SUBJECT: MANAGERIAL ECONOMICS FOR ROBOTICS		Semester	V
Course Code	**BRA501**	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 behaviors 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).**

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

Reference Books:

1. Varian, H.R. "Intermediate Microeconomics"
2. Besanko, D., & Braeutigam, R.R. "Microeconomics"
3. Autor, D.H., "Why Are There Still So Many Jobs? The History and Future of Workplace Automation"
4. 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		Semester	V
Course Code	**BRA502**	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
Examination nature (SEE)	Theory		

Course objectives:

- To understand the fundamental principles of fluid mechanics as applied to hydraulic and pneumatic systems.
- To analyze the operation and performance of various hydraulic and pneumatic components, such as pumps, actuators, valves, and compressors.
- To design and simulate hydraulic and pneumatic circuits for industrial applications, ensuring efficient and reliable system performance.
- To develop skills in troubleshooting and maintaining hydraulic and pneumatic systems, with a focus on minimizing downtime and improving system reliability.
- To explore the integration of hydraulic and pneumatic systems in automated processes and understand their role in modern industrial automation.

Teaching-Learning Process (General Instructions)

These are sample Strategies; that 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 Hydraulic Power: Definition of hydraulic system, advantages, limitations, applications, Pascal's law, structure of hydraulic control system, problems on Pascal's law.

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.

MODULE-2

Hydraulic Actuators and Motors: Classification cylinder and hydraulic motors, Linear Hydraulic Actuators [cylinders], single and double acting cylinder, Mechanics of Hydraulic Cylinder Loading, mounting arrangements, cushioning, special types of cylinders, problems on cylinders, construction and working of rotary actuators such as gear, vane, piston motors, Hydraulic Motor Theoretical Torque, Power and Flow Rate, Hydraulic Motor Performance, problems, symbolic representation of hydraulic actuators (cylinders and motors).

Control Components in Hydraulic Systems: 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, 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 and temperature compensated FCV, symbolic representation.

MODULE-3

Hydraulic Circuit Design And Analysis: Control of Single and Double -Acting Hydraulic Cylinder, Regenerative circuit, Pump Unloading Circuit, Double Pump Hydraulic System, Counter balance Valve Application, Hydraulic Cylinder Sequencing Circuits, Automatic cylinder reciprocating system, Locked Cylinder using Pilot check Valve, Cylinder synchronizing circuit using different methods, factors affecting synchronization, Speed Control of Hydraulic Cylinder, Speed Control of Hydraulic Motors, Safety circuit, Accumulators, types, construction and applications with circuits.

Maintenance of Hydraulic System: Hydraulic Oils - Desirable properties, general type of Fluids, Sealing Devices, Reservoir System, Filters and Strainers, wear of Moving Parts due to solid - particle Contamination, temperature control (heat exchangers), Pressure switches, trouble shooting.

MODULE-4

Introduction to Pneumatic Control: Definition of pneumatic system, advantages, limitations, applications, Choice of working medium Characteristic of compressed air. Structure of Pneumatic control System, fluid conditioners and FRL unit. Pneumatic Actuators: Linear cylinder - Types, Conventional type of cylinder- working, End position cushioning, seals, mounting arrangements- Applications. Rod - Less cylinder types, working, advantages, 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. Simple Pneumatic Control: Direct and indirect actuation pneumatic cylinders, speed control of cylinders - supply air throttling and Exhaust air throttling and Exhaust air throttling.

MODULE-5

Signal Processing Elements: Use of Logic gates - OR and AND gates in pneumatic applications. Practical Examples involving the use of logic gates, Pressure dependant controls- types - construction - practical applications, Time dependent controls principle, Construction, practical applications. 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 directional control valves, Use of relay and contactors. Control circuitry for simple signal cylinder application.

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

Sl.NO	Experiments
1	Design and analysis of Hydraulic circuit for Speed Control of single and double acting cylinders.
2	Sequencing of two Hydraulic cylinders using sequence valves.
3	Design of regenerative Hydraulic circuit.
4	Hydraulic circuit using counterbalance valve.
5	Design and analysis of synchronization circuit for two cylinders.
6	Controlling of hydraulic linear and rotary actuators using PLC.
7	Speed Control of hydraulic cylinders and motors using solenoid valves.
8	Design of simple Hydraulic circuit for Hydraulic Jack.
9	Pneumatic circuit for Speed Control of double acting cylinders.
10	Pneumatic circuit for Speed Control of Pneumatic motor.
11	Sequencing of two Pneumatic cylinders using sequence valves.
12	Sequencing of two Pneumatic cylinders using Proximity switches.

Course outcomes (Course Skill Set):

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

- Explain the knowledge gained on hydraulic and pneumatic systems and its components.
- Understand the working principle of various hydraulic and pneumatic components.
- Apply working principles of Hydraulic and Pneumatic Systems for various applications.
- Determine cause for hydraulic and pneumatic system break down and performance of hydraulic pumps, motors.

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.

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 theory component 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 the test 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 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 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 a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

Suggested Learning Resources:

Books

1. Saeed B. Niku, "Introduction to Robotics – Analysis, Control, Applications", Wiley India Pvt. Ltd., 2010.
2. R. Mittal, Nagrath, "Robotics and Control", McGraw Hill Education, 2017.

Suggested Reference Books:

1. Hydraulics and Pneumatics, Jagadeesha T; I. K. International Publishing House Pvt. Ltd., 2015.
2. Hydraulics and Pneumatics, Andrew Parr; Jaico Books, 1993.
3. Fluid Power with Application, Anthony Esposito, Seventh Edition, Pearson Education Ltd., 2014

Web links and Video Lectures (e-Resources):

- https://onlinecourses.nptel.ac.in/noc22_me36/preview
- VTU, E- learning
- MOOCS
- Open courseware

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

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

ROBOT OPERATING SYSTEM		**Semester**	**V**
Course Code	**BRA503**	CIE Marks	50
Teaching Hours/Week (L: T:P)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	**04**	Exam Hours	03
Examination nature (SEE)	Theory		

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 MoveIt! 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

Suggested Learning Resources:

Text Books:

1. Lentin Joseph, "Mastering ROS for Robotics Programming", Packt Publishing, 2015.
2. Studies in Computational Intelligence, 1051, Anis Koubaa - Robot Operating System (ROS) The Complete Reference 7 (2023, Springer)
3. Lentin Joseph, Aleena Johny - Robot Operating System (ROS) for Absolute Beginners_ Robotics Programming Made Easy (2022, Apress)
4. Lentin Joseph_ Jonathan Cacace - Mastering ROS for Robotics Programming - Second Edition_ Design, build, and simulate complex robots using the Robot Operating Sy (2018, Packt Publishing)

VIRTUAL INSTRUMENTATION LAB		**Semester**	**V**
Course Code	**BRAL504**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2:0	SEE Marks	50
Total Hours of Pedagogy	12 sessions	Total Marks	100
Credits	01	Exam Hours	03
Examination nature (SEE)	**Practical**		

Course objectives:

Students will be able to

- Understanding Virtual Instrument concepts and data acquisition operation
- Creating Virtual Instruments for practical works

Sl. No.	**Experiments**
1	Creating Virtual Instrumentation for simple applications- Invert The State Of Boolean Indicator Twice A See Until Program Is Stopped By User.
2	Programming exercises for loops in virtual instrumentation-Continuous Monitoring of Temperature (Generated using Random no 0<t
3	Programming exercises for graphs- Display Random Number into 3 different CHARTS (STRIP, SLOPE, SWEEP) and understand the difference between these in the UI. 4
4	Programming Exercises on case and sequence structures:-Design the simple Calculator, making use of the inherent GUI present in the virtual instrumentation software.
5	Programming Exercises on Arrays– Take a 2Darray input from the user and perform various array(and matrix) manipulations on it
6	Programming Exercises on File Input output System – Read and write from ASCII and TDMS files.
7	Real time temperature acquisition and continuous monitoring using Virtual Instrumentation
8	Developing voltmeter using DAQ cards – Acquiring a voltage and displaying it on a 'meter' indicator on the UI, thus designing a voltmeter
9	Developing Signal Generator using DAQ Card – Using analog output; amplitude, shape and frequency controlled by user
10	Data acquisition through Virtual Instrumentation – Read voltage and current of the 50 Hz supply to compute power and power factor
11	Design and Development of Filter Analysis using DAQ card – Acquire audio and filter out bands using different filters and compare effects
12	Real time sequential control of any batch process – Water level control or Temperature control

Course outcomes (Course Skill Set):

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

- Understand, design and develop data acquisition systems for Various Sensor using DAQ Cards.
- Analyze the importance& applications of LabVIEW in real time Environment.

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 10 marks.
- 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-up on time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8th week of the semester and the second test shall be conducted after the 14th week of the semester.
- In each 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. 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 50 Marks.
- SEE shall be conducted jointly by the two examiners, one internal examiner from the same institute and an external examiner from the other institute, 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 questions lot 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, writeup-20%, Conduction procedure and result in -60%, Viva-voce20% 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% Marks allotted to the procedure part to be made zero.
- The duration of SEE is 03 hours Rubrics suggested in Annexure-II of Regulation book

Suggested Learning Resources:

- https://www.youtube.com/watch?v=ZHNlKyYzrPE
- https://www.ni.com/pdf/manuals/373427j.pdf

etc....

Design of Automation System		Semester	V
Course Code	**BRA515A**	CIE Marks	50
Teaching Hours/Week (L: T:P)	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:

Students will be able

- To introduce students to the fundamental principles and components of automation systems.
- To equip students with the knowledge and skills required to design and analyze automation systems.
- To familiarize students with the integration of various subsystems in an automation system.
- To develop the ability to design control systems for automation applications.
- To provide students with hands-on experience in designing and implementing automation solutions.

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 Automation Systems: Introduction to Automation, Definitions and scope of automation, Types of automation: Fixed, programmable, and flexible automation. Automation System Components, Sensors, actuators, controllers, and Human-Machine Interfaces (HMIs). Applications of Automation in Industry like, manufacturing, material handling, and robotics. Design Considerations, Safety, reliability, and maintainability in automation systems.

MODULE-2

Sensors and Actuators in Automation: Introduction to Sensors, Types of sensors: Proximity, temperature, pressure, and vision sensors. Sensor selection criteria and interfacing with controllers. Actuators and Drives: Types of actuators: Electric, pneumatic, and hydraulic actuators. Servo motors, stepper motors, and their control. Integration of Sensors and Actuators: Interfacing and communication protocols, Real-time control and feedback loops.

MODULE-3

Programmable Logic Controllers (PLCs) and Automation Programming: Introduction to PLCs, Architecture and components of PLCs. PLC programming languages: Ladder logic, Function Block Diagram (FBD), and Structured Text. PLC Programming Techniques: Basic PLC operations: Logic, timing, and counting. Advanced PLC programming: Data handling, PID control, and networking

PLC Applications in Automation: Case studies of PLC applications in industrial automation, Integration of PLCs with SCADA systems.

