CONTROL ENGINEERING		Semester	VII
Course Code	**BRI701**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	4:0:0	SEE Marks	50
Total Hours of Pedagogy	50	Total Marks	100
Credits	04	Exam Hours	03
Examination nature (SEE)	THEORY		

Course objectives:

- To develop comprehensive knowledge and understanding of modern control theory, industrial automation, and systems analysis.
- To model mechanical, hydraulic, pneumatic and electrical systems.
- To represent system elements by blocks and its reduction techniques.
- To understand transient and steady state response analysis of a system.
- To carry out frequency response analysis using polar plot, Bode plot.
- To analyse a system using root locus plots.
- To study different system compensators and characteristics of linear systems

Teaching-Learning Process (General Instructions)

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

- **Interactive Lectures**: Utilize demonstrations and multimedia to clarify modern control theory and industrial automation concepts.
- **Simulation Exercises**: Employ software tools like MATLAB/Simulink for practical system modeling and analysis.
- **Group Projects**: Facilitate collaborative learning through group analysis of transient and steady-state system responses.
- **Problem-Based Learning**: Use real-world case studies for frequency response analysis to enhance critical thinking.
- **Visualization Tools**: Integrate software for visualizing root locus plots and compensator designs to solidify understanding.
- **Continuous Assessment**: Implement regular quizzes and assignments to reinforce key topics and track student progress.

Module-1

Introduction to Control System: Introduction to control system block diagram. Importance of Control Systems. Components of control. Explanation with the help of the liquid level control system. Significance of actuators and sensors. Types of actuators, Types of sensors. Open loop control and closed loop control. Use of relays, switches and contactors for simple and sequential control systems.

Module-2

Control system representation: Mathematical representation of simple mechanical, electrical, thermal, hydraulic systems. Block diagram representation and reduction. Signal flow graph. Transfer function of these systems. Pole zero concepts. Analogous Systems: Direct and inverse analogs for mechanical, thermal and fluid systems.

Block diagram Algebra:

General representation of a feedback control system, transfer functions, rules of block diagram algebra, reduction of block dia. to obtain closed loop transfer function. Signal flow graphs : Mason's gain formula

Module-3

Time domain analysis: Time response of first order, second order systems. Analysis of steady state error, Type of system and steady state error, Time response specifications. Effect of parameter variation on open loop and closed loop system response, sensitivity. Effect of feedback on system response, stability and disturbance.

Steady state operation:
Steady state analysis for general block dia. for a control system, steady state characteristics, equilibrium in a system.

Transient Response:
Transient response and steady state analysis of unit, step input, general operational representation for a differential equation of control system, distinct, repeated and complex conjugate zeros, general form of transient response, Routh's stability criterion for a control system.

Module-4

Stability: Concept of stability, Effect of pole zero location on stability, Routh- Hurwitz criterion. Root Locus method for analysis of gain margin, phase margin and stability.

Control system analysis in frequency domain: Concept of frequency domain behavior, Bode Plot for analyzing systems in frequency domain. Frequency domain performance specifications. Correlation between time domain and frequency domain specification. Nyquist Analysis.

Module-5

State Space Approach: Representation of system in state space, Converting transfer function model into state space model. Non uniqueness of state space model, Canonical representation, Eigenvalues, Solution of state equations, Concept of State feedback control, controllability, Observability

Course outcome (Course Skill Set)

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

1. Analyze the mathematical model of the control system.
2. Solve to get a time domain response.
3. Analyze stability of the system.
4. Use bode plot for frequency domain analysis.
5. Analyze the control system in state space.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

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

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

Semester-End Examination:

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

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

Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

1. Nagrath & M. Gopal "Control System Engineering", Anshan, 2008.
2. Norman S. Nice, "Control System Engineering", Wiley, 2008.
3. Modern control theory, Katsuhiko Ogata, Pearson Education International , Fifth edition.
4. "Control systems Principles and Design", M.Gopal, 3rd Edition, TMH, 2000.

REFERENCE BOOKS:

1. Control system engineering, Norman S Nise, John Wiley &Sons, Inc., Sixth edition
2. Modern control systems, Richard C. Dorf, Robert H Bishop, Pearson Education International, Twelfth edition.
3. Automatic control systems, Farid Golnaraghi, Benjamin C Kuo, John Wiley & Sons, Inc., Nineth edition
4. "Feedback control systems", Schaum's series, 2001.
5. System dynamics and control, Eronini-Umez, Thomas Asia Pte ltd., Singapore 2002.

