Performance Excellence James R. Evans and William M Lindsay Cengage Learning. 9th edition
2. Four revolutions in management Shoji Shiba, Alan Graham, David Walden Oregon 1990
3. Organizational Excellence through TQM H. Lal New age Publications 2008
4. Engineering Optimization Methods and Applications A Ravindran, K, M. Ragsdell Willey India Private Limited 2nd Edition,2006

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=5pMWmU_8lfI&list=PLPjSqITyvDeUUUwunyiwq41yJZofQEzMI
2. https://www.youtube.com/watch?v=MWQdHyDZGdY

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Team Projects
- Seminar
- Flipped Classroom

PROJECT MANAGEMENT		Semester	VI
Course Code	**BRI654A**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3 Hours
Examination type (SEE)	**Theory**		

Course objectives:

- To understand how to break down a complex project into manageable segments and use of effective project management tools and techniques to arrive at solution and ensure that the project meets its deliverables and is completed within budget and on schedule.
- To impart knowledge on various components, phases, and attributes of a project.
- To prepare students to plan, develop, lead, manage, and successfully implement and deliver projects within their chosen practice area.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk method for Problem Solving.
3. Adopt flipped classroom teaching method.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Introduction: Definition of project, characteristics of projects, understand projects, types of projects, scalability of project tools, project roles Project Selection and Prioritization – Strategic planning process, Strategic analysis, strategic objectives, portfolio alignment – identifying potential projects, methods of selecting projects, financial mode / scoring models to select projects, prioritizing projects, securing and negotiating projects.

Module-2

Planning Projects: Defining the project scope, Project scope checklist, Project priorities, Work Breakdown Structure (WBS), Integrating WBS with organisation, coding the WBS for the information system.

Scheduling Projects: Purpose of a project schedule, historical development, how project schedules are limited and created, develop project schedules, uncertainty in project schedules, Gantt chart.

Module-3

Resourcing Projects: Abilities needed when resourcing projects, estimate resource needs, creating staffing management plant, project team composition issues, Budgeting Projects: Cost planning, cost estimating, cost budgeting, establishing cost control. Project Risk Planning: Risk Management Planning, risk identification, risk analysis, risk response planning, Project Quality Planning and Project Kick off: Development of quality concepts, project quality management plan, project quality tools, kick off project, baseline and communicate project management plan, using Microsoft Project for project baselines.

Module-4

Performing Projects: Project supply chain management: - Plan purchasing and acquisitions, plan contracting, contact types, project partnering and collaborations, project supply chain management. 28 Project Progress and Results: Project Balanced Scorecard Approach, Internal project, customer, financial issues, Finishing the project: Terminate project early, finish projects on time, secure customer feedback and approval, knowledge management, perform administrative and contract closure.

Module-5

Network Analysis: Introduction, network construction - rules, Fulkerson's rule for numbering the events, AON and AOA diagrams; Critical path method (CPM) to find the expected completion time of a project, floats; PERT or finding expected duration of an activity and project, determining the probability of completing a project, predicting the completion time of project; crashing of simple projects.

Course outcome (Course Skill Set)

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

CO1: Understand the selection, prioritization and initiation of individual projects and strategic role of project management.

CO2: Understand the work breakdown structure by integrating it with organization.

CO3: Understand the scheduling and uncertainty in projects.

CO4: Understand risk management planning using project quality tools.

CO5: Understand the activities like purchasing, acquisitions, contracting, partnering and collaborations related to performing projects.

CO6: Determine project progress and results through balanced scorecard approach

CO7: Draw the network diagram to calculate the duration of the project and reduce it using crashing.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks(18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
- The students have to answer 5 full questions(for 100 marks), selecting one full question from each module.
- Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

1. Project Management Timothy J Kloppenborg Cengage Learning Edition 2009.
2. Project Management -A systems approach to planning scheduling and controlling Harold kerzner CBS publication.
3. Project Management S Choudhury McGraw Hill Education (India) Pvt.Ltd. New Delhi2016.
4. Project Management Pennington Lawrence McGraw Hill.
5. Project Management A Moder Joseph and Phillips New Yark Van Nostrand Reinhold.
6. Project Management, Bhavesh M. Patal Vikas publishing House.