MODULE-4

Industrial Networks and Communication Protocols: Introduction to Industrial Networks, Overview of communication protocols: Modbus, Profibus, Ethernet/IP, and CAN bus. Network topology and communication media. Network Design for Automation Systems: Designing robust and scalable industrial networks, Ensuring network security and reliability. Communication Interfaces and Data Acquisition: Interfacing controllers, sensors, and actuators with networks, Real-time data acquisition and monitoring.

MODULE- 5

Advanced Topics in Automation System Design: Integration of Automation Systems, System integration methodologies and challenges. Design of automated production lines and assembly systems
Control System Design: Design of control systems for automation using PID and advanced control strategies. Model Predictive Control (MPC) and adaptive control in automation. Case studies of advanced automation systems in industries like automotive, electronics, and healthcare. Emerging trends: IoT in automation, Industry 4.0, and smart manufacturing

Course outcome (Course Skill Set)

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

CO1: Understand the core concepts and components of automation systems.
CO2: Analyze the performance and efficiency of different automation systems.
CO3: Design and integrate automation systems for various industrial applications.
CO4: Develop control strategies for automation using PLCs, sensors, and actuators.
CO5: Implement and troubleshoot automation systems in real-world scenarios.

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

Suggested Learning Resources:

Text Books:

1. "Automation, Production Systems, and Computer-Integrated Manufacturing" by Mikell P. Groover.
2. "Introduction to Robotics: Mechanics and Control" by John J. Craig.
3. "Programmable Logic Controllers: Principles and Applications" by John W. Webb and Ronald A. Reis.

Reference Books:

1. "Industrial Automation and Robotics" by A.K. Gupta and S.K. Arora (Indian Authors)
2. "Mechatronics: Principles, Concepts, and Applications" by Mahalik N.P. (Indian Author)

Web links and Video resources:

NPTEL Courses:

1. **"Industrial Automation and Control" by IIT Kharagpur**
2. **"Control Engineering" by IIT Delhi**

YouTube Channels:

- **Automation Direct (for PLC and automation tutorials)**
- **RealPars (for industrial automation training videos)**

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

- Course seminar
- Term project

AUTONOMOUS ROBOTS		**Semester**	**V**
Course Code	**BRA515B**	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
Examination nature (SEE)	**Theory**		

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 AssessmentTest 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

WIRELESS SENSORS NETWORKS FOR ROBOTICS		**Semester**	**V**
Course Code	**BRA515C**	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:

- know the basic knowledge about wireless sensor networks.
- impart knowledge in networking using sensors.
- study about the tools used in networking.
- understand the basic in wireless architecture.
- learn about the different techniques used in networking

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.
- Flipped classroom teaching method.
- Collaborative (Group) learning in the class.
- Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

OVERVIEW OF WIRELESS SENSOR NETWORKS

Challenges for Wireless Sensor Networks, Enabling Technologies for Wireless Sensor Networks. Types of wireless sensor networks. Single-Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes.

Module-2

ARCHITECTURES

Network Architecture -Sensor Network Scenarios, Optimization Goals and Figures of Merit, Gateway Concepts. Operating Systems and Execution Environments.

Module-3

NETWORKING SENSORS

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

Module-4

INFRASTRUCTURE ESTABLISHMENT

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

Module-5

SENSOR NETWORK PLATFORMS AND TOOLS

Sensor Node Hardware – Berkeley Motes, Programming Challenges, Node-level software platforms, Node-level Simulators, State-centric programming.

Course Outcome (COs) (Course Skill Set)

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

1. Recall the basic concepts and components of wireless sensor networks, including types of wireless sensor networks, single-node architecture, and network architecture.
2. Explain the functions of single-node architecture, network architecture, and MAC protocols in wireless sensor networks.
3. Apply the concepts of MAC protocols and energy-efficient routing to design a basic wireless sensor network architecture.
4. Analyze the energy consumption patterns and optimization goals in different wireless sensor network architectures.
5. Evaluate the effectiveness of different MAC protocols and routing strategies in achieving energy efficiency in wireless sensor networks.

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:

Books

1. Holger Karl & Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", John Wiley, 2005.
2. Feng Zhao & Leonidas J.Guibas, "Wireless Sensor Networks- An Information Processing Approach", Elsevier, 2007.

Reference Books:

1. KazemSohraby, Daniel Minoli, &TaiebZnati, "Wireless Sensor Networks- Technology, Protocols, And Applications", John Wiley, 2007.
2. Anna Hac, "Wireless Sensor Network Designs", John Wiley, 2003.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/106/105/106105160/
2. https://onlinecourses.swayam2.ac.in/arp19_ap52/preview

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

IMAGE PROCESSING		Semester	V
Course Code	**BRA515D**	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:

- Understand the sensing, acquisition and storage of digital images.
- Study the image fundamentals and mathematical transforms necessary for image processing.
- Learn the digital processing systems and corresponding terminology.
- Know the base image transformation domains and methods.
- Have an understanding of colour models, type of image representations and related statistics.
- Study the image enhancement techniques, compression procedures, segmentation, representation techniques and image restoration.

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.
- Flipped classroom teaching method.
- Collaborative (Group) learning in the class.
- Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

INTRODUCTION TO IMAGE PROCESSING

Introduction of Coordinate representation and Pixel, Raster Scan & Random Scan systems, Video controller and raster scan display processor, image processing fundamentals, Applications, Image processing system components, Image sensing and acquisition, Sampling and quantization, Neighbours of pixel adjacency connectivity, regions and boundaries and Distance measures.

Module-2

IMAGE ENHANCEMENT

Frequency and Spatial Domain, Contrast Stretching, Histogram Equalization, Low pass and High pass filtering.

Module-3

IMAGE RESTORATION

Noise models, mean, order-statistics, adaptive filters, Band reject, Band pass and notch filters.

Module-4

COLOUR IMAGE PROCESSING

Colour models, Pseudo colour Image processing, Colour transformation and segmentation.

Module-5

IMAGE COMPRESSION

Fundamentals, Models, Error free and lossy compression, Standards, Boundary extraction, Region filtering, Connected component extraction.

Course Outcome (COs) (Course Skill Set)

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

1. recall the basic concepts image processing, image storage and types of transformations that can be applied to images.
2. explain the domains and methods of image processing.
3. apply the correctness of algorithms using inductive proofs and loop invariants.
4. analyze the image restoration & Enhancement techniques, colour image processing.
5. evaluate the compression procedures, image segmentation and representation techniques, image restoration.

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:

Books

1. Digital Image Processing, Second Edition by Rafel C. Gonzalez and Richard E. Woods, Pearson Education

Reference Books:

1. Digital Image Processing by Bhabatosh Chanda and Dwijesh Majumder, PHI
2. Fundamentals of Digital Image Processing by Anil K Jain, PHI
3. Digital Image Processing Using Matlab, Rafel C. Gonzalez and Richard E. Woods, Pearson Education

Web links and Video Lectures (e-Resources):

3. https://onlinecourses.nptel.ac.in/noc22_ee116/preview
4. https://www.coursera.org/learn/digital
5. https://cse19-iiith.vlabs.ac.in/

Quality Control and Maintenance Management		Semester	VI
Course Code	**BRA601**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	4:0:0:0	SEE Marks	50
Total Hours of Pedagogy	52	Total Marks	100
Credits	**04**	Exam Hours	03
Examination nature (SEE)	Theory		

Course objectives:

1. To provide students with a comprehensive understanding of quality control concepts, tools, and techniques.
2. To introduce the principles of maintenance management and their application in industry.
3. To prepare students for the practical challenges of maintaining quality in manufacturing and service industries.
4. To enhance problem-solving skills and decision-making capabilities in the context of quality and maintenance management.

Pedagogy (General Instructions)

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

1. The lecture method (L) should encompass a variety of teaching techniques beyond traditional lectures. Incorporate case studies, simulations, role-playing, and hands-on activities to help students grasp complex concepts in quality control and maintenance management.
2. Organize visits to local manufacturing plants and service facilities to observe real-world quality control and maintenance practices. Engage with industry professionals to provide students with insights into the latest tools, technologies, and methodologies used in the field.
3. Use videos, animations, and software simulations to demonstrate the functioning of quality control tools (like control charts and Six Sigma) and maintenance management systems (like CMMS). Visual representations can help clarify abstract concepts and processes.
4. Encourage group projects and collaborative learning activities in the classroom. Assign students to work together on case studies, problem-solving exercises, and real-world scenarios to foster teamwork and deepen their understanding of the subject matter.
5. Pose at least three HOTS questions in each class session to promote critical thinking. Questions should challenge students to analyze, evaluate, and create solutions based on the concepts discussed, rather than just recalling information.
6. Adopt Problem Based Learning (PBL) to develop students' analytical skills. Present them with real-world problems related to quality control and maintenance management, requiring them to research, hypothesize, and propose solutions. This approach fosters deeper learning and practical application of knowledge.
7. Introduce topics using multiple representations, such as diagrams, flowcharts, mathematical models, and verbal descriptions. This approach accommodates different learning styles and helps students understand the material from various perspectives.
8. Discuss how every concept taught in the course can be applied in real-world scenarios. Use case studies from industry to illustrate the practical importance of quality control and maintenance management principles, making the subject more relevant and engaging for students.
9. Encourage instructors to develop and implement innovative teaching strategies tailored to their students' needs. This could include flipped classrooms, peer teaching, interactive workshops, or incorporating the latest technology trends in the field, such as IoT and AI in maintenance.
10. Provide regular feedback to students through formative assessments, quizzes, and interactive discussions. Use this feedback to adapt teaching strategies and ensure that students are meeting the desired learning outcomes throughout the course

Module-1 INTRODUCTION

Definition and Importance of Quality: Understanding quality and its role in manufacturing and service industries. Evolution of Quality Control: Historical development of quality control methods. Basic concepts of TQM - TQM Framework, Contributions of pioneers like Deming, Juran, and Crosby. Barriers to TQM. ISO Standards and Certification: Overview of ISO 9000 series. Certification process and benefits for organizations. Quality Assurance, Quality Control: Distinction between QA and QC.

Module-2 TQM PRINCIPLES

Leadership - Quality Statements, Strategic quality planning, Quality Councils - Employee involvement - Motivation, Empowerment, Team and Teamwork, Recognition and Reward, Performance appraisal - Continuous process improvement - PDCA cycle, 5S, Kaizen - Supplier partnership - Partnering, Supplier selection, Supplier Rating.

Module-3 TQM TOOLS AND TECHNIQUES

The seven traditional tools of quality - New management tools - Six sigma: Concepts, Methodology, applications to manufacturing, service sector including IT - Bench marking - Reason to bench mark, Bench marking process - FMEA - Stages, Types. Quality Circles - Cost of Quality - Quality Function Deployment (QFD) - Taguchi quality loss function - TPM- Concepts, improvement needs - Performance measures.