Web links and Video Lectures (e-Resources):

. https://nptel.ac.in/courses/108106098

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

- Course seminar
- Term project

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NATURAL LANGUAGE PROCESSING		Semester	VI
Course Code	**BRI702**	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 learn the fundamentals of natural language processing
- To understand the use of CFG and PCFG in NLP
- To understand the role of semantics of sentences and pragmatics
- To apply the NLP techniques to IR applications

Teaching-Learning Process (General Instructions)

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

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

Module-1

Introduction : Origins and challenges of NLP – Language Modeling: Grammar-based LM, Statistical LM - Regular Expressions, Finite- State Automata – English Morphology, Transducers for lexicon and rules, Tokenization, Detecting and Correcting Spelling Errors, Minimum Edit Distance

Module-2

WORD LEVEL ANALYSIS : Unsmoothed N-grams, Evaluating N-grams, Smoothing, Interpolation and Backoff – Word Classes, Part-of-Speech Tagging, Rule-based, Stochastic and Transformation-based tagging, Issues in PoS tagging – Hidden Markov and Maximum Entropy models.

Module-3

SYNTACTIC ANALYSIS : Context-Free Grammars, Grammar rules for English, Treebanks, Normal Forms for grammar – Dependency Grammar – Syntactic Parsing, Ambiguity, Dynamic Programming parsing – Shallow parsing – Probabilistic CFG, Probabilistic CYK, Probabilistic Lexicalized CFGs - Feature structures, Unification of feature structures.

Module-4

SEMANTICS AND PRAGMATICS : Requirements for representation, First-Order Logic, description Logics – Syntax-driven Semantic analysis, Semantic attachments – Word Senses, Relations between Senses, Thematic Roles, selectional restrictions – Word Sense Disambiguation, WSD using Supervised, Dictionary & Thesaurus, Bootstrapping methods – Word Similarity using Thesaurus and distributional methods.

Module-5

DISCOURSE ANALYSIS AND LEXICAL RESOURCES: Discourse segmentation, Coherence – Reference Phenomena, Anaphora Resolution using Hobbs and CenteRIng algorithm – Co reference Resolution – Resources: Porter Stemmer, Lemmatizer, Penn Treebank, Brill's Tagger, Word Net, PropBank, FrameNet, Brown Corpus, and British National Corpus (BNC).

Course outcome (Course Skill Set)

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

- To tag a given text with basic Language feature
- To design an innovative application using NLP components
- To implement a rule based system to tackle morphology/syntax of a language
- To design a tag set to be used for statistical processing for real-time application
- To compare and contrast the use of different statistical approaches for different types of NLP applications.

PRACTICAL COMPONENT OF IPCC

1. Write a python program to perform tokenization by word and sentence using python/nltk.
2. Write a python program to eliminate stopwords using python/nltk.
3. Write a python program to perform stemming using python/nltk.
4. Write a python program to perform Parts of Speech tagging using python/nltk.
5. Write a python program to perform lemmatization using python/nltk.
6. Write a python program for chunking using python/nltk.
7. Write a python program to perform Named Entity Recognition using python/nltk.
8. Write a python program for CYK parsing (CockeYounger-Kasami Parsing) or Chart Parsing.
9. Write a python program to find all unigrams, bigrams and trigrams present in the given corpus
10. Write a python program to find the probability of the given 31 statement "This is my cat" by taking the an example corpus into consideration.

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**)

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored 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. Daniel Jurafsky, James H. Mar□n—Speech and Language Processing: An Introduc□on to Natural Language Processing, Computational Linguistics and Speech, Pearson Publication, 2014.
2. 2. Steven Bird, Ewan Klein and Edward Loper, —Natural Language Processing with Python||, First Edi□on, O_Reilly Media, 2009.
3. Tanveer Siddiqui, U.S. Tiwary, —Natural Language Processing and Informa□on RetRIeval||, Oxford University Press, 2008., smart environments and Industry 4.Springer 2019

REFERENCE BOOKS:

1. Breck Baldwin, —Language Processing with Java and LingPipe Cookbook, Atlan□c Publisher, 2015.
2. RIchard M Reese, —Natural Language Processing with Java||, O_Reilly Media, 2015.
3. Ni□n Indurkhya and Fred J. Damerau, —Handbook of Natural Language Processing, Second Edition, Chapman and Hall/CRC Press, 2010.

Web links and Video Lectures (e-Resources):

- https://archive.nptel.ac.in/courses/106/105/106105158/
- VTU, E- learning
- MOOCS
- Open courseware

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

- Course seminar
- Term project

CLOUD COMPUTING		Semester	7
Course Code	**BRI703**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	50 hours	Total Marks	100
Credits	04	Exam Hours	3 Hours
Examination type (SEE)	**Theory**		

Course objectives:

- To introduce the basic principles of cloud computing, cloud native application development and deployment, containerization principles, micro-services and application scaling.
- To equip the students to understand major industry players in the public cloud domain for application development and deployment.

Teaching-Learning Process (General Instructions)

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

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

Module-1

Distributed Computing Taxonomy – Cluster, Grid, P2P, Utility, Cloud, Edge, Fog computing paradigms; Introduction to Cloud Computing – Cloud deployment models (Private, Public, and Hybrid),Cloud architecture, Characteristics of Cloud, Cloud delivery models (XaaS), , Major use cases of Cloud; disadvantages and best practices.

Module-2

Major public cloud players in the market; Security Issues and Challenges; Cloud Native application development – Introduction to JavaScript Cloud native application development.