Web links and Video Lectures (e-Resources):

- https://onlinecourses.nptel.ac.in/noc24_mg01/preview
- https://onlinecourses.nptel.ac.in/noc19_mg30/preview

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Case studies
- Quiz
- Topic Seminar presentation
- Assignments
- Group Activities

UNMANNED AERIAL VEHICLES (UAV)		Semester	VI
Course Code	**BRI654B**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	Theory		

COURSE OBJECTIVES:

The objectives of this course are to:

1. Acquire the knowledge of basic concepts needed in modelling and analysing an unmanned system.
2. To expose students to the development of UAV
3. To expose students to the type of payloads used in UAV
4. To study path planning.
5. To understand the avionics hardware used in the UAV.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. The lecturer's approach (L) does not have to be limited to traditional methods of teaching. It is possible to incorporate alternative and effective teaching methods to achieve the desired outcomes.
2. Utilize videos and animations to illustrate the functioning of different techniques used in the manufacturing of smart materials.
3. Foster collaborative learning exercises within the classroom to encourage group participation and engagement.
4. Pose a minimum of three Higher Order Thinking (HOT) questions during class discussions to stimulate critical thinking among students.
5. Implement Problem-Based Learning (PBL) as an approach that enhances students' analytical skills and nurtures their ability to design, evaluate, generalize, and analyze information, rather than solely relying on rote memorization.

Module-1

Introduction to UAV: Introduction Aviation History and Overview of UAV systems, Classes and Missions of UAVs, Definitions and Terminology, UAV fundamentals, Examples of UAV systems-very small, small, Medium and Large UAV

Module-2

The Air Vehicle Basic Aerodynamics: Basic Aerodynamics equations, Aircraft polar, the real wing and Airplane, Induced drag, the boundary layer, Flapping wings, Total Air-Vehicle Drag. Performance: Overview, climbing flight, Range and Endurance – for propeller-driven aircraft, range- a jet-driven aircraft, Guiding Flight.

Module-3

Avionics Hardware: Overview, Stability, longitudinal, lateral, dynamic stability, Aerodynamics control, pitch control, lateral control, Autopilots, sensor, controller, actuator, airframe control, inner and outer loops, Flight-Control Classification, Overall Modes of Operation, Sensors Supporting the Autopilot.

Module-4

Operating Systems: Propulsion Overview, Thrust Generation, Powered Lift, Sources of Power, The Two-Cycle Engine, The Rotary Engine, The Gas Turbine, Electric Motors, and Sources of Electrical Power. Loads and Structures Loads, Dynamic Loads, Materials, Sandwich Construction, Skin or Reinforcing Materials, Resin Materials, Core Materials, Construction Techniques.

Module-5

Communication Payloads and Controls: Air Vehicle and Payload Control, Reconnaissance/Surveillance Payloads, Weapon Payloads, Other Payloads, Data-Link Functions and Attributes, Data-Link Margin, Data-Rate Reduction, Launch Systems, Recovery Systems, Launch and Recovery Trade-offs

Course Outcomes (COs)(Course Skill Set)

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

CO1: Apply the basic concepts of UAV systems.
CO2: Explain the basic aerodynamics, performance, stability and control required for UAV.
CO3: Identify different hardware components for UAV
CO4: Apply the knowledge of UAV and select suitable propulsion system and materials for construction of micro aerial vehicle.
CO5: Perform system testing for unmanned aerial vehicles.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination (SEE):

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
- The students have to answer 5 full questions, selecting one full question from each module.
- Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

TEXT BOOKS:

1. DGCA RPAS Guidance Manual, Revision 3, 2020
2. Introduction to UAV Systems-Paul Gerin Fahlstrom, Thomas James Gleason Unmanned Aerial Vehicle-Landen Rosen
3. Paul G Fahlstrom, Thomas J Gleason, "Introduction to UAV Systems", UAV Systems, Inc, 1998..
4. Reg Austin "Unmanned Aircraft Systems UAV design, development and deployment", Wiley, 2010.

REFERENCE BOOKS:

1. Unmanned Aerial Vehicles: DOD's Acquisition Efforts
2. Unmanned Aerial Vehicles-Valavanis, Kimon P, Handbook of Unmanned Aerial Vehicles-Valavanis, K.,Vachtsevanos, George J

3. Dr. Armand J. Chaput, "Design of Unmanned Air Vehicle Systems", Lockheed Martin Aeronautics Company, 200.
4. Kimon P. Valavanis, "Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy", Springer, 2007.
5. Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, Inc, 1998.