Module-4 MAINTENANCE

Definition and objectives of maintenance management. Impact of maintenance on productivity and costs. Types of Maintenance: Preventive Maintenance, Predictive Maintenance, Corrective Maintenance, Breakdown Maintenance, elements of preventive maintenance – checklist, schedule, procedure. Key performance indicators (KPIs) for maintenance. Mean Time Between Failures (MTBF), Mean Time to Repair (MTTR).

Module-5 TOTAL PRODUCTIVE MAINTENANCE:

Principles; preparatory stages of implementation – TPM organisation structure, creation; basic TPM policies and aids, master plan. TPM IMPLEMENTATION: Small group activities, autonomous maintenance, establishing planned maintenance, training, developing equipment management program.

Course outcome (Course Skill Set)

At the end of the course the student will be :

CO1: Able to **Define** and explain the importance of quality in both manufacturing and service industries.

CO2:Able to **Apply** TQM principles to real-world scenarios, including leadership in quality management, strategic quality planning, and the formation of quality councils.

CO3: Able to **use** traditional and new quality management tools effectively, including the seven traditional tools of quality, Six Sigma methodologies, and benchmarking processes.

CO4: Able to **understand and implement** different types of maintenance strategies, such as preventive, predictive, corrective, and breakdown maintenance.

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. Dale H.Besterfiled, Carol B.Michna,Glen H. Besterfield,Mary B.Sacre,Hemant Urdhwareshe and Rashmi Urdhwareshe, "Total Quality Management", Pearson Education Asia, Revised Third Edition, Indian Reprint, Sixth Impression, 2013.
2. Robinson C J and Ginder A P, "Implementing TPM", Productivity Press, USA, 1995.

Reference Books:

1. James R. Evans and William M. Lindsay, "The Management and Control of Quality", 8th Edition, First Indian Edition, Cengage Learning, 2012.
2. Janakiraman. B and Gopal .R.K., "Total Quality Management - Text and Cases", Prentice Hall (India) Pvt. Ltd., 2006.
3. Suganthi.L and Anand Samuel, "Total Quality Management", Prentice Hall (India) Pvt. Ltd., 2006.
4. ISO 9001-2015 standards.
5. Dhillon B S, "Maintainability, Maintenance and Reliability for Engineers", CRC Press, 2006.

Web links and Video Lectures (e Resources):

- https://archive.nptel.ac.in/courses/110/101/110101150/
- https://archive.nptel.ac.in/courses/110/105/110105088/
- https://www.youtube.com/watch?v=f58SW0Hwcf0
- https://archive.nptel.ac.in/courses/105/102/105102176/
- https://www.digimat.in/nptel/courses/video/105102176/L39.html
- NPTEL: Total Quality Management by Prof. N. K. Tewari (IIT Kanpur)

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

- Project based study
- Case study

Additive Manufacturing		Semester	VI
Course Code	**BRA602**	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
Examination nature (SEE)	**Theory**		

Course objectives:

- Understand the fundamental principles and evolution of Additive Manufacturing (AM) technologies.
- Explore various AM processes, including Vat Photopolymerization, Material Jetting, and Binder Jetting.
- Learn about the material science aspects and post-processing techniques in AM.
- Analyze the role of CAD in AM, including data formats and process selection.
- Investigate the application of AM across different industry domains, such as aerospace and healthcare.

Teaching-Learning Process (General Instructions)

These are sample Strategies; that teachers 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 skills such as evaluating, generalizing, and analyzing information.
5. Conduct Laboratory Demonstrations and Practical Experiments to enhance experiential skills.

MODULE-1

Introduction to Additive Manufacturing: Introduction to AM, AM evolution, Distinction between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and Types of materials for AM. **Vat Photopolymerization AM Processes:** Stereolithography (SL), Materials, Process Modeling, SL resin curing process, SL scan patterns, Micro-stereolithography, Mask Projection Processes, Two-Photon vat photopolymerization, Process Benefits and Drawbacks, Applications of Vat Photopolymerization, Material Jetting and Binder Jetting AM Processes.

MODULE-2

Extrusion-Based AM Processes: Fused Deposition Modelling (FDM), Principles, Materials, Process Modelling, Plotting and path control, Bio-Extrusion, Contour Crafting, Process Benefits and Drawbacks, Applications of Extrusion-Based Processes.

Sheet Lamination AM Processes: Bonding Mechanisms, Materials, Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM and UC applications.

MODULE-3

Powder Bed Fusion AM Processes: Selective laser Sintering (SLS), Materials, Powder fusion mechanism and powder handling, Process Modelling, SLS Metal and ceramic part creation, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes.

Directed Energy Deposition AM Processes: Process Description, Material Delivery, Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition, Processing-structure-properties, relationships, Benefits and drawbacks, Applications of Directed Energy Deposition Processes.

MODULE-4

Materials science for AM - Multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, microstructural studies, Structure property relationship.

Post Processing of AM Parts: Support Material Removal, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement, Preparation for use as a Pattern, Property Enhancements using Non-thermal and Thermal Techniques.

MODULE-5

CAD for Additive Manufacturing: CAD Data formats, Data translation, Data loss, STL format.

Guidelines for Process Selection: Introduction, Selection Methods for a Part, Challenges of Selection, Example System for Preliminary Selection, Process Planning and Control.

Additive Manufacturing Application Domains: Aerospace, Electronics, Health Care, Defence, Automotive, Construction, Food Processing, Machine Tools

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

Sl.NO	Experiments
1	3D Modelling of a single component.
2	Assembly of CAD modelled Components
3	Exercise on CAD Data Exchange.
4	Generation of .stl files.
5	Simulation using CURA software
6	Identification of a product for Additive Manufacturing and its AM process plan.
7	Printing of identified product on an available AM machine.
8	Post processing of additively manufactured product.
9	**Can be Demo experiments for CIE** Inspection and defect analysis of the additively manufactured product.
10	**Can be Demo experiments for CIE** Comparison of Additively manufactured product with conventional manufactured counterpart
11	**Can be Demo experiments for CIE** Explore how topology optimization can be used in additive manufacturing to reduce weight while maintaining structural integrity.
12	**Can be Demo experiments for CIE** Study the microstructure of metal parts produced by additive manufacturing.

Course outcomes (Course Skill Set):

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

CO1 Understand the working principle and process parameters of AM processes

CO2 Explore the applications of AM processes in various fields

CO3 Select the suitable material and process for fabricating a given product

CO4 Apply the knowledge in Material science in Additive Manufacturing components

CO5 Design and develop a product for AM Process

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.

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 theory component 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 the test 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 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 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 a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

Suggested Learning Resources:

Text Books:

1. Lan Gibson, David W. Rosen and Brent Stucker, "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.
2. Andreas Gebhardt, "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing", Hanser Publisher, 2011.
3. Khanna Editorial, "3D Printing and Design", Khanna Publishing House, Delhi.

Reference Books:

1. CK Chua, Kah Fai Leong, "3D Printing and Rapid Prototyping- Principles and Applications", World Scientific, 2017.
2. J.D. Majumdar and I. Manna, "Laser-Assisted Fabrication of Materials", Springer Series in Material Science, 2013.
3. L. Lu, J. Fuh and Y.S. Wong, "Laser-Induced Materials and Processes for Rapid Prototyping", Kulwer Academic Press, 2001.
4. Zhiqiang Fan And Frank Liou, "Numerical Modelling of the Additive Manufacturing (AM) Processes of Titanium Alloy", In Tech, 2012.

Web links and Video Lectures (e-Resources):

1. NPTEL - Additive Manufacturing
2. Science Direct - Additive Manufacturing: Materials, Processes, Quantifications and Applications
3. https://www.youtube.com/watch?v=zTgjpEXRCXQ
4. NPTEL Video Lectures - Additive Manufacturing (by IIT Kanpur)

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

1. Project based learning
2. Model making
3. Case study, etc

Image Processing and Machine Vision		Semester	VI
Course Code	**BRA613A**	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:

- To Understand the Fundamentals of Digital Image Processing.
- To Master Point Processing Techniques.
- To Develop Proficiency in Image Enhancement.
- To Explore Image Morphology and Restoration Techniques.
- To Apply Image Segmentation and Machine Vision Algorithms.

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

Digital Image Fundamentals and Point processing:
Introduction-Steps in Digital image processing, concept of spatial and intensity resolution, Relationships between pixels. **Point Processing:** Image Negative, Log Transform, Power Law transform, Bit plane slicing, Contrast stretching, Histogram equalization and Histogram Specification.

Module-2

IMAGE ENHANCEMENT :

Spatial Domain filtering : The Mechanics of Spatial Filtering, **Smoothing Spatial Filters**-Linear Filters-Averaging filter, Order-Statistic Filters- Median filter, Application of Median filtering for Noise removal **Sharpening Spatial Filters-** The Laplacian, Unsharp Masking and High boost Filtering, Using First-Order Derivatives —The Gradient- Sobel, Prewitt and Roberts **Frequency Domain Filtering:** Introduction to 2-

D DFT and its application in frequency domain filtering, Wavelet transform, Haar transform **Frequency Domain Filtering Fundamentals**, Fourier Spectrum and Phase angle ,Steps for Filtering in the Frequency Domain, Correspondence Between Filtering in the Spatial and Frequency Domains, Frequency domain Image Smoothing and sharpening filter - Ideal, Butterworth , Gaussian.

Module-3

Image morphology and restoration:

Morphology: Erosion and Dilation, Opening and Closing, The Hit-or-Miss Transformation, Boundary extraction, Hole filling, Thinning and thickening **Restoration:** A Model of the Image Degradation/Restoration Process, Noise models, Removal periodic noise, Principle of Inverse filtering.

Module-4

Image segmentation:

Point, Line, and Edge Detection: Detection of Isolated Points, Line detection, edge models, Canny's edge detection algorithm, Edge linking: Local processing and boundary detection using regional processing (polygonal fitting) **Thresholding :** Foundation, Role of illumination and reflectance, Basic global thresholding **Region Based segmentation:** Region Growing, Region Splitting and merging

Module-5

Introduction to machine vision and descriptors:

Principle of machine vision , real world applications, chain code, simple geometric border representation, Fourier Transform of boundaries, Boundary description using segment sequences, Introduction to Texture, co-occurrence matrix,

Machine Vision Algorithms: Knowledge representation, Classification Principles, Classifier setting, Classifier Learning, Confusion Matrix, K-means clustering algorithm, Introduction, bays decision theory continuous case, two category classification, Bayesian classifier, Support vector machine

Course outcome (Course Skill Set)

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

- **CO1:** Recall the basic steps in digital image processing, including the concept of spatial and intensity resolution, and the relationships between pixels.
- **CO2:** Explain the concepts of spatial and intensity resolution, and the relationships between pixels in digital image processing.
- **CO3:** Apply point processing techniques, such as log transform and histogram equalization, to enhance digital images.
- **CO4:** Analyze the effects of different spatial and frequency domain filtering techniques on image enhancement.
- **CO5:** Evaluate the effectiveness of different image enhancement techniques for improving image quality in various digital image processing scenarios.