Public Cloud – Using public cloud for infrastructure management (compute and storage services), Web application deployment using public cloud services, and Deploying container images in public cloud

Module-3

Overview of cognitive services, Case study on architecting cloud-based solutions for a chosen scenario.

Virtualization – Basics, Cloud vs. Virtualization, Need for Virtualization – Pros and cons of Virtualization – Types of Virtualization – System VM, Process VM, Virtual Machine monitor – Virtual machine properties - Interpretation and binary translation, HLL VM - Hypervisors – Xen, KVM , VMware, Virtual Box, Hyper-V.

Module-4

Containers – Introduction to Dockers and containers, containerization vs. virtualization, docker architecture, Use cases, Learn how to build container images, Operations on container images.

Module-5

Kubernetes –Introduction to Kubernetes, Kubernetes architecture, creating and running containers, Deploying a Kubernetes cluster, cluster components, common kubectl commands, Pods, Running Kubernetes locally via minikub.

Course outcome (Course Skill Set)

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

1. Summarize the basic principles of cloud computing.
2. Apply cloud native application development for containerization and container orchestration.
3. Analyze different types of cloud services – Delivery models, Deployment models
4. Implement different solution approaches in Cloud – containers in public cloud, setting up private cloud and convert monolithic applications to containers

PRACTICAL COMPONENT OF IPCC

1. Install virtualbox with Linux OS on top of windows
2. Install a C compiler in the virtual machine.
3. Install google app engine and create a web applications using JAVA.
4. Google app engine python hello world example using eclipse.
5. Simulate a cloud scenario using cloudsim and run a scheduling algorithm.
6. Copy files from one virtual machine to another
7. Create, deploy and launch virtual machines in Openstack
8. Install HADOOP single node cluster

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**)

5. The question paper will have ten questions. Each question is set for 20 marks.
6. 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.
7. The students have to answer 5 full questions, selecting one full question from each module.

8. 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. Rajkumar Buyya et.al. Mastering cloud computing, McGraw Hill Education; 2013.
2. Matthias K, Kane SP. Docker: Up & Running: Shipping Reliable Containers in Production. "O'Reilly Media, Inc.";2018.
3. "Kubernetes Up & Running" by Kelsey Hightower, Brendan Burns, and Joe Beda

Reference Books

1. Kocher PS. Microservices and Containers. Addison-Wesley Professional; 2018.
2. Sarkar A, Shah A. Learning AWS: Design, build, and deploy responsive applications using AWS Cloud components. Packt Publishing Ltd; 2018.
3. Menga J. Docker on Amazon Web Services: Build, deploy, and manage your container applications at scale. PacktPublishing Ltd; 2018.
4. Bentley W. OpenStack Administration with Ansible 2. Packt Publishing Ltd; 2016

Web links and Video Lectures (e-Resources):

- .https://www.digimat.in/nptel/courses/video/106105167/L01.html
- https://nptel.ac.in/courses/106105167

ROBOT SAFETY AND MAINTENANCE		Semester	VII
Course Code	**BRI714A**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	THEORY		

Course objectives:

This course will enable students to,

1. Learn the key safety standards and rules for robots in industries.
2. Understand how to analyze and assess risks in robotic systems.
3. Design robots with built-in safety and reliability features.
4. Master basic techniques for maintaining robots and preventing failures.
5. Explore how humans and robots can work safely together in shared spaces

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) need not to be only traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes.
2. Use of Video/Animation to explain functioning of various concepts.
3. Encourage collaborative (Group Learning) Learning in the class.
4. Ask at least three HOT (Higher order Thinking) questions in the class, which promotes critical thinking.
5. Adopt Problem Based Learning (PBL), which fosters student's Analytical skills, develop design thinking skills such as the ability to design, evaluate, generalize, and analyze information rather than simply recall it

Module-1

Introduction to Robot Safety and Reliability

Overview of Robot Safety and Reliability: Evolution and importance of robot safety in modern industries. Key facts, figures, and case studies on robot-related accidents. Scope and challenges in ensuring robot reliability and safety. Basic classification of robot systems and their applications. Overview of standards and regulations in robot safety.

Basic Terminology and Mathematical Foundations: Definitions: reliability, safety, redundancy, and error recovery. Mathematical tools for reliability analysis (Boolean algebra, probability). Introduction to probability distributions relevant to robot systems. Overview of Laplace transforms for reliability calculations. Applications of mathematical concepts in safety design

Module-2

Reliability and Safety Analysis

Reliability Configurations and Failure Analysis: Series, parallel, and k-out-of-n system reliability configurations. Understanding failure density and hazard rate functions. Mean Time to Failure (MTTF) and Mean Time to Repair (MTTR). Introduction to Failure Modes and Effects Analysis (FMEA). Practical applications of FMEA in robotic systems.

Safety Analysis Techniques: Basics of Fault Tree Analysis (FTA) and probability evaluation. Hazard and Operability Studies (HAZOP) for robot safety. Interface safety analysis in integrated robot systems. Markov methods for reliability and safety assessment. Pros and cons of key safety analysis methods.