Web links and Video Lectures (e-Resources):

- https://roboticscasual.com/ros-tutorial-pick-and-place-task-with-the-moveit-c-interface/
- https://www.mdpi.com/2072-4292/11/12/1443
- https://www.britannica.com/technology/unmanned-aerial-vehicle
- https://www.rand.org/topics/unmanned-aerial-vehicles.html
- https://youtu.be/S-XiFIRVkgQ
- https://www.youtube.com/watch?v=VCZK2iexDso

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Adaptation of Content from Different Disciplines
- Constructivist Approaches to Learning
- Situated Learning Methodology
- Flipped Classroom
- Gamification
- Online Interactive Tools
- Collaborative and Individual Project-Based Assessment

FUNDAMENTALS OF ROBOTICS		Semester	VI
Course Code	**BRI654C**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40 hours	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	Theory		

Course objectives:

The objectives of this course are to:

1. Define and describe the history and evolution of robotics
2. Identify and categorize different types of robots and their applications in various industries.
3. Explain the basic components of a robot, including sensors, actuators, controllers, and power sources.
4. Understand the integration of these components in the design and operation of robotic systems.
5. Describe and apply the concepts of forward and inverse kinematics to robotic manipulators.
6. Analyze the velocity, statics, and dynamics of robots using Jacobian matrices and Lagrange-Euler formulations.
7. Understand the fundamentals of control systems, including open-loop and closed-loop control, and PID controllers.
8. Identify and describe different types of sensors used in robotics, including proximity, vision, force/torque, and tactile sensors.
9. Explore the design and control of humanoid robots and the challenges of human-robot interaction (HRI).
10. Assess the safety considerations, ethical issues, and societal impact of robotics and automation.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. The lecturer's approach (L) does not have to be limited to traditional methods of teaching. It is possible to incorporate alternative and effective teaching methods to achieve the desired outcomes.
2. Utilize videos and animations to illustrate the functioning of different techniques used in the manufacturing of smart materials.
3. Foster collaborative learning exercises within the classroom to encourage group participation and engagement.
4. Pose a minimum of three Higher Order Thinking (HOT) questions during class discussions to stimulate critical thinking among students.
5. Implement Problem-Based Learning (PBL) as an approach that enhances students' analytical skills and nurtures their ability to design, evaluate, generalize, and analyse information, rather than solely relying on repetition.

MODULE-1

Introduction to Robotics: - Overview of Robotics, Definition, History, and Evolution of Robotics. Different Types of Robots, Applications of Robotics in various industries. Basic Components of a Robots: Sensors, Actuators, Controllers, Power Sources. Kinematics and Dynamics of Robots: Forward and Inverse Kinematics. Static and Dynamic Analysis of Robots. Robot Programming Basics: Introduction to Robot Programming Languages (e.g., Python, ROS).

MODULE-2

Robot Kinematics and Dynamics: Kinematic Chains: Degrees of Freedom (DOF), Types of Joints, Types of Links, Homogeneous Transformation Matrices. Robot Arm Kinematics: Denavit-Hartenberg (D-H) Parameters. Forward and Inverse Kinematics for Serial Manipulators. Velocity and Statics: Jacobian Matrices, Singularities and Redundancies. Dynamics: Lagrange-Euler Formulations, Newton-Euler Formulation.

MODULE-3

Robot Control Systems: Control System Fundamentals: Open-loop vs. Closed-loop Control, PID Controllers, and Control Strategies. Trajectory Planning and Control: Path Planning Algorithms, Trajectory Generation Techniques, Position, Velocity, and Force Control. Advanced Control Techniques: Adaptive Control, Robust Control, Model Predictive Control (MPC). Implementation of Control Systems: Digital Control Implementation, Introduction to Real-Time Control Systems.

MODULE-4

Sensing and Perception in Robotics: Introduction to Sensors: Types of Sensors: Proximity, Vision, Force/Torque, Tactile, etc. Vision Systems: Camera Models, Image Processing Techniques, Object Detection and Recognition, 3D Vision and Stereo Vision. Sensor Fusion: Data Integration from Multiple Sensors. Perception Systems: Environmental Mapping and Localization, Simultaneous Localization and Mapping (SLAM), Autonomous Navigation and Path Planning.

MODULE-5

Robotics and Automation Applications: Industrial Robotics: Types of Industrial Robots (SCARA, Articulated, Cartesian), Applications in Manufacturing (Welding, Assembly, Material Handling), Safety in Robotics. Mobile Robotics: Types of Mobile Robots (Wheeled, Legged, Aerial), Navigation and Localization Techniques, Autonomous Driving Technologies. Humanoid Robotics: Design and Control of Humanoid Robots, Human-Robot Interaction (HRI). Ethical Issues in Robotics, Impact of Robotics on Society, Emerging Trends (e.g., Swarm Robotics, AI Integration).