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. Milan Sonka, Vaclav Hlavac, Roger Boyle, —Image Processing, Analysis, and Machine Vision|| Cengage Engineering, 3rd Edition, 2013
2. Gonzales and Woods, —Digital Image Processing||, Pearson Education, India, Third Edition,
3. R. O. Duda and P. E. hart, Pattern classification and scene analysis, Wiley Interscience publication
4. Christopher M. Bishop; Pattern Recognition and Machine Learning, Springer, 2006

Reference books:

1. Anil K.Jain, —Fundamentals of Image Processing||, Prentice Hall of India, First Edition, 1989.
2. W Pratt, —Digital Image Processing||, Wiley Publication, 3rd Edition, 2002
3. Forsyth and Ponce, Computer vision: A modern approach, PHI
4. Frank Y Shish ,Image Processing and Pattern Recognition: Fundamentals and Techniques, Wiley Wiley-IEEE Press, 2010

Web links and Video Lectures (e-Resources):

https://www.youtube.com/playlist?list=PLaHodugB5x-Ddy_H951h0VHjOjfzZNCBh
https://www.coursera.org/learn/introduction-computer-vision-watson-opencv?msockid=34eaeb57b8ce6a80074bff8ab9636bc4

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

- **Implementation of Spatial Filters:** students will implement different spatial filters such as averaging, median, and Gaussian filters on noisy images and compare the outcomes.
- **Edge Detection Experiments:** Assign students to implement and compare various edge detection algorithms like Sobel, Prewitt, and Canny on the same image. They should analyze the strengths and weaknesses of each method.
- **Frequency Domain Filtering:** Students will use the 2D Discrete Fourier Transform (DFT) to transform an image to the frequency domain, apply filters (like Butterworth or Gaussian), and then transform it back to the spatial domain.
- **Morphological Operations Workshop:** Have students implement basic morphological operations such as erosion, dilation, opening, and closing on binary images to extract boundaries or fill holes.
- **Segmentation Project:** Students will work on a project that involves segmenting different regions in an image using techniques like thresholding, region growing, or region splitting and merging. They can apply these techniques to medical images, satellite images, or any relevant dataset.

Computer Integrated Machining		Semester	VI
Course Code	**BRA613B**	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:

- Understand the principles and components of Computer Integrated Manufacturing Systems (CIMS).
- Learn the fundamentals of Numerical Control (NC) and Computer Numerical Control (CNC) machine tools.
- Explore the methodologies and tools involved in Production Planning, Control, and Computerized Process Planning (CAPP).
- Gain knowledge on Group Technology (GT) and Cellular Manufacturing systems.
- Analyze the components, applications, and benefits of Flexible Manufacturing Systems (FMS) and Automated Guided Vehicle Systems (AGVS).

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 analysing information.

Module-1

Introduction to Computer integrated Manufacturing Systems: Manufacturing Systems, Types of Manufacturing Systems, , Machine Tools and related equipment's, Material Handling Systems, Computer monitoring and control, Manufacturing support systems, The Product Cycle and CAD/CAM, Functions of computers in CIMS: CIMS Data Files, System Reports, Benefits of Computer integrated Manufacturing Systems. Fundamentals of Numerical Control: Basic concepts of NC, Classification of NC- Point to Point and contouring, Incremental and absolute system, Open loop and closed loop system, Advantages of NC.

Module-2

NC/ CNC Machine Tools: General architecture of CNC Machine, Components of the CNC Systems: Machine Control Unit, CNC Driving system components: Hydraulic, Servo Motors, Stepper Motors, and Feedback Devices: Encoder, Resolver, Indexing, Tachometers, Counting devices.

Module-3

Production Planning And Control And Computerised Process Planning Process planning – Computer Aided Process Planning (CAPP) – Logical steps in Computer Aided Process Planning – Aggregate Production Planning and the Master Production Schedule – Material Requirement planning – Capacity Planning- Control Systems-Shop Floor Control Inventory Control – Brief on Manufacturing Resource Planning-II (MRP-II) & Enterprise Resource Planning (ERP) - Simple Problems.

Module-4

Cellular Manufacturing: Group Technology (GT), Part Families – Parts Classification and coding – Simple Problems in Opitz Part Coding system – Production flow Analysis – Cellular Manufacturing – Composite part concept – Machine cell design and layout – Quantitative analysis in Cellular Manufacturing – Rank Order Clustering Method - Arranging Machines in a GT cell – Hollier Method – Simple Problems.

Module-5

Flexible Manufacturing System (FMS) And Automated Guided Vehicle System (AGVS): Types of Flexibility - FMS – FMS Components – FMS Application & Benefits – FMS Planning and Control– Quantitative analysis in FMS – Simple Problems. Automated Guided Vehicle System (AGVS) – AGVS Application – Vehicle Guidance technology – Vehicle Management & Safety.

Course outcome (Course Skill Set)

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

1. Demonstrate an understanding of the functions and benefits of Computer Integrated Manufacturing Systems (CIMS).
2. Identify and describe the architecture and components of CNC machine tools.
3. Apply the concepts of Computer-Aided Process Planning (CAPP) and Production Planning in manufacturing scenarios.
4. Solve problems related to Group Technology (GT) and Cellular Manufacturing, including part classification and machine cell design.
5. Evaluate the flexibility, planning, and control aspects of Flexible Manufacturing Systems (FMS) and Automated Guided Vehicle Systems (AGVS).

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:

Text Books

1. Mikell. P. Groover "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall of India, 2008.
2. Radhakrishnan P. Subramanyan S. and Raju V., "CAD/CAM/CIM", 2nd Edition, New Age International (P) Ltd, New Delhi, 2000.
3. Groover, M. P. and Zimmers, E. W., CAD/CAM: Computer Aided Design & Manufacturing, 2006, Pearson Education India
4. M. Koren—Computer Controls of Manufacturing Systems, Mc-Graw Hill, 1983

Text Books

1. Martin J. —Numerical control of machine tools".
2. P.N. Rao – CAD/CAM Principles and Applications Mc-Graw Hill 2002
3. Y. Koren & J. Benuri -"Numerical control of machine tools -Khanna, 1992
4. Hood-Daniel P., and Kelly J.F., Build Your Own CNC Machine, 2009, Springer-Verlag New York

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=yk_0T2_Yphc
- https://www.sciencedirect.com/journal/automation-and-computer-integrated-manufacturing
- https://www.youtube.com/watch?v=kAqrAXXztFI
- https://www.youtube.com/watch?v=zwEkqOcGxv0
- https://www.youtube.com/watch?v=1YTC23hgbYk
- https://www.youtube.com/watch?v=zv-mA6B-2L0

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

- Project based work
- Individual / group activity
- Model making

Thermal Management of Electronic Equipment's		Semester	VI
Course Code	**BRA613C**	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:

- Understand the principles of heat transfer and its impact on electronic equipment.
- Analyse various cooling techniques for electronic components and systems.
- Design and implement effective thermal management solutions for electronic systems in robotics and automation.
- Evaluate the performance of thermal management systems using simulation and experimental methods.

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 Thermal Management: Introduction, Importance, Overview, and Consequences of Thermal Management in Electronics. Basics of heat transfer like, modes of heat transfer, significance of Thermal conductivity, and thermal resistance in electronics. Thermal properties of common electronic materials (metals, semiconductors, insulators), and Introduction to thermal interface materials (TIMs). Methods of temperature measurement in electronic systems (thermocouples, infrared sensors, thermistors).

Module-2

Thermal Analysis and Modelling: Thermal Circuit Analysis, Simplified thermal models for electronic components. Simulation Tools for Thermal Analysis like, ANSYS, COMSOL, or similar for thermal simulation. Thermal Management in PCB Design like**,** Heat generation and dissipation in PCBs.

Module-3

Cooling Techniques for Electronic Equipments: Passive Cooling Methods like, Heat sinks, natural convection, thermal interface materials. Design considerations for passive cooling. Active Cooling Techniques like, Forced convection, fans, blowers, liquid cooling, thermoelectric coolers. Design and selection criteria for active cooling solutions.

Module-4

Thermal Management in Robotics and Automation: Thermal Challenges in Robotics and Automation like, Heat sources in robotic systems: motors, power electronics, and sensors. Thermal Management Solutions for Robotics like, Integration of cooling systems in robots and automation equipment. Thermal Design Considerations; Design optimization for thermal performance in robotics.

Module-5

Thermal Management in Design and Reliability: Reliability Analysis of Electronic Systems Failure modes related to thermal stress. Thermal Testing Techniques like, Thermal imaging, infrared thermography, and temperature sensors. Reliability and Thermal Stress like, Impact of thermal cycling on component life, and Testing for thermal reliability and standards.

Course Outcome (COs) (Course Skill Set)

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

CO1: Understand the fundamental principles of heat transfer and their application in electronic systems.
CO2: Analyze the thermal performance of electronic components and systems.
CO3: Design and evaluate thermal management solutions using passive and active cooling techniques.
CO4: Assess the reliability and efficiency of electronic systems under thermal constraints.
CO5: Apply thermal management strategies in the design of robotics and automation 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 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. "Thermal Management of Electronics" by V. S. Murali Krishna, Publisher: McGraw-Hill Education India
2. "Heat Transfer in Electronic Equipment" by C.P. Gupta & R. Prakash, Publisher: Wiley India.

Reference Books:

1. "Fundamentals of Heat and Mass Transfer" by P. K. Nag, Publisher: McGraw-Hill Education India.
2. "Electronic Cooling and Thermal Control Systems" by S. P. Sukhatme, Publisher: Orient BlackSwan
3. "Thermal Management for LED Applications" by Clemens J.M. Lasance, Publisher: Springer

Web links and Video Lectures (e-Resources):

- **NPTEL Courses**: like,
  1. "Thermal Management of Electronics" by IIT Kharagpur
  2. "Heat Transfer" by IIT Madras
- **YouTube Channels**:
  1. Cooling Techniques for Electronics (by Engineers Academy)
  2. Thermal Management in Electronics (by Binghamton University)

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

1. Activity based learnings
2. Project based learnings
3. Simulation of thermal profiles in PCBs using software's
4. Group projects

Artificial Intelligence for Automation		Semester	VI
Course Code	**BRA613D**	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:

1. Study the concepts of Artificial Intelligence in automation.
2. Learn the methods of solving problems using Artificial Intelligence.
3. Introduce the concepts of Expert Systems and machine learning.
4. Learn about planning and reasoning artificial intelligence.
5. Solve the risk in artificial intelligence.

