SCHEME OF EXAMINATION

&

DETAILED SYLLABUS

(2nd Year)

FOR

BACHELOR OF TECHNOLOGY (B.TECH/M.TECH) DUAL DEGREE

FOR

INDUSTRIAL INTERNET OF THINGS

(4+2 Years)

Offered at University School of Automation and Robotics

from A.S. 2021-22 onwards

University School of Automation and Robotics

GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY,
EAST DELHI CAMPUS, SURAJMAL VIHAR, DELHI 110092

Prof. Ajay S. Singholi
Professor In-charge, USAR
Guru Gobind Singh Indraprastha University
(East Delhi Campus)
Surajmal Vihar, Delhi-110092

Programme Outcomes

1. *Engineering Knowledge* (PO01): Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. *Problem Analysis* (PO02): Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
3. *Design/Development of Solutions* (PO03): Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. *Conduct Investigations of Complex Problems* (PO04): Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions for complex problems:
    a) that cannot be solved by straightforward application of knowledge, theories and techniques applicable to the engineering discipline as against problems given at the end of chapters in a typical text book that can be solved using simple engineering theories and techniques;
    b) that may not have a unique solution. For example, a design problem can be solved in many ways and lead to multiple possible solutions;
    c) that require consideration of appropriate constraints / requirements not explicitly given in the problem statement such as cost, power requirement, durability, product life, etc.;
    d) which need to be defined (modeled) within appropriate mathematical framework; and
    e) that often require use of modern computational concepts and tools, for example, in the design of an antenna or a DSP filter
5. *Modern Tool Usage* (PO05): Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
6. *The Engineer and Society* (PO06): Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. *Environment and Sustainability* (PO07): Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. *Ethics* (PO08): Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. *Individual and Team Work* (PO09): Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. *Communication* (PO10): Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

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11. ***Project Management and Finance*** **(PO11):** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. ***Life-long Learning*** **(PO12):** Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

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Course / Paper Group Codes:
BS: Basic Science
HS: Humanities, social science, management
MC: Mandatory courses
PC: Programme Core, that is course / paper offered in the discipline of the programme as a compulsory paper.
SC: School Core, that is course / paper offered in the discipline of the school as a compulsory paper.

Definitions:
Batch: The batch of the student shall mean the year of the first time enrolment of the students in the programme of study in the first semester. Lateral entry students admitted in the 3rd semester / 2nd year shall be designated as students admitted in the previous batch as they are admitted one year later. A student re-admitted in a programme of study in a lower / later batch shall be considered as the student of the original batch for the purpose calculation of duration of study.

Programme of study shall mean Bachelor of Technology.

Acronyms:
APC: Academic programme committee comprising of all faculty of the school.
L: Number of Lecture hours per week
T/P: Number of Tutorial / Practical Hours per week
C: Number of credits assigned to a course / paper
COE: Controller of Examinations of the Examinations Division of the University.
SGPA/CGPA: Semester/Cumulative Grade Point Average.
NUES: No term end examination shall be held. The evaluation shall be conducted as per the scheme of examinations as described in the scheme of study.

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Third Semester					
Group	Code	Paper	L	T/P	Credits
Theory Papers					
BS	ABS 201	Linear and Abstract Algebra	3	-	3
PC	ARI 203	Artificial Intelligence and Its Applications	4	-	4
PC	ARM 205	Computer Networks	3	-	3
PC	ARI 207	Analog Electronics	4	-	4
SC	ARI 209	Switching Theory and Logic Design	4	-	4
PC	ARD 211	Data Structures	4	-	4
HS/MS	ECO 213	Engineering Economics	2	-	2
Practical / Viva Voce					
PC	ARD 251	Artificial Intelligence Lab	-	2	1
PC	ARI 253	Basic Electronics Lab	-	2	1
PC	ARD 255	Data Structures Lab	-	2	1
Total			24	6	27

Fourth Semester					
Group	Code	Paper	L	T/P	Credits
Theory Papers					
PC	ARI 202	Internet of Things	4	-	4
PC	ARA 204	Mechatronic Systems and Applications	4	-	4
PC	ARA 206	Fundamentals of Automation	4	-	4
PC	ARI 208	Control Systems	4	-	4
PC	ARI 210	Electrical Machines and Drives	3	-	3
BS	ABS 212	Convex Optimization	3	-	3
HS/MS	MS 214	Accountancy for Engineers	2	-	2
Practical / Viva Voce					
PC	ARI 252	IoT Lab	-	2	1
PC	ARI 254	Mechatronics Lab	-	2	1
PC	ARM 256	Object Oriented Programing using Java Lab	-	2	1
Total			24	6	27