Module-3

Robot Safety Design and Implementation

Safety in Design and Operation: Safety considerations during the design phase of robots. Safety measures in robot installation and programming. Safe operation and maintenance practices for robotic systems. Responsibilities of manufacturers and end-users in safety. Understanding weak points in robot design and operations.

Robot Safeguards and Safety Features : Physical safeguards: barriers, warning signs, and protective enclosures. Intelligent safety systems and their applications. Common robot safety features and their functions. Safety measures for robotic welding (laser, gas-shielded arc, resistance). Emergency procedures and fault recovery systems.

Module-4

Maintenance of Robot Systems

Types and Tools for Maintenance: Categories of robot maintenance: preventive, predictive, and corrective. Common tools and measuring instruments for robot inspection. Diagnostic approaches for robot systems. Periodic maintenance schedules and their benefits. Examples of maintenance practices in industrial robots.

Maintenance Safety Guidelines: Guidelines for safeguarding maintenance personnel. Safe shutdown and startup procedures during maintenance. Safety considerations for hydraulic and electric robots. Preventive measures for reducing maintenance-related accidents. Risk management during robot inspections and repairs.

Module-5

Human Factors and Risk Mitigation

Human Factors in Robot Workplaces: Worker-machine interaction in robotic environments. Importance of worker training and ergonomic considerations. Job design to accommodate robotic automation. Role of communication between workers and management. Challenges of human-robot collaboration.

Accident Analysis and Prevention: Root cause analysis of robot-related accidents. Common causes and sources of robot accidents. Recommendations to prevent human injuries. Understanding and applying robot-related safety standards. Methods for estimating accident probabilities and improving safety.

Course outcome (Course Skill Set)

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

1. Describe the importance of robot safety and reliability and apply mathematical tools for system design.
2. Analyse reliability configurations and safety risks using techniques like FMEA and FTA.
3. Design robotic systems with safety features and operational protocols.
4. Implement maintenance strategies and safety guidelines for robotic systems.
5. Assess human factors and risk mitigation strategies in robotic workplaces.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

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

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

Semester-End Examination:

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

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

Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Textbooks

1. Dhillon, B. S. *Robot System Reliability and Safety: A Modern Approach*. Springer, 2024.
2. Gupta, Brij B., and Nadia Nedjah, eds. *Safety, Security, and Reliability of Robotic Systems*. CRC Press, 2023.
3. Craig, John J. *Introduction to Robotics: Mechanics and Control*. 3rd ed. Pearson Education, 2005.
4. Kurfess, Thomas R., ed. *Robotics and Automation Handbook*. CRC Press, 2005.
5. Groover, Mikell P. *Industrial Robotics: Technology, Programming, and Applications*. McGraw-Hill Education, 2008..

Reference Books

1. Bevoc, Louis, and Nathan Brusselli. *Robotics, Maintenance Programs, Engineering, and Skilled Trades: Essential Skills for Manufacturers*. Independently Published, 2019.
2. Gu, Edward Y. L., and Jian S. Dai. *Advanced Dynamics Modeling of Robotic Systems*. Springer, 2015.
3. Fiorini, Paolo, and Paolo Dario. *Human-Robot Interaction: Principles, Systems, and Technology*. CRC Press, 2016.
4. Starr, Justin, and Christopher Quick. *Robotic Safety Systems: An Applied Approach*. Routledge, 2022.
5. Kurfess, Thomas R. *Robotics: Principles and Practice*. Wiley, 2012.

Web links and Video Lectures (e-Resources):

Video References:

- IIT Kharagpur. *Robotics.* Accessed November 30, 2024. https://archive.nptel.ac.in/courses/112/105/112105249/.
- IIT Palakkad. *Mechanics and Control of Robotic Manipulators.* Accessed November 30, 2024. https://archive.nptel.ac.in/courses/112/106/112106304/.
- *Industrial Robotics: Theories for Implementation.* NPTEL. Accessed November 30, 2024. https://onlinecourses.nptel.ac.in/noc23_me143/preview.
- University at Buffalo. *Collaborative Robot Safety: Design and Deployment.* Accessed November 30, 2024. https://www.coursera.org/learn/collaborative-robot-safety/.
- *Fundamentals of Robotics and Industrial Automation.* Coursera. Accessed November 30, 2024. https://www.coursera.org/learn/fundamentals-of-robotics--industrial-automation.
- *Introduction to the Collaborative Robot Safety: Design and Deployment Course.* YouTube. Accessed November 30, 2024. https://www.youtube.com/watch?v=j-NU710WjM0.

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

- Seminar

COMPUTER NETWORKS		Semester	VII
Course Code	**BRI714B**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	THEORY		

Course objectives:

This course will enable students to,

- Study the TCP/IP protocol suite, switching criteria and Medium Access Control protocols for reliable and noisy channels.
- Learn network layer services and IP versions.
- Discuss transport layer services and understand UDP and TCP protocols.