Pedagogy (General Instructions)

These are sample Strategies; which teacher 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. Arrange visits to nearby power plants, receiving station and substations to give brief information about the electrical power generation.
3. Show Video/animation films to explain functioning of various machines.
4. Encourage collaborative (Group Learning) Learning in the class.
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical

thinking.

6. Adopt Problem Based Learning (PBL), which fosters student's Analytical skills, develop thinking skills such asthe ability to evaluate, generalize, and analyze information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
10. Individual teacher can device the innovative pedagogy to improve the teaching-learning.

Module-1 Introduction to Automation

Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations. Production Economics - Methods of Evaluating Investment Alternatives, Costs in Manufacturing, Break Even Analysis, Unit cost of production, Cost of Manufacturing Lead time and Work-in-process.

Module-2 Introduction to Artificial Intelligence

Introduction-Foundations of AI- History of AI Intelligent agents: Agents and Environment- Reactive agent-deliberative- goal-driven, utility driven, and learning agents -Artificial Intelligence programming techniques. Introduction to ML and DL Concepts

Module-3 Knowledge Representation and Reasoning

Ontologies-foundations of knowledge representation and reasoning-representing and reasoning about objects-relations- events actions- time- and space- predicate logic-situation calculus-description logics-reasoning with defaults,-reasoning about knowledge-sample applications- Representing Knowledge and reasoning in an Uncertain Domain- Bayes rule-bayesian networks-probabilistic inference sample applications- Planning: planning as search- partial order planning- construction and use of planning graphs.

Module-4 Expert systems

Expert systems – Architecture of expert systems, Roles of expert systems – Knowledge Acquisition – Meta knowledge, Heuristics. Typical expert systems – MYCIN, DART, XOON.

Module-5 Industrial AI applications and Case studies

Applications of Industrial AI in Monitoring, optimization and control.AI applications in Industry Automation using -natural language processing-computer vision-speech recognition-computer vision.

Course outcome (Course Skill Set)

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

1. Recall the fundamental concepts of industrial automation and the foundational aspects of artificial intelligence and machine learning.
2. Explain the key principles and strategies of industrial automation, artificial intelligence and machine learning, including their applications in automation and decision-making processes.
3. Apply the artificial intelligence techniques to solve basic automation problems and optimize manufacturing processes.
4. Analyze the effectiveness of automation and artificial intelligence techniques in optimizing and improving decision-making in Automation.
5. Evaluate the impact on the efficiency and effectiveness of industrial processes, considering various optimization techniques and real-world 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:

- 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. Rich and Knight, "Artificial Intelligence", 3rd Edition, Tata McGraw Hill, 2014.
2. M.P.Groover, "Automation, Production Systems and Computer Integrated Manufacturing", 5th edition, Pearson Education, 2009.

Reference Books

1. Anuradha Srinivasaraghavan, Vincy Joseph "Machine Learning", Wiley, 2019.
2. Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", 2nd Edition, Prentice Hall, 2003.
3. Rajiv Chopra, "Deep Learning", 1st edition, Khanna Publishing House,2018.

Web links and Video Lectures (e-Resources):

Web Link:

- Coursera: Fundamentals of Automation
- Coursera: Machine Learning by Andrew Ng

Video Lecture:

- YouTube: Automation Systems Overview by Siemens
- YouTube: Python AI Programming by NPTEL
- YouTube: Bayesian Networks by NPTEL
- YouTube: Knowledge Representation in AI by NPTEL

Automotive Electronics		Semester	VI
Course Code	**BRA654A**	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:

- To Understand the Evolution and Fundamentals of Automotive Electronics
- To Analyze the Basics of Electronic Engine Control Systems
- To Explore Automotive Sensors and Actuators
- To Examine Digital Engine Control Systems and Networking
- To Evaluate Automotive Diagnostics and Future Technologies

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

Automotive Fundamentals Overview

Evolution of Automotive Electronics, Automobile Physical Configuration, Survey of Major Automotive Systems, The Engine - Engine Block, Cylinder Head, Four Stroke Cycle, Engine Control, Ignition System- Spark plug, High voltage circuit and distribution, Spark pulse generation, Ignition Timing, Diesel Engine, Drive Train - Transmission, Drive Shaft, Differential, Suspension, Brakes, Steering System, Starter Battery --Operating principle

The Basics of Electronic Engine Control-

Motivation for Electronic Engine Control- Exhaust Emissions, Fuel Economy, Concept of an Electronic Engine control system, Definition of General terms, Definition of Engine performance terms, Engine mapping, Effect of Air/Fuel ratio, spark timing and EGR on performance, Control Strategy, Electronic Fuel control system, Analysis of intake manifold pressure, Electronic Ignition.

Module-2

Automotive Sensors:

Automotive Control System applications of Sensors and Actuators - Variables to be measured, Airflow rate sensor, Strain Gauge MAP sensor, Engine Crankshaft Angular Position Sensor, Magnetic Reluctance Position Sensor, Hall effect Position Sensor, Shielded Field Sensor, Optical Crankshaft Position Sensor, Throttle Angle Sensor (TAS), Engine Coolant Temperature (ECT) Sensor, Exhaust Gas Oxygen (02/EGO) Lambda Sensors, Piezoelectric Knock Sensor.

Automotive Engine Control Actuators-

Solenoid, Fuel Injector, EGR Actuator, Ignition System

Module-3

Digital Engine Control Systems:

Digital Engine control features, Control modes for fuel Control (Seven Modes), EGR Control, Electronic Ignition Control -Closed loop Ignition timing, Spark Advance Correction Scheme, Integrated Engine Control System- Secondary Air Management, Evaporative Emissions Canister Purge, Automatic System Adjustment, System Diagnostics.

Control Units-

Operating conditions, Design, Data processing, Programming, Digital modules in the Control unit, Control unit software.

Module-4

Automotive Networking:

Bus Systems- Classification, Applications in the vehicle, Coupling of networks, Examples of networked vehicles, Buses - CAN Bus, UN Bus, MOST Bus, Bluetooth, Flex Ray, Diagnostic Interfaces.

Vehicle Motion Control -

Typical Cruise Control System, Digital Cruise Control System, Digital Speed Sensor, Throttle Actuator, Digital Cruise Control configuration, Cruise Control Electronics (Digital only), Antilock Brake System (ABS).

Module-5

Automotive Diagnostics:

Timing Light, Engine Analyzer, On-board diagnostics, Off-board diagnostics, Expert Systems, Occupant Protection Systems -Accelerometer based Air Bag systems.

Future Automotive Electronic Systems-

Alternative Fuel Engines, Electric and Hybrid vehicles, Fuel cell powered cars, Collision Avoidance Radar warning Systems, Low tire pressure warning system, Heads Up display, Speech Synthesis, Navigation - Navigation Sensors - Radio Navigation, Signpost navigation, dead reckoning navigation, Voice Recognition Cell Phone dialling, Advanced Cruise Control, Stability Augmentation, Automatic driving Control.

Course outcome (Course Skill Set)

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

1. Describe the basics of automobile dynamics and design electronics.
2. Acquire an overview of automotive components, subsystems, and basics of Electronic Engine Control in today's automotive industry.
3. Use available automotive sensors and actuators while interfacing with microcontrollers/ microprocessors during automotive system design.
4. Understand the networking of various modules in automotive systems, communication protocols and diagnostics of the sub systems.
5. Design and implement the electronics that attribute the reliability, safety, and smartness to the automobiles, providing add-on comforts and get fair idea on future Automotive Electronic 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 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
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- 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. William B. Ribbens, "Understanding Automotive Electronics", 6th Edition, Elsevier Publishing.
2. Robert Bosch GmbH (Ed.) Bosch Automotive Electrics and Automotive Electronics Systems and Components, Networking and Hybrid Drive, 5th edition, John Wiley & Sons Inc., 2007.

Humanoid Robots		Semester	**VI**
Course Code	**BRA654B**	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. Understand the fundamental principles and design aspects of humanoid robots.
2. Explore the mechanical, electrical, and software components involved in humanoid robot construction.
3. Analyze the dynamics, kinematics, and control strategies specific to humanoid robots.
4. Develop and implement algorithms for motion planning, perception, and interaction in humanoid robots.
5. Examine the ethical, social, and practical implications of deploying humanoid robots in real-world scenarios

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of thevarious 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 Humanoid Robots: H**istory and Evolution of Humanoid Robots**, Milestones in humanoid robotics development. Design and Architecture of Humanoid Robots, Anatomy of humanoid robots: head, torso, limbs. Actuators and sensors used in humanoid robots. Overview of popular humanoid robots (ASIMO, Atlas, NAO). Applications of Humanoid Robots, Use cases in healthcare, education, entertainment, and manufacturing. Ethical considerations of Robots.

Module-2

Kinematics and Dynamics of Humanoid Robots: Forward and Inverse Kinematics, Mathematical modeling of humanoid robot joints and limbs. Dynamics of Humanoid Robots, Newton-Euler and Lagrangian dynamics for humanoids, Stability and balance control. ZMP (Zero Moment Point) and its role in stable walking.

Module-3

Control Systems for Humanoid Robots: Motion Control and Path Planning, PID control, adaptive control, and hybrid control techniques. Balance and Posture Control, Real-time balance control systems, Posture optimization for humanoid robots. Sensor Integration and Feedback Control, Use of IMUs, force sensors, and vision systems in control loops. Sensor fusion techniques for accurate perception.

Module-4

Perception and AI in Humanoid Robots: Sensory Systems in Humanoid Robots, Visual, auditory, and tactile sensors network and data processing. Computer Vision and Object Recognition, Image processing techniques for humanoids, Object detection and recognition using machine learning. Artificial Intelligence in Humanoid Robots, Natural language processing and speech recognition, Human-robot interaction and decision-making systems.

Module-5

Future Trends in Humanoid Robots: Human-Robot Collaboration, Techniques for safe and efficient human-robot interaction. Challenges in Humanoid Robotics, Energy efficiency, durability, and reliability issues, Social and legal challenges in deploying humanoid robots. Advances in AI, materials, and actuation technologies.

Course Outcomes (COs) (Course Skill Set)

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

CO1: Understand the fundamental concepts and design principles of humanoid robots.
CO2: Analyze the kinematics, dynamics, and control systems used in humanoid robots.
CO3: Design and implement motion planning and control algorithms for humanoid robots.
CO4: Explore the sensory systems, perception, and AI integration in humanoid robots.
CO5: Evaluate the applications, challenges, and future trends of humanoid robots in various domains.