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DETAILED SYLLABUS FOR 3RD SEMESTER

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Paper Code: ABS 201	**L**	**T/P**	**Credits**
Subject: Linear and Abstract Algebra	3	-	3

Marking Scheme

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 15 marks.
3. Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes:

CO1:	Ability of students to utilize first approach to the subject of algebra, which is one of the basic pillars of modern mathematics.
CO2:	Ability of students to implement algebraic statements about vector addition, scalar multiplication, inner products projections, norms, orthogonal vectors, linear independence, spanning sets, subspaces.
CO3:	Ability of students to use certain structures called groups, some related structures along with application of matrices.
CO4:	Ability of students to depict good mathematical maturity and implement mathematical thinking and skill.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	1	-	-	-	-	-	1	2
CO2	2	3	3	3	1	-	-	-	-	-	1	2
CO3	2	3	3	3	1	-	-	-	-	-	2	3
CO4	3	3	3	3	1	-	-	-	-	-	2	3

Unit I **[14]**

Vector spaces: The n dimensional vectors, vector spaces, subspaces, spanning sets, linear dependence of vectors, basis and dimensions, linear transformation, null space and range space of a linear transformation, rank and nullity, rank and nullity theorem, inverse of a linear transformation, composition of linear map, matrices of a linear transformation and its transpose, the minimal polynomial

Unit II **[6]**

Inner product spaces: Inner product spaces, norm of a vector, Schwarz's inequality, normed vector space, orthonormal sets, Gram Schmidt orthogonalization process

Unit III **[6]**

Group theory: Introduction to groups, definition and example of groups, elementary properties of groups. Finite groups, subgroups and their examples. Cyclic groups. Permutation

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groups, Caley theorem, cosets, Lagrange's theorem, Normal subgroups and factor groups, Isomorphism and homomorphism.

Unit IV **[14]**

Ring theory: Definition and examples of rings, Properties of rings, Subrings, Integral domains.

Text Books:

1. Herstein, I. N. (2006). *Topics in algebra*. John Wiley & Sons.
2. Deisenroth, M. P., Faisal, A. A., & Ong, C. S. (2020). *Mathematics for machine learning*. Cambridge University Press.

Reference Books:

1. Gallian, J. A. (2021). *Contemporary abstract algebra*. Chapman and Hall/CRC.
2. Bhattacharya P.B,Jain S.K., Nagpaul S.R. (1986). *Basic abstract algebra*. ISBN 0-521-30990-5,31107-1 Cambridge University Press.
3. Leversha G. (1987). *The Mathematical Gazett*. Cambridge University Press Online ISSN: 2056-6328.

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	L	T/P	Credits
Paper Code: ARA 203			
Subject: Artificial Intelligence and Its Applications	4	-	4

Marking Scheme

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 15 marks.
3. Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes:

CO1:	Ability of students to implement the mechanisms of robot along with its grippers. Furthermore to understand kinematics of robot using DH representation
CO2:	Ability of students to utilize the differential motion and velocities of robot using jacobian.
CO3:	Ability of students to use the dynamic analysis of forces using Lagrangian and Newtonian method.
CO4:	Ability of students to implement the online and offline programming of robots.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	3	2	-	-	1	3	1	2
CO2	3	3	3	3	3	1	-	-	2	3	1	2
CO3	3	3	3	3	3	1	-	-	3	3	2	3
CO4	3	3	3	3	3	3	-	-	3	3	2	3

Unit I **[8]**

Introduction to Artificial Intelligence: AI problems, foundation of AI and history of AI intelligent agents: Agents and Environments, the concept of rationality, the nature of environments, structure of agents, problem solving agents, problem formulation.

Expert System: Definition, role of knowledge, architecture, and life cycle of Expert System

Unit II **[12]**

Searching: Searching for solutions, uninformed search strategies – Breadth first search, depth first Search. Search with partial information (Heuristic search) Hill climbing, A*, AO* Algorithms, Problem reduction, Game Playing-Adversarial search, Games, mini-max algorithm, optimal decisions in multiplayer games, Problem in Game playing, Alpha-Beta pruning, Evaluation functions.

Knowledge representation issues, predicate logic: logic programming, semantic nets-frames and inheritance, constraint propagation, representing knowledge using rules, rules-based deduction systems. Reasoning under uncertainty, review of probability, Baye's probabilistic interferences and dempster Shafer theory.