Demonstrate the working of different concepts of networking layers and protocols.

Teaching-Learning Process (General Instructions)

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

6. Lecturer method (L) need not to be only traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes.
7. Use of Video/Animation to explain functioning of various concepts.
8. Encourage collaborative (Group Learning) Learning in the class.
9. Ask at least three HOT (Higher order Thinking) questions in the class, which promotes critical thinking.
10. Adopt Problem Based Learning (PBL), which fosters student's Analytical skills, develop design thinking skills such as the ability to design, evaluate, generalize, and analyze information rather than simply recall it

Module-1

Introduction: Data Communications, Networks, Network Types, Networks Models: Protocol Layering, TCP/IP Protocol suite, The OSI model, Introduction to Physical Layer: Transmission media, Guided Media, Unguided Media: Wireless. Switching: Packet Switching and its types.

Textbook: Ch. 1.1 - 1.3, 2.1 - 2.3, 7.1 – 7.3, 8.3.

Module-2

Data Link Layer: Error Detection and Correction: Introduction, Block Coding, Cyclic Codes. Data link control: DLC Services: Framing, Flow Control, Error Control, Connectionless and Connection Oriented, Data link layer protocols, High Level Data Link Control. Media Access Control: Random Access, Controlled Access. Check Sum and Point to Point Protocol

Textbook: Ch. 10.1-10.4, 11.1 -11.4, 12.1 - 12.2

Module-3

Network Layer: Network layer Services, Packet Switching, IPv4 Address, IPv4 Datagram, IPv6 Datagram, Introduction to Routing Algorithms, Unicast Routing Protocols: DVR, LSR, PVR, Unicast Routing protocols: RIP, OSPF, BGP, Multicasting Routing-MOSPF

Textbook: Ch. 18.1, 18.2, 18.4, 22.2,20.1-20.3, 21.3.2

Module-4

Introduction to Transport Layer: Introduction, Transport-Layer Protocols: Introduction, User Datagram Protocol, Transmission Control Protocol: services, features, segments, TCP connections, flow control, Error control, Congestion control.

Textbook: Ch. 23.1- 23.2, 24.1-24.3.4, 24.3.6-24.3.9

Module-5

Introduction to Application Layer: Introduction, Client-Server Programming, Standard Client- Server Protocols: World Wide Web and HTTP, FTP, Electronic Mail, Domain Name System (DNS), TELNET, Secure Shell (SSH)

Textbook: Ch. 25.1-25.2, 26.1-26.6

Course outcome (Course Skill Set)

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

- Explain the fundamentals of computer networks.
- Apply the concepts of computer networks to demonstrate the working of various layers and protocols in communication network.
- Analyze the principles of protocol layering in modern communication systems.
- Demonstrate various Routing protocols and their services using tools such as Cisco packet tracer.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

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

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

Semester-End Examination:

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

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

Suggested Learning Resources:

Books

TEXT BOOKS:

1. Behrouz A. Forouzan, Data Communications and Networking, 5th Edition, Tata McGraw-

REFERENCE BOOKS:

1. Larry L. Peterson and Bruce S. Davie: Computer Networks – A Systems Approach, 4th Edition, Elsevier, 2019.
2. Nader F. Mir: Computer and Communication Networks, 2nd Edition, Pearson Education, 2015.
3. William Stallings, Data and Computer Communication 10th Edition, Pearson Education, Inc., 2014.

Web links and Video Lectures (e-Resources):

- https://www.digimat.in/nptel/courses/video/106105183/L01.html
- http://www.digimat.in/nptel/courses/video/106105081/L25.html
- https://nptel.ac.in/courses/10610

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

- Implementation of various protocols using open source simulation tools.
- Simulation of Personal area network, Home area network, achieve QoS etc.

Wireless Communication		Semester	VI
Course Code	**BRI714C**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory	Total Marks	100
Credits	03	Exam Hours	03

Course Learning Objectives (CLOs)

The course will enable the students to:

- Define the fundamental concepts in Wireless Communication.
- Evaluate techniques followed in GSM and TDMA Technology.
- Understand the CDMA Technology.
- Understand the LTE-4G and Multi-Carrier Modulation.
- Understand the Basic operations of Air interface in a LTE 4G system.

Teaching-Learning Process (General Instructions)

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

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

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

Module-1

Mobile Radio Propagation

Large Scale Path Loss - Free Space Propagation Model, Relating Power to Electric Field, Three Basic Propagation Mechanisms -Reflection (Ground Reflection),Diffraction, Scattering, Practical Link Budget.

Fading and Multipath :

Broadband wireless channel, Delay Spread and Coherence Bandwidth, Doppler Spread and Coherence Time, Angular spread and Coherence Distance (text 1-2.4) Statistical Channel Model of a Broadband Fading Channel.

The Cellular Concept :

Cellular Concept, Analysis of Cellular Systems, Sectoring.