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):

1. For the Assignment component of the CIE, there are 25 marks and for the InternalAssessment Test component, there are 25 marks.
2. The first test will be administered after 40-50% of the syllabus has been covered, and thesecond 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-basedthen 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 othermethods 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 commonquestion 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 (witha 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. **"Humanoid Robotics: A Reference" by Prahlad Vadakkepat and Aurobinda Routray** (Indian Authors).
2. **"Introduction to Humanoid Robotics" by Shuuji Kajita, Hirohisa Hirukawa, Kensuke Harada, and Kazuhito Yokoi**
3. "Robotics and Control" by R.K. Mittal and I.J. Nagrath

Reference Books:

1. "Humanoid Robots: Modeling and Control" by Dragomir N. Nenchev, Atsushi Konno, and Yoshihiko Nakamura.
2. "Humanoid Robotics and Neuroscience: Science, Engineering and Society" by Gordon Cheng.
3. "Advanced Robotics: Redundancy and Optimization" by Ying Luo, C. S. George Lee, and Bin Liang

Web links and Video Lectures (e-Resources):

- "Robotics and Artificial Intelligence (AI)" by MIT Open Course Ware https://www.youtube.com/user/MIT
- "Humanoid Robotics" by Lecture Snippets, https://www.youtube.com/user/LectureSnippets
- Robotics" by IIT Kanpur
- "Artificial Intelligence for Robotics" by IIT Bombay
- **NAO Robot Tutorials by Soft Bank Robotics** Link

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

- Online Interactive Tools
- Collaborative and Individual Project-Based Assessment
- Quizzes/Assignment, etc

Fundamentals of Robotics & Applications		Semester	VI
Course Code	**BRA654C**	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 Overview:

Robotics is an interdisciplinary branch of electronic engineering and mechanical engineering. Robotics involves design, construction, operation, and use of robots. The goal of robotics is to design machines that can help and assist humans. Robotics integrates fields of mechanical engineering, electrical engineering, information engineering, mechatronics, electronics, bioengineering, computer engineering, control engineering, software engineering, mathematics, etc.

Course Objectives:

The objectives of this course are to:

1. Understand and discuss the fundamental elementary concepts of Robotics.
2. Provide insight into different types of robots.
3. Explain intelligent module for robotic motion control.
4. Educate on various path planning techniques.
5. Illustrate the working of innovative robotic devices

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of thevarious 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 Robotics: Introduction to Robotics and Automation, laws of robot,brief history of robotics, basic components of robot, robot specifications, classification of robots, human system and robotics, safety measures in robotics, social impact, Robotics market and the future prospects, advantages and disadvantages of robots.

Module-2

Robot Anatomy and Motion Analysis: Anatomy of a Robot, Robot configurations: polar, cylindrical, Cartesian, and jointed arm configurations, Robot links and joints, Degrees of freedom: types of movements, vertical, radial and rotational traverse, roll, pitch and yaw, Wok volume/envelope, Robot kinematics: Introduction to direct and inverse kinematics, transformations and rotation matrix.

Module-3

Robot Drives and End Effectors: Robot drive systems: Hydraulic, Pneumatic and Electric drive systems, classification of end effectors, mechanical grippers, vacuum grippers, magnetic grippers, adhesive gripper, gripper force analysis and gripper design, 1 DoF, 2 DoF, multiple degrees of freedom robot hand, tools as end effectors, Robot control types: limited sequence control, point-to-point control, playback with continuous path control, and intelligent control.

Module-4

Path Planning: Definition-Joint space technique, Use of P-degree polynomial-Cubic, polynomial-Cartesian space technique, parametric descriptions, straight line and circular paths, position and orientation planning.

Module-5

Robotics Applications: Material Handling: pick and place, palletizing and depalletizing, machining loading and unloading, welding & assembly, Medical, agricultural and space applications, unmanned vehicles: ground, ariel and underwater applications, robotic for computer integrated manufacturing. Types of robots: Manipulator, Legged robot, wheeled robot, aerial robots, Industrial robots, Humanoids, Cobots, Autonomous robots, and Swarm robots

Course Outcomes (COs) (Course Skill Set)

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

1. Understand the significance, social impact and future prospects of robotics and automationin various engineering applications.
2. Identify and describe the components and anatomy of robotic system.
3. Know about various path planning techniques and analyze different motions of robotics system
4. Use the suitable drives and end-effectors for a given robotics application.
5. Apply robotics concept to automate the monotonous and hazardous tasks and categorizevarious types of robots based on the design and applications in real world scenarios.

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):

- For the Assignment component of the CIE, there are 25 marks and for the InternalAssessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and thesecond 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-basedthen 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 othermethods 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 (witha 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. S.R. Deb, Robotics Technology and flexible automation, Tata McGraw-Hill Education,2009.
2. Mikell P. Groover et. al., "Industrial Robots - Technology, Programming andApplications", McGraw Hill, Special Edition, (2012).
3. Ganesh S Hegde, "A textbook on Industrial Robotics", University science press, 3rdedition, 2017.

REFERENCE BOOKS:

1. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – AnIntegrated Approach", Eastern Economy Edition, Prentice Hall of India Pvt. Ltd., 2006.
2. Fu K S, Gonzalez R C, Lee C.S.G, "Robotics: Control, Sensing, Vision and Intelligence",McGraw Hill, 1987. https://www.robots.com/applications.
3. https://www.asme.org/engineering-topics/articles/bioengineering/top-6robotic-applications-in-medicine.

Web links and Video Lectures (e-Resources):

- https://roboticscasual.com/ros-tutorial-pick-and-place-task-with-the-moveit-c-interface/
- https://roboticscasual.com/ros-tutorial-simulate-ur5-robot-in-gazebo-urdf-explained/
- https://roboticscasual.com/the-best-degrees-to-work-in-robotics/
- https://roboticscasual.com/robotics-tutorials/
- https://www.ieee-ras.org/educational-resources-outreach/educational-material-in-robotics-and- automation
- https://www.academia.edu/20361073/Web_Based_Control_and_Robotics_Education_pdf
- https://github.com/Developer-Y/cs-video-courses
- https://www.isa.org/

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
- Quizzes/Assignment, etc

FLUID MECHANICS		Semester	VI
Course Code	**BRA654D**	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:

- To have a working knowledge of the basic properties of fluids and understand the continuum approximation.
- To calculate the forces exerted by a fluid at rest on submerged surfaces and understand the force of buoyancy.
- To understand the flow characteristic and dynamics of flow field for various Engineering applications.
- To know how velocity changes and energy transfers in fluid flows are related to forces and torques and to understand why designing for minimum loss of energy in fluid flows is so important.
- To discuss the main properties of laminar and turbulent pipe flow and appreciate their differences and the concept of boundary layer theory.
- Understand the concept of dynamic similarity and how to apply it to experimental modelling.
- To appreciate the consequences of compressibility in gas flow and understand the effects of friction and heat transfer on compressible flows.

Teaching-Learning Process (General Instructions)

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

1. Power-point Presentation,
2. Video demonstration or Simulations
3. Chalk and Talk are used for Problem Solving
4. Laboratory Demonstrations and Practical Experiments

MODULE-1

Basics: Introduction, Properties of fluids-mass density, weight density, specific volume, specific gravity, viscosity, surface tension, capillarity, vapour pressure, compressibility and bulk modulus. Concept of continuum, types of fluids etc., pressure at a point in the static mass of fluid, variation of pressure, Pascal's law, Absolute, gauge, atmospheric and vacuum pressures pressure measurement by simple, differential manometers and mechanical gauges.

Fluid Statics: Total pressure and center of pressure for horizontal plane, vertical plane surface and inclined plane surface submerged in static fluid.

MODULE-2

Fluid Kinematics: Types of Flow-steady, unsteady, uniform, non-uniform, laminar, turbulent, one, two and three dimensional, compressible, incompressible, rotational, irrotational, stream lines, path lines, streak lines, velocity components, convective and local acceleration, velocity potential, stream function, continuity equation in Cartesian co-ordinates. Rotation, vorticity and circulation, Laplace equation in velocity potential and Poisson equation in stream function, flow net, Problems.

MODULE-3

Fluid Dynamics: Momentum equation Euler's equation, Integration of Euler's equation to obtain Bernoulli's equation, Bernoulli's theorem, Application of Bernoulli's theorem such as venturi meter, orifice meter, rectangular and triangular notch, pitot tube related numerical.

MODULE-4

Loss of head due to friction in pipes, Major and minor losses, pipes in series and parallel.
Laminar and Turbulent flow: Flow through circular pipe, Power absorbed in viscous flow in bearings, Poiseuille equation.
Dimensional Analysis: Derived quantities, dimensions of physical quantities, dimensional homogeneity, Rayleigh method, Buckingham Pi-theorem, dimensionless numbers, similitude, types of Similitude.

MODULE-5

Compressible flows: Speed of sound, adiabatic and isentropic steady flow, Isentropic flow with area change stagnation and sonic properties.
Introduction to CFD: Necessity, limitations, philosophy behind CFD, applications

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

CO1: Identify and calculate the key fluid properties used in the analysis of fluid behavior.
CO2: Understand and apply the principles of pressure, buoyancy and floatation
CO3: Apply the knowledge of fluid dynamics while addressing problems of mechanical and chemical engineering.
CO4: Understand the concept of boundary layer in fluid flow and apply dimensional analysis to form dimensionless numbers in terms of input output variables.
CO5: Understand the basic concept of compressible flow and CFD
CO 6: Conduct basic experiments of fluid mechanics and understand the experimental uncertainties.

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):

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- For the course, CIE marks will be based on a scaled-down sum of two tests and othermethods 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 (witha 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

- Fox, R. W., Pitchard,P.J.,and McDonald, A. T., (2010), Introduction to Fluid Mechanics, 7thEdition, John Wiley & Sons Inc.
- Cimbala, J.M., Cengel, Y. A. (2010),Fluid Mechanics: Fundamentals and Applications, McGraw-Hill
- Frank M White., (2016), Fluid Mechanics, 8thEdition , McGraw Hill Additional **Reference**

Books:

- A text book of Fluid Mechanics and Hydraulic Machines, Dr. R K Bansal, Laxmi publishers
- Fundamentals of Fluid Mechanics, Munson, Young, Okiishi&Hebsch, John Wiley Publicationss, 7th Edition

Web links and Video Lectures (e-Resources):

- Nptel.ac.in
- VTU, E- learning
- MOOCS
- Open courseware

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

- Industrial visits
- Course seminar
- Term project

FINITE ELEMENT ANALYSIS LAB		Semester	**VI**
Course Code	**BRAL606**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2*:0	SEE Marks	50
Total Hours of Pedagogy	14 sessions	Total Marks	100
Credits	01	Exam Hours	03
Examination nature (SEE)	**Practical**		

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

Course objectives:

- 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 theknowledge and skills needed to effectively evaluate finite element analyses.