Course objectives:

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

1. Understand the Evolution and Impact of Robotics
2. Comprehend the Components and Functionality of Robotic Systems
3. Apply Kinematic and Dynamic Principles in Robotics
4. Design and Implement Robot Control Systems
5. Integrate Sensing and Perception in Robotic Systems
6. Explore Industrial and Mobile Robotics Applications

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
2. The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
3. Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
4. For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination (SEE):

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
- The students have to answer 5 full questions, selecting one full question from each module.
- Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Text Books

1. "Introduction to Robotics: Mechanics and Control" by John J. Craig
2. "Robot Dynamics and Control" by Mark W. Spong, Seth Hutchinson, and M. Vidyasagar
3. "Industrial Robotics: Technology, Programming, and Applications" by Mikell P. Groover.

Reference Books

1. "Robotics: Control, Sensing, Vision, and Intelligence" by K. S. Fu, R. C. Gonzalez, and C. S. G. Lee
2. "Mobile Robotics: A Practical Introduction" by Ulrich Nehmzow
3. "Robotics: Control, Sensing, Vision, and Intelligence" by K. S. Fu, R. C. Gonzalez, and C. S. G. Lee

Web links and Video Lectures (e-Resources):

1. https://r.search.yahoo.com/_ylt=Awr1QPl_2bxmzQQARE67HAx.;_ylu=Y29sbwNzZzMEcG9zAzUEdnRpZAMEc2VjA3Ny/RV=2/RE=1724862079/RO=10/RU=https%3a%2f%2fonlinecourses.nptel.ac.in%2fnoc21_me76%2fpreview/RK=2/RS=I2YeqcwGEnm9kZWFeDJwOBMbkGc-
2. https://www.khanacademy.org/partner-content/stanford-robotics
3. https://robohub.org/
4. https://www.youtube.com/playlist?list=PLTgRMOcmRb3NX4I5BZ8mfFR58o3TYRHaN
5. https://www.youtube.com/watch?v=3GvE5dEXO2Q&list=PLUl4u3cNGP61MdtwGTqZA0MreSaDybji8

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Building a simple robotic arm
- Microcontroller based simple real-time control system implementation
- Design and build a robot capable of path planning
- Course related seminar

OPERATIONS RESEARCH		Semester	VI
Course Code	**BRI654D**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	
Examination nature (SEE)	THEORY		

Course objectives:

- To introduce students to use quantitative methods and techniques for effective decisions–making;
- Mathematical model formulation and solving business decision problems.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Use of Chalk and Talk method
- Video lectures, lecture projections in class
- Individual and Group assignments

Module-1

Introduction: Evolution of OR, definition of OR, scope of OR, application areas of OR, steps (phases) in OR study, characteristics and limitations of OR, models used in OR, linear programming (LP) problem formulation and solution by graphical method. The simplex method using slack variables.

Module-2

Transportation Problem: Formulation of transportation problem, types, initial basic feasible solution using different methods, optimal solution by MODI method, degeneracy in transportation problems, application of transportation problem concept for maximization cases. Assignment Problem: Formulation, types, application to maximization cases and travelling salesman problem.

Module-3

PERT-CPM: Techniques: Introduction, network construction rules, Fulkerson's rule for numbering the events, AON and AOA diagrams; Critical path method to find the expected completion time of a project, floats; PERT for finding expected duration of an activity and project, determining the probability of completing a project, predicting the completion time of project; crashing of simple projects.

Module-4

Game Theory: Formulation of games, types, solution of games with saddle point, graphical method of solving mixed strategy games, dominance rule for solving mixed strategy games.

Queuing Theory: Queuing systems and their characteristics, Pure birth and Pure death models (only equations), empirical queuing models (M/M/1 model).

Module-5

Sequencing: Basic assumptions, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule-'n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines. Sequencing 2 jobs on 'm' machines using graphical method.

Course outcome (Course Skill Set)

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

1. Understand the importance, phases, & limitations of operations research.
2. Formulate a real-world problem in OR as a mathematical model.
3. Apply PERT and CPM network techniques to solve project management problems.
4. Choose appropriate OR models to solve transportation problem, assignment model, game theory, queuing theory and sequencing models.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
- The students have to answer 5 full questions, selecting one full question from each module.
- Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

1. Operations Research, P K Gupta and D S Hira, 7th Edition, Chand Publications, New Delhi
2. Operations Research, R. Panneerselvam, 3rd Edition, PHI
3. Operations Research Theory, Methods & Applications, S.D. Sharma, Kedarnath Ramanath & Co, 2012.
4. Operations Research, A M Natarajan, P Balasubramani, Pearson Education, 2005
5. Introduction to Operations Research, Hillier and Lieberman, 8th Edn, McGraw Hill,

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses/112106134

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Use appropriate software tools to solve real world problems Operations Research for different businesses