Module-2

GSM and TDMA Technology

GSM System overview :

Introduction, GSM Network and System Architecture, GSM Channel Concept.

GSM System Operations:

GSM Identities, System Operations-Traffic cases, GSM Infrastructure Communications.

Module-3

CDMA Technology

CDMA System Overview :

Introduction, CDMA Network and System Architecture.

CDMA Basics :

CDMA Channel Concepts, CDMA System (Layer 3) operations, 3GCDMA.

Module-4

LTE-4G

Key Enablers for LTE 4G :

OFDM, SC-FDE, SC-FDMA, Channel Dependant Multiuser Resource Scheduling, Multi-Antenna Techniques, Flat IP Architecture, LTE Network Architecture.

Multi-Carrier Modulation :

Multicarrier concepts, OFDM Basics, OFDM in LTE, Timing and Frequency Synchronization, Peak to Average Ration, SC Frequency Domain Equalization, Computational Complexity Advantage of OFDM and SC-FDE.

Module-5

LTE - 4G

OFDMA and SC-FDMA :

Multiple Accesses for OFDM Systems, OFDMA, SCFDMA, Multiuser Diversity and Opportunistic Scheduling, OFDMA and SC-FDMA in LTE, OFDMA system Design Considerations.

The LTE Standard :

Introduction to LTE and Hierarchical Channel Structure of LTE, Downlink OFDMA Radio Resources, Uplink SC-FDMA Radio Resources.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

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

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

Semester-End Examination:

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

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

Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Text Books

[1] "Fundamentals of LTE"Arunabha Ghosh, Jan Zhang, JeffereyAndrews, Riaz Mohammed, Pearson education (Formerly Prentice Hall, Communications Engg and Emerging Technologies), ISBN-13: 978-0-13- 703311-9.

[2] "Introduction to Wireless Telecommunications Systems and Networks", Gary Mullet, First Edition, Cengage Learning India Pvt Ltd., 2006, ISBN -13: 978-81-315-0559-5.

Reference Books/Journal

[1] "Wireless Communications: Principles and Practice" Theodore Rappaport,2• Edition, Prentice Hall Communications Engineering and Emerging Technologies Series, 2002, ISBN 0-13-042232-0

[2] LTE for UMTS Evolution to LTE-Advanced' Harri Holma and Antti Toskala, Second Edition - 2011, John

Wiley & Sons, Ltd. Print ISBN: 9780470660003.
Web links and Video Lectures (e-Resources):
• https://nptel.ac.in/courses/117102062
Activity Based Learning (Suggested Activities in Class)/ Practical Based learning • Seminar

Automation in Manufacturing Systems		Semester	VII
Course Code	**BRI714D**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	48	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	THEORY		

Course objectives:

This course will enable students to,

1. To understand the concepts of automation in manufacturing systems
2. To impart the knowledge of a line balancing and assembly systems
3. To explore the idea of robotics and understand the computerized manufacturing planning
4. To gain the knowledge of automated inspection and shop floor control
5. To understand the concepts of additive manufacturing and latest trends in manufacturing

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) need not to be only traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes.
2. Use of Video/Animation to explain functioning of various concepts.
3. Encourage collaborative (Group Learning) Learning in the class.
4. Ask at least three HOT (Higher order Thinking) questions in the class, which promotes critical thinking.
5. Adopt Problem Based Learning (PBL), which fosters student's Analytical skills, develop design thinking skills such as the ability to design, evaluate, generalize, and analyze information rather than simply recall it

Module-1

Introduction: Production system facilities, Manufacturing support systems, Automation in systems, Automation principles &strategies

Manufacturing Operations: Manufacturing operations, Product/production relationship, Production concepts and Mathematical models & costs of manufacturing operations. Problems on mathematical models

Module-2

Line Balancing: Methods of line balancing, Numerical problems on largest candidate rule, Kilbridge's and Wester's method, and ranked positional weights method, computerized line balancing methods.

Automated Assembly System: Design for automated assembly, types of automated assembly system, Parts feeding devices, Analysis of single and multi-station assembly machines

Module-3

Computerized Manufacture Planning and AGVS:

Computer aided process planning (CAPP): Retrieval and Generative systems, and benefits of CAPP. Material requirement planning, Inputs to MRP system, working of MRP, Outputs and benefits. Automated Guided Vehicles System: Applications, Guidance and routing,

Module-4

Inspection Technologies

Automated inspection, coordinate measuring machines - construction, Operation & programming, Software, application & benefits, Flexible inspection system, Inspection probes on machine tools, Machine vision, Optical inspection techniques non-optical inspection technologies.

Shop Floor Control and Automatic Identification Techniques:

Shop floor control, Factory data collection system, Automatic identification methods, Bar code technology, Automatic data collection systems, An introduction to QR code Technology

Module-5

Additive Manufacturing Systems: Basic principles of additive manufacturing, Slicing CAD models for AM, Advantages and limitations of AM technologies, Recent trends in manufacturing, Hybrid manufacturing

Future of Automated Factory: Trends in manufacturing, the future automated factory, Human workers in future automated factory, Social impact.