Sl.NO	**Experiments**
1	Introduction to FEA software, Preprocessing tools, Solver tools and Postprocessing tools.
2	Analysis of Bars of constant cross section area, tapered cross section area and stepped bar subjected to Point forces, Surface forces and Body forces (Minimum 2 exercises of different types)
3	Analysis of trusses (Minimum 2 exercises of different types)
4	Analysis of Beams – Simply supported, cantilever, Propped cantilever beams with point load
5	Analysis of Beams – UDL, beams with varying load
6	Stress Analysis of a rectangular plate with a circular hole.
7	Thermal Analysis – 1D problem with conduction and convection boundary conditions (Minimum 2 exercises of different types)
8	Thermal Analysis – 2D problem with conduction and convection boundary conditions (Minimum 2 exercisesof different types)

	Demonstration Experiments (For CIE)
9	Dynamic Analysis to find: Natural frequency of beam with fixed – fixed end condition, Response of beam with fixed – fixed end conditions subjected to forcing function
10	Dynamic Analysis to find: Natural frequency of bar, Response of Bar subjected to forcing functions
11	Demonstrate the use of graphics standards (IGES, STEP etc) to import the model from modeler to solver.
12	Demonstrate one example of contact analysis to learn the procedure to carry out contact analysis.

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 isoperimetricelements.
- 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, heattransfer, 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). A student shall be deemed to havesatisfied 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 beevaluated for 10 marks.
- 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-up on time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8^{th} week of thesemester and the second test shall be conducted after the 14^{th} week of the semester.
- In each 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. Rubricssuggested 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 50 Marks.
- SEE shall be conducted jointly by the two examiners, an internal examiner from the same institute and another external examiner from other institute, 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 byexaminers.
- Students can pick one question (experiment) from the questions lot 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, 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% Marks allotted to the procedure part to be made zero.The duration of SEE is 03 hours

Rubrics suggested in Annexure-II of Regulation book

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, 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

Design of Robotic Components		Semester	VI
Course Code	**BRA657A**	CIE Marks	50
Teaching Hours/Week(L:T:P:S)	1:0:0:0	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	01
Examination nature (SEE)	Theory		

Course objectives:

The objectives of this course are to:

1. To provide students with a comprehensive understanding of the fundamental principles, mechanics, and control of robotic systems, including the design and functioning of mechanical manipulators, actuators, and sensors.
2. To develop skills in analyzing, designing, and integrating various robotic components, such as actuators, power transmission systems, and control systems, for efficient and effective robotic applications.
3. To equip students with the knowledge of advanced robotic control techniques, simulation tools, and emerging technologies, preparing them to innovate and solve real-world challenges in robotics design 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. **Interactive Lectures and Discussions:** Conduct engaging lectures that include theoretical explanations, visual aids, and real-life examples of robotic applications.
2. **Hands-on Workshops and Laboratory Sessions:** Organize practical sessions where students can work with robotic kits, sensors, actuators, and controllers.
3. **Group Projects and Collaborative Learning:** Assign group projects that require students to collaboratively design and develop robotic systems or components. This fosters teamwork, enhances problem-solving skills, and allows for the application of diverse ideas and techniques.
4. **Simulation-Based Learning:** Utilize simulation tools such as MATLAB/Simulink or ROS (Robot Operating System) to model and analyze robotic systems.
5. **Case Studies and Industry Examples:** Present case studies and industry examples to illustrate the application of robotic components and systems in various fields, such as manufacturing, healthcare, and autonomous vehicles. This approach helps bridge the gap between theory and practice.
6. **Flipped Classroom Approach:** Assign pre-class readings or videos on specific topics to allow students to come prepared for in-depth discussions and problem-solving activities during the class. **Guest Lectures and Industry Interaction.**

Module-1

Fundamentals of Robotics and Robotic Components

Introduction to Robotics: Definition, scope, and applications of robotics, Basic anatomy of a robot: Structure, joints, actuators, and sensors. **Overview of Robotic Components,** Mechanical components: Links, joints, gears, and transmissions, Electrical components: Motors (DC, stepper, servo),

Module-2

Mechanics and Control of Mechanical Manipulators

Description of position and orientation, Forward kinematics of manipulators, Inverse kinematics of manipulators, Velocities, static forces, singularities, Dynamics, Trajectory generation, Manipulator design and sensors

Module-3

Actuators and Power Transmission in Robotics

Types of Actuators: Electric actuators: DC motors, stepper motors, and servo motors, Hydraulic and pneumatic actuators: **Actuator Dynamics and Control:** Actuator characteristics: Torque, speed, power, and efficiency, Control of actuators: Position, velocity, and torque control. **Power Transmission Elements:** Gears, belts, and chains

Module-4

Design and Analysis of Robotic Systems

Design Principles for Robotic Components: Mechanical design aspects: Structural integrity, weight, and material selection, Electrical design aspects: Power requirements, safety, and reliability.

Module-5

Control Systems in Robotics

Fundamentals of Robotic Control: Open-loop and closed-loop control systems, PID control and its applications in robotics. **Integration of Sensors and Actuators with Controllers:** Real-time control and feedback mechanisms, Communication protocols and interfacing techniques.

Course outcome (Course Skill Set)

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

1. **Demonstrate a solid understanding of the fundamental principles of robotics,** including the structure and function of mechanical components, actuators, sensors, and control systems.
2. **Analyze and solve kinematic and dynamic problems related to robotic manipulators,** including forward and inverse kinematics, trajectory planning, and the design of manipulator control systems.
3. **Design and integrate various robotic components,** such as actuators, power transmission elements, and sensors, to develop efficient and functional robotic systems.
4. **Apply advanced control techniques,** such as PID control, adaptive control, and intelligent control systems, to optimize the performance of robotic systems in real-time applications.
5. **Utilize simulation tools and software** to model, design, and analyze robotic systems, understanding the impact of design choices on the performance and reliability of robotic components.

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 of100) 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 25marks.
- The first test will be administered after 40 50% of the syllabus has been covered, and these tests 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 test 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 01 mark. 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

1. "Introduction to Robotics: Mechanics and Control" by John J. Craig, Pearson Education, 4th Edition, 2006.
2. "Fundamentals of Robotics: Analysis and Control" by Robert J. Schilling. Simon & Schuster Trade, Facsimile Edition,1996.
3. "Robotics and Control" by R.K. Mittal and I.J. Nagrath Tata McGraw-Hill, 1st Edition.2003.

Reference Books

1. "Design of Machine Elements" by V.B. Bhandari, Tata McGraw-Hill, 2nd Edition, 2010.
2. "Robotics: Control, Sensing, Vision, and Intelligence" by K.S. Fu, R.C. Gonzalez, and C.S.G. Lee, Vol. 1. New York: McGraw-Hill, 1987.

Web links and Video Lectures (e-Resources):

- NPTEL Course on Robotics by Prof. C. Amarnath, IIT Bombay: NPTEL Robotics
- MIT Open Course Ware: Introduction to Robotics: MIT OCW Robotics

BUSINESS ANALYTICS		Semester	VI
Course Code	**BRA657B**	CIE Marks	50
Teaching Hours/Week (L:T:P:S)	0:2:0	SEE Marks	50
Total Hours of Pedagogy	30	Total Marks	100
Credits	01	Exam Hours	01
Examination nature (SEE)	**Theory**		

Course objectives

The course will enable the students to:

1. Understand the Fundamentals of Business Analytics
2. Equip students with the ability to interpret data, identify trends, and make informed decisions using analytical tools and techniques that drive business success.
3. Students will learn how to utilize popular analytical tools (e.g., Excel, R, Python, Tableau) to perform descriptive, predictive, and prescriptive analytics.
4. Develop problem-solving and critical thinking skills by applying business analytics techniques to real-world business problems and case studies from industries like automation and manufacturing.
5. Foster awareness of the ethical, legal, and social implications of data usage in business analytics, including issues related to privacy, data security, and bias.

Teaching-Learning Process(General Instructions)

These are sample strategies, which teacher scan 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 TO BUSINESS ANALYTICS

Overview of Business Analytics: Definition, Importance, and Applications, Descriptive Analytics, Summarizing business data using measures of central tendency and variability, Introduction to Data Types, Structured vs. Unstructured Data, Role of Business Analytics in Decision-Making Tools and Software for Business Analytics: Overview of popular tools like Excel, R, Python, and Tableau.

Module-2

DATA COLLECTION, CLEANING, AND PREPROCESSING

Data Collection Techniques: Surveys, Web Scraping, IoT Data from Robotics, Sensors.
Data Cleaning: Handling missing data, outliers, and inconsistencies.
Data Preprocessing: Normalization, Standardization, and Encoding techniques.
Data Integration: Combining data from multiple sources such as ERP systems, IoT devices in robotics, implementing data cleaning and preprocessing techniques using Python

Module-3

PREDICTIVE ANALYTICS

Introduction to Predictive Analytics: Overview and importance in business decision-making, Statistical Modeling: Regression analysis, time series forecasting. Machine Learning Techniques: Supervised learning methods

Tools: Introduction to machine learning libraries like Scikit-learn, Building a predictive model using a simple dataset for sales forecasting, Predictive analytics in supply chain management, demand forecasting in manufacturing

Module-4

PRESCRIPTIVE ANALYTICS

Introduction to Prescriptive Analytics: Techniques and optimization methods, Decision Analysis, Decision trees, sensitivity analysis, scenario analysis, Optimization Techniques, Linear programming, integer programming.

Application in Robotics and Automation: Optimizing production schedules, resource allocation in robotics-based systems, Solving optimization problems using Python (PuLP library) or Excel Solver

Module-5

ADVANCED TOPICS AND APPLICATIONS

Big Data Analytics: Overview of Big Data and its role in business analytics. Cloud Computing for Business Analytics: Tools like AWS, Azure, and Google Cloud. AI in Business Analytics: Role of AI and deep learning in predictive and prescriptive analytics. Real-World Applications: Robotics in e-commerce, warehouse automation, predictive maintenance. Ethical and Legal Considerations: Data privacy, ethical use of analytics in business.

Future Trends in Business Analytics: IoT analytics, block chain in analytics.

Course outcome (Cos)

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

- **CO 1: Define key concepts and tools** in business analytics, including descriptive analytics, predictive analytics, and prescriptive analytics.
- **CO 2: Explain the role and importance of business analytics** in decision-making across various domains, particularly in robotics and automation industries.
- **CO 3: Apply data collection, cleaning, and preprocessing techniques** using Python and other tools like Excel, R, and Tableau to solve real-world business problems.
- **CO 4: Analyze business data using predictive models** such as regression and machine learning, identifying trends and making data-driven forecasts to improve business processes.
- **CO 5: Develop and implement optimization models** for resource allocation and production scheduling using prescriptive analytics techniques, integrating data from multiple sources.