VIRTUAL INSTRUMENTATION AND AUTOMATION LAB		Semester	**6**
Course Code	**BRIL606**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2:0	SEE Marks	50
Credits	01	Exam Hours	100
Examination nature (SEE)	**Practical**		

Course objectives:

- To understand the Programming techniques of Virtual Instrumentation lab View
- To Understand the use of Arrays and Looping function in lab view
- To perform the basic arithmetic and Boolean operation
- To introduce the fundamental concepts of Scientific Programming using Lab View Analog and digital measurements principles
- Data Acquisition operation - basics skills and Creating Virtual Instruments for practical works

Sl.NO	**Experiments**
1	To perform basic arithmetic operations using LabVIEW
2	Verification of Half Adder and Full adder using LabVIEW
3	Program to find Addition of First n natural numbers using for and while loop using LabVIEW
4	Implementation of Array functions using LabVIEW (Even Numbers and Odd Number Using While Loop In An Array)
5	Creating Virtual Instrumentation for simple applications- Invert the State Of Boolean Indicator Twice A See Until Program Is Stopped By User using LabVIEW
6	Programming exercises for loops-Continuous Monitoring of Temperature using LabVIEW
7	Programming Exercises on case and sequence structures: -Design the simple Calculator.
8	Factorial of a Give Number Using For Loop using LabVIEW
9	Sorting Even Numbers Using While Loop In An Array using LabVIEW
10	Developing Signal Generator using DAQ Card
11	Real time sequential control of any batch process

Course outcomes (Course Skill Set):

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

- Develop LabVIEW programming which employs simulating and analyzing the data for real time automation
- Engage in designing, implementing, analyzing and demonstrating an application using tools in available in LabVIEW through an open-ended experiment.
- Design applications that use plug in DAQ boards and built in analysis functions to process the data.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation (CIE):

CIE marks for the practical course are **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment is to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments are designed by the faculty who is handling the laboratory session and are made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled down to **30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct a test of 100 marks after the completion of all the experiments listed in the syllabus.
- In a test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The marks scored shall be scaled down to **20 marks** (40% of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and marks of a test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

- SEE marks for the practical course are 50 Marks.
- SEE shall be conducted jointly by the two examiners, an internal examiner from the same institute and an external examiner from other institute, are appointed by the University.
- The examination schedule and names of examiners are informed to the university before the conduction of the examination. These practical examinations are to be conducted between the schedule mentioned in the academic calendar of the University.
- All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the questions lot prepared by the examiners jointly.

- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 15% of Marks allotted to the procedure part are to be made zero.

The minimum duration of SEE is 02 hours

Suggested Learning Resources:

-

APPLICATIONS OF RASPBERRY PI CONTROLLERS		Semester	**6**
Course Code	**BRI657A**	CIE Marks	50
Teaching Hours/Week (L:T:P:S)	0:0:2*:0	SEE Marks	50
Total Hours of Pedagogy	12 Lab Sessions	Total Marks	100
Credits	01	Exam Hours	03

Additional One hour may be considered for instructions if required

Course objectives:

This course will enable students to:

- To understand and use Raspberry Pi controllers.

Sl.NO.	**Experiments**
1	Creating the sensor project.
2	Creating the actuator project.
3	Creating a controller.
4	Creating a camera.
5	To study the architecture of SOC Broadcom-2835 application board of Raspberry Pi.
6	To demonstration the OS (Debian) for RPiina SD card preparation, configuration of Raspberry Pi during first booting and use of remote SS Hlikeputty
7	To demonstrate the basic linux commands on Raspberry pi.
8	To create a data base & Store the value in Raspberry Pi.
9	To install Android on Raspberry Pi.
10	To Set up RPi first time without using screen, mouse, keyboard.
11	To interface ADC at GPIO so Raspberry Pi for measuring analog voltage.

LIST OF EQUIPMENTS BATCH OF 30 STUDENTS:

Raspberry Pi controller Kits–10 numbers 10 Systems with server

All related components with respect to the experiments.

Course outcomes (Course Skill Set):

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

- Apply Raspberry Pi controller in different fields.

R - PROGRAMMING		Semester	6
Course Code	**BRI657B**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2:0	SEE Marks	50
Total Hours of Pedagogy	12 Lab Sessions	Total Marks	100
Credits	01	Exam Hours	3
Examination type (SEE)	**Practical**		

Course objectives:

- .To explore and understand how R and R Studio interactive environment.
- To understand the different data Structures, data types in R.
- To learn and practice programming techniques using R programming.
- To import data into R from various data sources and generate visualizations.
- To draw insights from datasets using data analytics techniques.