Course outcome (Course Skill Set)

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

1. Explain the basics of productions, automation system and manufacturing operations. Solve the simple problems on mathematical model.
2. Analyze and solve problems on line balancing
3. Explain CAPP and MRP system and analyze the AGVS
4. Understand the inspection tech
5. Explain the modern trends in additive manufacturing and automated factory

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

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

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

Semester-End Examination:

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

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

Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

Text Books:

1. Automation, Production Systems and Computer-Integrated Manufacturing, by Mikell P Groover, 4th Edition, 2015, Pearson Learning.
2. CAD / CAM Principles and Applications by P N Rao, 3rd Edition, 2015, Tata McGraw-Hill.
3. CAD/CAM/CIM, Dr. P. Radhakrishnan, 3rd edition, New Age International Publishers, New Delhi.

Reference Books:

1. "CAD/CAM" by Ibrahim Zeid, Tata McGraw Hill.
2. Principles of Computer Integrated Manufacturing", S.Kant Vajpayee, 1999, Prentice Hall of India, New Delhi.
3. "Work Systems And The Methods, Measurement And Management of Work", Groover M. P.,Pearson/Prentice Hall, Upper Saddle River, NJ, 2007.
4. "Computer Automation in Manufacturing", Boucher, T. O., Chapman & Hall, London, UK, 1996.
5. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, 2nd Ed. (2015), Ian Gibson, David W. Rosen, Brent Stucker"Understanding Additive Manufacturing", Andreas Gebhardt, Hanser Publishers,
6. 2011 Industry 4.0: The Industrial Internet of Things, Apress, 2017, by Alasdair Gilchrist

Web links and Video Lectures (e-Resources):
• 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 • Seminar

INTRODUCTION TO MOBILE ROBOTICS		Semester	VII
Course Code	BRI755A	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

Course objectives

The course will enable the students to:

- Provide knowledge on the application of mobile robotics
- Understand the fundamentals of mobile robotics and their components.
- Learn the design and control strategies for mobile robots.
- Develop skills in programming and simulation of mobile robotic systems.
- Apply knowledge to real-world scenarios and projects.

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 andTalk 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 MOBILE ROBOTICS

Overview of Mobile Robotics,Definition and classification of mobile robots,Historical development and current trends Types of Mobile Robots,Wheeled, tracked, and legged robots,Autonomous vehicles, remote-controlled robots, Applications in Industrial, medical, exploration, and service robots.

Teaching-Learning Process	1. Power-pointPresentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving/ Whiteboard

Module-2

KINEMATICS AND DYNAMICS OF MOBILE ROBOTS

Kinematics, Forward and inverse kinematics, Differential drive and omni-wheeled robots Dynamics,Forces and torques,Motion planning and control, Path Planning,Trajectory planning and obstacle avoidance.

Teaching-Learning Process	1. Power-pointPresentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving/Whiteboard

Module-3

SENSORS AND PERCEPTION

Types of Sensors,Range sensors ,LIDAR, sonar, IR,Vision sensors ,cameras, computer vision techniques, Sensor Fusion,Combining data from multiple sensors Environmental Perception,Mapping and localization techniques ,SLAM, Implementing basic SLAM algorithms.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving/ Whiteboard

Module-4

CONTROL SYSTEMS FOR MOBILE ROBOTS

Control Architectures,Reactive, deliberative, and hybrid control,Control Algorithms,PID control, State-space control, and adaptive control,Simulation and Implementation,Using simulation software tools like MATLAB or ROS to model and control mobile robots.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving/ Whiteboard

Module-5

INTEGRATION AND ARCHITECTURE.

System Integration with Combining sensors, actuators, and control systems, Real-world Applications, Design and implementation of a mobile robot for a specific application,Performance of mobile robots controlled through the web–System Description–Software,Case studies of mobile robots in various industries.

Teaching-Learning Process	1. Power-pointPresentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving/Whiteboard

Course outcome (Cos)

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

CO 1:Describe the fundamental principles and types of mobile robots, including their components and applications

CO 2: Explain the kinematic and dynamic models to analyze and solve problems related to the movement and control of mobile robots.

CO 3:Evaluate the performance of different sensor systems and their integration in mobile robots for environmental perception and navigation

CO 4: **Assess** the performance of a mobile robot system through simulation and experimentation, and reflect on the results to propose improvements.

CO 5:**Design and implement** control algorithms for mobile robots, including PID control and other control strategies, to achieve desired behaviors and performance

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

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

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

Semester-End Examination:

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

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

Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources

Text Books

1. "Introduction to Autonomous Robots: Mechanisms, Sensors, Actuators, and Algorithms" by Nikolaus Correll et al., 2022, MIT Press.
2. "Robotics: Modelling, Planning and Control" by Bruno Siciliano et al., 2009, Springer.
3. "Mobile Robotics: Technology and Applications" by D. K. Pratihar, 2007 by Alpha Science International Ltd.