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Unit III **[10]**

Fuzzy Systems: Crisp sets, Fuzzy sets: Basic types and concepts, characteristics and significance of paradigm shift, Representation of fuzzy sets, Operations, membership functions, Classical relations and fuzzy relations, fuzzification, defuzzification, fuzzy reasoning, fuzzy inference systems, fuzzy control system, fuzzy clustering, applications of fuzzy systems. Euro-fuzzy systems, neuro-fuzzy modeling; neuro-fuzzy control.

Unit IV **[10]**

Introduction to Machine Learning: What is Machine Learning, Learning from Data, History of Machine Learning, Big Data for Machine Learning, Leveraging Machine Learning, Descriptive vs Predictive Analytics, Artificial Intelligence and Machine Learning, Types of Machine Learning, Supervised, Unsupervised, Semi-supervised, Reinforcement Learning, Introduction to Neural Network and Deep Learning.

Textbooks

1. Elaine R., Kevin K. (2009). *Artificial Intelligence*. Tata McGraw Hill.
2. Ross T. J. (1995). *Fuzzy Logic with Engineering Applications*. McGraw-Hill.
3. Russel S., Norvig P. (2003). *Artificial Intelligence – A Modern Approach*. Second Edition. Pearson Education
4.

Reference Books

1. Nilsson N. (1982). *Principles of Artificial Intelligence*. Morgan Kaufmann.
2. Poole D., Mackworth A., Goebel R. (1998). *Computational Intelligence: a logical approach*. Oxford University Press.

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Paper Code: ARM 205	**L**	**T/P**	**Credits**
Subject: Computer Networks	3	-	3

Marking Scheme

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 15 marks.
3. Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes:

CO1:	Ability of students to design machine components, mechanisms, predict failure and understand the physical properties of materials.
CO2:	Ability of students to implement fundamentals of basic tools for stress, strain and deformation analysis and determine the stresses, strains and deformations produced by applied loads.
CO3:	Ability of students to analyze and design components and structural members subjected to tension, compression, torsion, bending and combined loads using fundamental concepts of stress, strain, elastic and inelastic behavior
CO4:	Ability of students to be able to conduct themselves in a professional manner and with regard to their responsibilities to society; especially with regard to design of mechanisms and prevention of failure

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	1	-	-	-	-	-	1	2
CO2	3	3	3	3	1	-	-	-	-	-	1	2
CO3	3	3	3	3	1	-	-	-	-	-	2	3
CO4	3	3	3	3	1	-	-	-	-	-	2	3

Unit I **[14]**

Introduction: Introduction: Internet History, Uses of computer networks, Network hardware, network software, Protocol layering, Reference models (OSI & TThis course will teach the basics of computer network and distributed big data storage and retrieval. Last Unit focuses on the use of cloud infrastructures and highlights its benefits to overcome the identified issues and to provide new approaches for managing huge volumes of heterogeneous data.
CP/IP), Network standardization.

The Physical Layer: Theoretical basis for data communication, Transmission media: Guided and Unguided media, Switching (circuit, packet), Multiplexing (FDM, WDM, and TDM), Overview of PSTN, ISDN, and ATM.

Unit II **[10]**

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The Data Link Layer: Data link layer design issues, Error detection and Correction Techniques, Elementary data link control protocols, Sliding window protocols, Example data link protocols (HDLC and PPP). The Medium Access Sublayer: The channel allocation problem, multiple access protocols, IEEE standard 802.3 & 802.11 for LANS and WLANs, Network devices-repeaters, hubs, Bridge, Switches and Routers

Transmission Networks: PDH Networks, SONET/SDH Networks, DWDM Networks, Introduction to Cell Switched Networks e.g Asynchronous Transfer Mode (ATM) and Packet Switched Networks

Unit III **[10]**

The Network Layer: Network layer design issues, routing algorithms, congestion control algorithms, Quality of Service, Introduction to IPv4 Addressing, Subnetworks and Subnetting, IPv4 protocol Packet Format, Forwarding of IP packets, IPv4 vs IPv6, Congestion control algorithms. Delay Models in Data Networks: Queueing Models, M/M/1 Queueing System, M/M/m/m and Markov Systems.

Transport layer: Transport layer services, Elements of transport protocols, Overview of UDP and TCP

Unit IV **[10]**

Networking for Big Data: Networking Theory and Design for Big Data (Networking Server for computation, Introduction to Traffic engineering inside a data center, data center as a collection of storage servers) Networking Security for big data.

Text Books:

1. Dimitri, B., & Robert, G. (2000). *Data networks*.
2. Stojcev, M. (2005). *Data Communications and Networking*, Behrouz A. Forouzan, McGraw-Hill Higher Education, Boston (2003), Softcover, pp. 973, plus XXXIV, ISBN: 0-07-251584-8.
3. Yu, S., Lin, X., Misic, J., & Shen, X. S. (Eds.). (2015). *Networking for big data* (Vol. 2). CRC Press.