Sl.NO	Experiments
1	Demonstrate the steps for installation of R and R Studio. Perform the following: a) Assign different type of values to variables and display the type of variable. Assign different types such as Double, Integer, Logical, Complex and Character and understand the difference between each data type. b) Demonstrate Arithmetic and Logical Operations with simple examples. c) Demonstrate generation of sequences and creation of vectors. d) Demonstrate Creation of Matrices e) Demonstrate the Creation of Matrices from Vectors using Binding Function. f) Demonstrate element extraction from vectors, matrices and arrays **Suggested Reading** – Text Book 1 – Chapter 1 (What is R, Installing R, Choosing an IDE – RStudio, How to Get Help in R, Installing Extra Related Software), Chapter 2 (Mathematical Operations and Vectors, Assigning Variables, Special Numbers, Logical Vectors), Chapter 3 (Classes, Different Types of Numbers, Other Common Classes, Checking and Changing Classes, Examining Variables)
2	Assess the Financial Statement of an Organization being supplied with 2 vectors of data: Monthly Revenue and Monthly Expenses for the Financial Year. You can create your own sample data vector for this experiment) Calculate the following financial metrics: a. Profit for each month. b. Profit after tax for each month (Tax Rate is 30%). c. Profit margin for each month equals to profit after tax divided by revenue. d. Good Months – where the profit after tax was greater than the mean for the year. e. Bad Months – where the profit after tax was less than the mean for the year. f. The best month – where the profit after tax was max for the year. g. The worst month – where the profit after tax was min for the year. **Note:** a. All Results need to be presented as vectors b. Results for Dollar values need to be calculated with $0.01 precision, but need to be presented in Units of $1000 (i.e 1k) with no decimal points c. Results for the profit margin ratio need to be presented in units of % with no decimal point. d. It is okay for tax to be negative for any given month (deferred tax asset) e. Generate CSV file for the data. **Suggested Reading** – Text Book 1 – Chapter 4 (Vectors, Combining Matrices)
3	Develop a program to create two 3 X 3 matrices A and B and perform the following operations: a) Transpose of the matrix b) addition c) subtraction d) multiplication **Suggested Reading** – Textbook 1 – Chapter 4 (Matrices and Arrays – Array Arithmetic)

<table>
<tr><td>4</td><td>Develop a program to find the factorial of given number using recursive function calls.
Suggested Reading – Reference Book 1 – Chapter 5 (5.5 – Recursive Programming)
Text Book 1 – Chapter 8 (Flow Control and Loops – If and Else, Vectorized If, while loops, for loops),
Chapter 6 (Creating and Calling Functions, Passing Functions to and from other functions)</td></tr>
<tr><td>5</td><td>Develop an R Program using functions to find all the prime numbers up to a specified number by the method of Sieve of Eratosthenes.
Suggested Reading – Reference Book
1 - Chapter 5 (5.5 – Recursive Programming)
Text Book 1 – Chapter 8 (Flow Control and Loops – If and Else, Vectorized If, while loops, for loops),
Chapter 6 (Creating and Calling Functions, Passing Functions to and from other functions)</td></tr>
<tr><td>6</td><td>The built-in data set mammals contain data on body weight versus brain weight. Develop R commands to:
a) Find the Pearson and Spearman correlation coefficients. Are they similar?
b) Plot the data using the plot command.
c) Plot the logarithm (log) of each variable and see if that makes a difference.
Suggested Reading – Text Book 1 –Chapter 12 – (Built-in Datasets) Chapter 14 – (Scatterplots)
Reference Book 2 – 13.2.5 (Covariance and Correlation)</td></tr>
<tr><td>7</td><td>Develop R program to create a Data Frame with following details and do the following operations.
<table>
<tr><th>itemCode</th><th>itemCategory</th><th>itemPrice</th></tr>
<tr><td>1001</td><td>Electronics</td><td>700</td></tr>
<tr><td>1002</td><td>Desktop Supplies</td><td>300</td></tr>
<tr><td>1003</td><td>Office Supplies</td><td>350</td></tr>
<tr><td>1004</td><td>USB</td><td>400</td></tr>
<tr><td>1005</td><td>CD Drive</td><td>800</td></tr>
</table>
a) Subset the Data frame and display the details of only those items whose price is greater than or equal to 350.
b) Subset the Data frame and display only the items where the category is either “Office Supplies” or “Desktop Supplies”
c) Create another Data Frame called “item-details” with three different fields item Code, Item Qty on Hand and ItemReorderLvl and merge the two frames
Suggested Reading –Textbook 1: Chapter 5 (Lists and Data Frames)</td></tr>
<tr><td>8</td><td>Let us use the built-in dataset air quality which has Daily air quality measurements in New York, May to September 1973. Develop R program to generate histogram by using appropriate arguments for the following statements.
a) Assigning names, using the air quality data set.
b) Change colors of the Histogram
c) Remove Axis and Add labels to Histogram
d) Change Axis limits of a Histogram
e) Add Density curve to the histogram
Suggested Reading –Reference Book 2 – Chapter 7 (7.4 – The ggplot2 Package), Chapter 24 (Smoothing and Shading)</td></tr>
</table>