Reference Books

1. "Probabilistic Robotics" by Sebastian Thrun et al., published by MIT Press on August 19, 2005, ISBN: 9780262201629
2. "Robotics: Principles and Practice" by S.K. Saha, McGraw Hill Education (India) Private Limited, 2014, ISBN: 978-93-3290-280-0.

Web links and Video Lectures (e-Resources)

- Control of Multiple Robots-Advanced Topics **https://www.coursera.org/lecture/robotics-flight/control-of-multiple-robots-sLAoY**
- MIT Open Courseware: Principles of Autonomy and Robotics

Activity Based Learning /Practical Based learning

- Hands-on activity: Exploring a basic mobile robot kit
- Simulation of kinematics using software tools
- Hands-on with different sensors and integration
- Designing and implementing control systems for a mobile robot
- Design and implementation of a mobile robot for a specific application

Additive Manufacturing		Semester	VI
Course Code	**BRI755B**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3 Hours
Examination type (SEE)	**Theory**		

Course objectives:

- 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, which teachers can use to accelerate the attainment of the various course outcomes.

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

Module-1

Introduction 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

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). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component. Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks

Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)

The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

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

Semester-End Examination:

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

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

Marks scored shall be proportionally reduced to 50 marks.

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. 2. Andreas Gebhardt, "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing", Hanser Publisher, 2011.
3. 3. Khanna Editorial, "3D Printing and Design", Khanna Publishing House, Delhi.

Reference Books:

1. 1. CK Chua, Kah Fai Leong, "3D Printing and Rapid Prototyping- Principles and Applications", World Scientific, 2017.
2. 2. J.D. Majumdar and I. Manna, "Laser-Assisted Fabrication of Materials", Springer Series in Material Science, 2013.
3. 3. L. Lu, J. Fuh and Y.S. Wong, "Laser-Induced Materials and Processes for Rapid Prototyping", Kulwer Academic Press, 2001.

4. 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

- Case studies
- Quiz
- Topic Seminar presentation
- Assignments
- Model making

AUTONOMOUS ROBOTS		Semester	VI
Course Code	**BRI755C**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3 Hours
Examination type (SEE)	**Theory**		

Course objectives:

- To 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). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

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The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

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

Semester-End Examination:

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

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

Suggested Learning Resources:

Text Books:

1. 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

FLEXIBLE MANUFACTURING SYSTEM		Semester	VI
Course Code	**BRI755D**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3 Hours
Examination type (SEE)	**Theory**		

Course objectives:

- 1. Study of different types of production
- 2. Knowledge of group technology(GT)
- 3. Introduction and need of FMS
- 4. Detailed study of flexible manufacturing cells and systems
- 5. FMS software

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

PRODUCTION SYSTEMS

Types of production- Job Shop, Batch and Mass production - Functions in manufacturing - Organization and information processing in manufacturing - Plant layout - Batch production - Work in progress inventory - Scheduling, problems.

Module-2

GROUP TECHNOLOGY

Formation of part families - Part classification - Coding system optiz, Multi Class - Production flow analysis - Machine cells design - Clustering methods - Modern algorithms - Benefits of GT-System planning - Objective, guide line, system definition and sizing - Human resources - Objective, staffing supervisor role.

Module-3

FLEXIBLE MANUFACTURING SYSTEMS

Introduction - Evolution - Definition - Need for FMS - Need for Flexibility - Economic Justification of FMSApplication Criteria - Machine tool Selection and Layout - Computer control system - Data files - Reports -Planning the FMS - Analysis Methods for FMS - Benefits and limitations.

Module-4

FLEXIBLE MANUFACTURING CELLS

Introduction - Cell description and classifications - Unattended machining - Component handling and storage system - Cellular versus FMS-System - Simulation, Hardware configuration - Controllers - Communication networks - Lean production and agile manufacturing.

Module-5

FMS SOFTWARE

Introduction - General Structure and requirements - Functional descriptions - Operational overview - Computer simulation - FMS installation - Objective - Acceptance testing - Performance goals - Expectations - Continued support.

Course outcomes (Course Skill Set):

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

1.Demonstrate basic concepts of flexible manufacturing systems.
2. Discuss concepts of manufacturing cells and unattended machining.
3. Explain in detail about manufacturer's driving force..
4. Discuss about software for FMS.
5. Explain FMS planning, hardware and implementation

Assessment Details (both CIE and SEE)

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4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Text Books:

1. William W. Luggen, Flexible Manufacturing Cells and Systems, Prentice Hall, New Jersey, 1991.
2. Mikell P. Groover, Automation Production Systems & Computer Integrated manufacturing, Prentice Hall of India, New Delhi, 1989.

REFERENCE BOOKS

1. David J. Parrish, Flexible Manufacturing, Butterworth-Heinemann, Newton, MA, USA, 1990.
2. Buffa, E. S., Modern Production and Operation Management, New York, 1985.
3. Jha, N.K. " Handbook of Flexible Manufacturing Systems", Academic Press Inc., 1991