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 50marks). 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 of100)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 25marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and these 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 01 mark. 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:

Text Books

1. Business Analytics: The Science of Data-Driven Decision Making" by U. Dinesh Kumar
2. "Fundamentals of Business Analytics" by R.N. Prasad and Seema Acharya
3. "Business Intelligence and Analytics: Systems for Decision Support" by Ramesh Sharda, Dursun Delen, and Efraim Turban

Reference Books

1. "Introduction to Statistical Learning" by Gareth James, Daniela Witten, Trevor Hastie, and Robert Tibshirani
2. "Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking" by Foster Provost and Tom Fawcett

Web links and Video Lectures (e-Resources):

- NPTEL Business Intelligence & Analytics Course: NPTEL
- Udemy Business Analytics Courses: Udemy
- Simplilearn's Free Business Analytics Course: Simplilearn.com

Activity Based Learning/Practical Based learning

- Basic data manipulation and visualization using Excel or Tableau.
- Implementing data cleaning and preprocessing techniques using Python (Pandas, NumPy).
- Building a predictive model using a simple dataset (e.g., sales forecasting).
- Solving optimization problems using Python (PuLP library) or Excel Solver
- Implementing a small AI-based analytics project, like predicting equipment failure using sensor data.

Operation Management		Semester	VI
Course Code	**BRA 657C**	CIE Marks	50
Teaching Hours/Week(L:T:P:S)	0:2:0:0	SEE Marks	50
Total Hours of Pedagogy	28 Hrs	Total Marks	100
Credits	01	Exam Hours	01
Examination nature (SEE)	**Theory**		

Course objectives:

The objectives of this course are to:

1. To provide a comprehensive understanding of the fundamental concepts of operations management, including process design, quality management, supply chain management, and production planning.
2. To develop analytical and problem-solving skills in managing operations, using various tools and techniques for optimizing processes, reducing costs, and improving efficiency.
3. To enhance knowledge of advanced operations management practices, including lean manufacturing, Six Sigma, and operations strategy, particularly in the context 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. **Interactive Lectures and Discussions:** Utilize interactive lectures with multimedia presentations and discussions to explain key concepts and theories in operations management.
2. **Case Study Analysis:** Introduce real-world case studies to analyze and discuss various operations management strategies and decision-making processes.
3. **Hands-on Workshops:** Conduct workshops on process design, inventory management, and production planning to provide practical experience.
4. **Group Projects and Presentations:** Assign group projects that require students to develop solutions for specific operations management problems or optimize processes.
5. **Use of Software Tools:** Teach students to use software tools like Excel, MATLAB, or specialized operations management software for data analysis, forecasting, and inventory management.
6. **Guest Lectures and Industry Visits:** Invite professionals from the industry to share their experiences and insights on the latest trends and best practices in operations management.
7. **Flipped Classroom Approach:** Assign pre-class readings or video lectures to encourage students to come prepared for interactive sessions and in-depth discussions.

Module-1

Introduction to Operations Management: Overview of Operations Management: Definition, scope, and importance of operations management, Differences between manufacturing and service operations. **Process Design and Analysis:** Types of processes: Job shop, batch, mass, and continuous, Process flow analysis and process mapping.

Module-2

Production Planning and Control: Forecasting: Importance of forecasting in operations, Qualitative and quantitative forecasting techniques. **Inventory Management:** Types of inventory, inventory costs, and inventory control systems, Economic Order Quantity (EOQ) and Just-In-Time (JIT) inventory systems.

Module-3

Quality Management: Introduction to Quality Management: Definition of quality, dimensions of quality, and quality management systems. **Total Quality Management (TQM):** Principles and practices of TQM. **Six Sigma and Lean Manufacturing:** Concepts and methodologies of Six Sigma. Lean principles: Value stream mapping, waste reduction, and continuous improvement.

Module-4

Supply Chain Management and Logistics: Introduction to Supply Chain Management: Definition, objectives, and components of a supply chain, Supply chain strategies: Push vs. pull, efficient vs. responsive supply chains. **Logistics Management:** Role of logistics in supply chain management, Transportation, warehousing, and inventory management in logistics.

Module-5

Operations Strategy and Emerging Trends: Operations Strategy: Developing an operations strategy aligned with business strategy, Competitive priorities in operations management: Cost, quality, flexibility, and delivery.

Course outcome (Course Skill Set)

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

1. **Understand the fundamental concepts and techniques of operations management** and their application in manufacturing and service industries.
2. **Analyze and optimize operational processes** using tools and techniques for process design, inventory management, and production planning.
3. **Implement quality management principles and techniques** such as TQM, Six Sigma, and lean manufacturing to improve operational efficiency.
4. **Develop and manage effective supply chain strategies,** including logistics, vendor management, and supplier relationship management.
5. **Apply advanced operations strategies and emerging trends,** such as robotics and automation, Industry 4.0, and sustainable operations, to enhance competitiveness and sustainability.

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 of100) 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 25marks.
- The first test will be administered after 40 50% of the syllabus has been covered, and these 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 test 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 01 mark. 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

1. "Operations Management: Theory and Practice" by B. Mahadevan, Pearson Education, 3rd Edition, 2018.
2. "Production and Operations Management" by K. Aswathappa and K. Shridhara Bhat Himalaya Publications, Edition 2018.
3. "Quality Control and Management" by S. K. Mandal, Vikas Publications, 1st Edition.2003.

Reference Books

1. "Supply Chain Management: Strategy, Planning, and Operation" by Sunil Chopra and Peter Meindl, 6th Edition, 2015.
2. "Operations Management for Competitive Advantage" by Richard B. Chase, Nicholas J. Aquilano, and F. Robert Jacobs, 2005.

Web links and Video Lectures (e-Resources):

- **NPTEL Course on Operations Management by Prof. G. Srinivasan, IIT Madras:** NPTEL Operations Management.
- **MIT Open Course Ware: Operations Management:** MIT OCW Operations Management.

Total Quality Management		Semester	VI
Course Code	**BRA 657D**	CIE Marks	50
Teaching Hours/Week(L:T:P:S)	0:2:0:0	SEE Marks	50
Total Hours of Pedagogy	28 hrs	Total Marks	100
Credits	01	Exam Hours	01
Examination nature (SEE)	Theory		

Course objectives:

The objectives of this course are to:

1. To provide students with a fundamental understanding of Total Quality Management (TQM) principles, including continuous improvement, customer focus, and total employee involvement.
2. To develop skills in using TQM tools and techniques for quality planning, control, and improvement in manufacturing and service operations.
3. To enhance knowledge of advanced quality management methodologies such as Six Sigma, Lean, and Statistical Process Control (SPC) and their application in 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. **Interactive Lectures and Discussions:** Deliver engaging lectures with multimedia presentations, case studies, and examples from the robotics and automation industry to explain key concepts of TQM.
2. **Case Study Analysis:** Analyze real-world case studies to understand the application of TQM principles, tools, and techniques in different industries, including robotics and manufacturing.
3. **Hands-on Workshops and Simulations:** Conduct practical sessions and workshops on using TQM tools like control charts, Pareto analysis, and FMEA, using software tools like Minitab or Excel.
4. **Group Projects and Presentations:** Assign group projects where students design a TQM strategy or implement quality improvement tools in a simulated environment or case study.
5. **Role-playing and Simulation Games:** Use role-playing exercises and simulation games to teach concepts of quality management, teamwork, leadership, and customer focus.
6. **Guest Lectures and Industry Interaction:** Invite industry experts to share insights and experiences related to quality management practices and challenges in robotic systems and automation.
7. **Flipped Classroom Approach:** Assign pre-class readings or videos on TQM topics to encourage students to come prepared for in-depth discussions and application-based learning.

Module-1

Introduction to Total Quality Management: Overview of TQM: Definition and evolution of Total Quality Management, Importance of quality in the context of robotics and automation. **Principles of TQM:** Customer focus, continuous improvement, and total employee involvement, Leadership and strategic planning for quality.

Module-2

TQM Tools and Techniques: Basic Quality Tools: Check sheets, histograms, Pareto charts, cause-and-effect diagrams, and scatter diagrams. **Quality Function Deployment (QFD) and Benchmarking:** Understanding customer requirements and translating them into product specifications. Types of benchmarking and steps in benchmarking processes.

Module-3

Quality Management Systems and Standards: Quality Management Systems (QMS): Overview of QMS and its components, Implementation and benefits of QMS in robotic manufacturing. **ISO 9000 Series and ISO 14000 Series:** ISO 9001:2015 Quality Management System standards, ISO 14001:2015 Environmental Management System standards.

Module-4

Six Sigma and Lean Management: Introduction to Six Sigma: Definition, objectives, and benefits of Six Sigma, DMAIC (Define, Measure, Analyze, Improve, Control) methodology. **Lean Principles:** Principles of Lean Manufacturing and Lean Robotics, Tools for Lean implementation: 5S, Kaizen, Value Stream Mapping (VSM).

Module-5

Statistical Process Control (SPC) and Continuous Improvement: Introduction to SPC: Fundamentals of Statistical Process Control, Control charts for variables and attributes. **Process Capability and**

Improvement: Process capability indices: Cp, Cpk, and process improvement strategies.

Course outcome (Course Skill Set)

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

1. **Understand and apply the fundamental principles of Total Quality Management (TQM),** including customer focus, continuous improvement, and employee involvement in various engineering contexts.
2. **Use a range of TQM tools and techniques** such as control charts, Pareto analysis, and FMEA to analyze and improve quality in manufacturing and service operations.
3. **Implement Quality Management Systems (QMS) and understand the requirements of ISO standards** for quality and environmental management, especially in the context of robotics and automation.
4. **Apply Six Sigma and Lean methodologies** to enhance operational efficiency, reduce waste, and improve quality in robotic systems and automated processes.
5. **Utilize Statistical Process Control (SPC) techniques** and continuous improvement strategies to monitor, control, and improve process quality in engineering 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 of100) 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 25marks.
- The first test will be administered after 40 50% of the syllabus has been covered, and these tests 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 test 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 01 mark. 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

1. "Total Quality Management" by Dale H. Besterfield . Besterfield-Michna, C., Besterfield, G. H., Besterfield-Sacre, M., Urdhwareshe, H., & Urdhwareshe, R, Pearson Education India. Revised Edition (1995): 3/e.
2. "Quality Control and Management" by S. K. Mandal, Vikas Publications, 1st Edition.2003.
3. "ISO 9001:2015 Explained" by Charles A. Cianfrani, Joseph J. Tsiakals, and John E. "Jack" West, 2nd Edition, 2001.

Reference Books

1. "Lean Six Sigma: Combining Six Sigma Quality with Lean Production Speed" by Michael L. George, Edition 2002.
2. "Introduction to Statistical Quality Control" by Douglas C. Montgomery, 8th Edition, Wiley, 2019.

Web links and Video Lectures (e-Resources):

- **NPTEL Course on Total Quality Management by Prof. M. P. Gupta, IIT Delhi:** NPTEL Total Quality Management
- **MIT Open Course Ware: Total Quality Management:** MIT OCW Total Quality Management