9	Design a data frame in R for storing about 20 employee details. Create a CSV file named "input.csv" that defines all the required information about the employee such as id, name, salary, start_date, dept. Import into R and do the following analysis. a) Find the total number rows & columns b) Find the maximum salary c) Retrieve the details of the employee with maximum salary d) Retrieve all the employees working in the IT Department. e) Retrieve the employees in the IT Department whose salary is greater than 20000 and write these details into another file "output.csv" **Suggested Reading** – Textbook 1 – Chapter 12(CSV and Tab Delimited Files)
10	Demonstrate the progression of salary with years of experience using a suitable data set (You can create your own dataset). Plot the graph visualizing the best fit line on the plot of the given data points. Plot a curve of Actual Values vs. Predicted values to show their correlation and performance of the model. Interpret the meaning of the slope and y-intercept of the line with respect to the given data. Implement using lm function. Save the graphs and coefficients in files. Attach the predicted values of salaries as a new column to the original data set and save the data as a new CSV file. **Suggested Reading** – Reference Book 2 – Chapter 20 (General Concepts, Statistical Inference, Prediction)

Course outcomes (Course Skill Set):

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

1. Explain the fundamental syntax of R data types, expressions and the usage of the R-Studio IDE
2. Develop a program in R with programming constructs: conditionals, looping and functions.
3. Apply the list and data frame structure of the R programming language.
4. Use visualization packages and file handlers for data analysis.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course are **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment is to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments are designed by the faculty who is handling the laboratory session and are made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled down to **30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct a test of 100 marks after the completion of all the experiments listed in the syllabus.

- In a test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The marks scored shall be scaled down to **20 marks** (40% of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and marks of a test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

- SEE marks for the practical course are 50 Marks.
- **SEE shall be conducted by the two examiners. One from the same institute as an internal examiner and another from a different institute as an external examiner, appointed by the university.**
- The examination schedule and names of examiners are informed to the university before the conduction of the examination. These practical examinations are to be conducted between the schedule mentioned in the academic calendar of the University.
- All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the questions lot prepared by the examiners jointly.
- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 15% of Marks allotted to the procedure part are to be made zero.

The minimum duration of SEE is 02 hours

Suggested Learning Resources:

Book:

1. Cotton, R. (2013). Learning R: A Step by Step Function Guide to Data Analysis. 1st ed. O'Reilly Media Inc.

References:

1. Jones, O., Maillardet. R. and Robinson, A. (2014). Introduction to Scientific Programming and Simulation Using R. Chapman & Hall/CRC, The R Series.
2. Davies, T.M. (2016) The Book of R: A First Course in Programming and Statistics. No Starch Press.

FINITE ELEMENT ANALYSIS LABORATORY			
Course Code	**BRI657C**	CIE Marks	50
Teaching Hours/Week (L:T:P:S)	0:0:2:0	SEE Marks	50
Total Hours of Pedagogy	12 Lab Sessions	Total Marks	100
Credits	01	Exam Hours	03
Examination type (SEE)	**Practical**		

Additional One hour may be considered for instructions if required

Course objectives: Students will be able

- To learn the basic principles of finite element analysis procedure
- To apply finite element solutions to structural, thermal, dynamic problems to develop the knowledge and skills needed to effectively evaluate finite element analyses.

Sl.NO	Experiments
1	Introduction to FEA software, Pre-processing tools, Solver tools and post-processing tools.
2	Analysis of Bars of constant cross section area, tapered cross section area and stepped bar subjected to Point forces (Minimum 1 exercise of different types)
3	Analysis of trusses (Minimum 2 exercises)
4	Analysis of Beams – Simply supported, cantilever, UDL, beams with varying load etc.
5	Stress analysis of a rectangular plate with a circular hole.
6	Dynamic Analysis to find natural frequency of beam with fixed – fixed end condition.
7	Dynamic Analysis to find natural frequency of bar subjected to self-weight.
8	Thermal Analysis with conduction and convection boundary conditions (Minimum 2 exercises of different types)
9	Demonstrate the use of graphics standards (IGES, STEP etc) to import the model from modeler to solver.
10	Demonstrate one example of contact analysis to learn the procedure to carry out contact analysis.
11	Demonstrate at least two different types of examples to model and analyze bars or plates made from composite material.

Course outcomes (Course Skill Set): At the end of the course the student will be able to:

1. Apply basics of theory of elasticity to continuum problems
2. Identify the application and characteristics of FEA elements such as bars, beams, plane and isoparametric elements.
3. Apply suitable boundary conditions to a global equation for bars, trusses, beams, heat transfer, and dynamic problems.
4. Formulate and solve Axi-symmetric and heat transfer problems.

Assessment Details(both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 35% (18 Marks out of 50) in the semester-end examination (SEE).

Continuous Internal Evaluation(CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with observation sheet and record write-up.

Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.

- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10marks.
- Total marks scored by the students are scaled downed to 30 marks (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-upon time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8^{th}week of the semester and these test shall be conducted after the 14^{th}week of the semester.
- In each test, write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability. Rubrics suggested in Annexure-II of Regulation book
- The average of 02 tests is scaled down to **20 marks** (40%of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and average marks of two tests is the total CIE marks scored by the student.

Semester End Evaluation(SEE):

- SEE marks for the practical course is 50Marks.
- SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the question slot prepared by the internal/external examiners jointly.
- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners. General rubrics suggested for SEE are mentioned here, write up-20%, Conduction procedure and result -60%, Viva-voce 20% of maximum marks. SEEf or practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)
- Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero. The duration of SEE is 03hours
- Rubrics suggested in Annexure-II of Regulation book

Suggested Learning Resources:

Text books

1. A first course in the Finite Element Method, Logan, D. L, Cengage Learning, 6th Edition 2016.
2. Finite Element Method in Engineering, Rao, S. S, Pergaman Int. Library of Science 5th Edition 2010.
3. Finite Elements in Engineering, Chandrupatla T. R PHI 2nd Edition 2013

Reference books

1. Finite Element Method, J. N. Reddy, McGraw -Hill International Edition.
2. Finite Elements Procedures Bathe K. J PHI

Web links and Video Lectures (e-Resources):

1. **https://archive.nptel.ac.in/courses/112/104/112104193/**
2. **https://ocw.mit.edu/courses/18-085-computational-science-and-engineering-i-fall-2008/video_galleries/video-lectures/**
3. **https://www.youtube.com/watch?v=Bjib1DFnFgE**

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ETHICS AND PUBLIC POLICY FOR AI		Semester	VI
Course Code	**BRI657D**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:0:0: 0	SEE Marks	50
Total Hours of Pedagogy	14	Total Marks	100
Credits	01	Exam Hours	1 Hour
Examination type (SEE)	**Theory**		

Course objectives:

- Enable the student to do a deep drive into societal challenges being addressed by NGO(s), social enterprises & The government and build solutions to alleviate these complex social problems through immersion, design & technology.
- Provide a formal platform for students to communicate and connect with their surroundings.
- Enable to create of a responsible connection with society.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Use of Chalk and Talk method
- Video lectures, lecture projections in class
  Individual and Group assignments

Module-1

Human Rights – Meaning, origin and Development. Notion and classification of Rights – Natural, Moral and Legal Rights. Civil and Political Rights, Economic, Social and Cultural Rights; collective / Solidarity Rights.

Module-2

Evolution of the concept of Human Rights Magana carta – Geneva convention of 1864. Universal Declaration of Human Rights, 1948. Theories of Human Rights.

Module-3

Theories and perspectives of UN Laws – UN Agencies to monitor and compliance.

Module-4

Human Rights in India – Constitutional Provisions / Guarantees.

Module-5

Human Rights of Disadvantaged People – Women, Children, Displaced persons and Disabled persons, including Aged and HIV Infected People. Implementation of Human Rights – National and State Human Rights Commission – Judiciary – Role of NGO's, Media, Educational Institutions, Social Movements.

Course outcome (Course Skill Set)

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

- Exhibit the basic knowledge of human rights.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous internal Examination (CIE)

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered

- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examinations (SEE)

SEE paper shall be set for 50 questions, each of the 01 marks. The pattern of the question paper is MCQ (multiple choice questions). The time allotted for SEE is **01 hour.** The student has to secure a minimum of 35% of the maximum marks meant for SEE.

Suggested Learning Resources:

Books

REFERENCES:

1. Kapoor S.K., "Human Rights under International law and Indian Laws", Central Law Agency,Allahabad, 2014.
2. Chandra U., "Human Rights", Allahabad Law Agency, Allahabad, 2014.
3. UpendraBaxi, The Future of Human Rights, Oxford University Press, New Delhi.

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