Reference Books:

1. Black, U. (1993). *Computer networks protocols, standards, and interfaces*. Prentice-Hall, Inc.
2. A. Tannenbaum. (2011) *Computer Networks*. 5th edition, Pearson.

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Paper Code: ARI 207	**L**	**T/P**	**Credits**
Subject: Analog Electronics	4	-	4

Marking Scheme

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 15 marks.
3. Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes:

CO1:	Ability of students to implement fundamental principles of analog electronics.
CO2:	Ability of students to implement sufficient basic knowledge to design diodes and transistor based circuits, op-amps and their applications.
CO3:	Ability of students to design and analyze various analog electronic circuits
CO4:	Ability of students to be able to utilize basic electronic devices such as diodes, BJT, FET transistors and multi-vibration circuits

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	3	2	2	3	1	1	1	3
CO2	3	3	3	3	3	1	2	3	2	1	1	3
CO3	3	3	3	3	3	1	3	3	3	2	2	3
CO4	3	3	3	3	3	3	3	3	3	2	2	3

Unit I **[12]**

Introduction: Review of semi-conductor Physics, Open-circuited p-n junction, Diode equation, PN diode as a rectifier (forward bias and reverse bias), wave shaping circuits, General idea about different wave shapers, RC and RL integrating and differentiating circuits with their applications, Diode clipping and clamping circuits and simple numerical problem on the circuits Clipper

Review of diode and BJT: Bias stabilization: Need for stabilization, fixed Bias, emitter bias, self-bias, bias stability with respect to variations in I_{co}, V_{BE} & β, Stabilization factors, thermal stability. Bias compensation techniques. Small signal amplifiers: CB, CE, CC configurations, hybrid model for transistor at low frequencies, RC coupled amplifiers, mid band model, gain & impedance, comparisons of different configurations, Emitter follower, Darlington pair(derive voltage gain, current gain, input and output impedance), Hybrid-model at high frequencies (π model).

Unit II **[12]**

Amplifiers and Oscillators: Small signal low frequency transistor amplifier circuits: h-parameter representation of a transistor, Analysis of single stage transistor amplifier using h-

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parameters: voltage gain, current gain, Input impedance and Output impedance.
Feedback Amplifiers: Feedback concept, Classification of Feedback amplifiers, Properties of negative Feedback amplifiers, Impedance considerations in different Configurations, Examples of analysis of feedback Amplifiers.
Power Amplifiers: Power dissipation in transistors, difference with voltage amplifiers, Amplifier classification (Class A, Class B, Class C, Class AB) class AB push pull amplifier, collector efficiency of each, and cross over distortion.

Unit III [6]
Field Effect Transistor: Introduction, Classification, FET characteristics, Operating point, Biasing, FET small signal Model, JFET characteristics (Qualitative and Quantitative discussion), Small signal model of JFET, MOSFET, MESFET and its characteristics (Enhancement and depletion mode), Comparison of various Transistors, Introduction to SCR and UJT.

Unit IV [6]
Operational Amplifiers: Ideal op-amp, Output offset voltage, input bias current, input offset current, slew rate, gain bandwidth product, Inverting and non-inverting amplifier, Differentiator, integrator, Square-wave and triangular-wave generators.
Multivibration Circuits: working principle of transistor as switch, Concept of multi-vibrator: astable, monostable, and bistable and their applications, Block diagram of IC555 and its working, IC555 as monostable and astable multi-vibrator.

Text Books:

1. J.Millman, C.C.Halkias, and Satyabratha Jit (2007). *Electronic Devices and Circuits*. Tata McGraw Hill, 2nd Edition.
2. Salivahanan and others. (2011) *Electronic Devices and Circuits*. Tata McGraw Hill
3. D. R. Cheruku and B. T. Krishna (2008). *Electronic Devices and Circuits*. Pearson

References:

1. T.F. Bogart Jr., J.S.Beasley and G.Rico (2004). *Electronic Devices and Circuits*. Pearson Education, 6th edition.
2. S.G.Burns and P.R.Bond (1998). *Principles of Electronic Circuits*. Galgotia Publications, 2nd Edition.
3. Millman and Grabel (1988). *Microelectronics*. Tata McGraw Hill
4. R. L. Boylestad and L. Nashlesky (2009). *Electronic Devices and Circuit Theory*. Pearson, 10th Edition.

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Paper Code: ARI 209	**L**	**T/P**	**Credits**
Subject: Switching theory and Logic Design	4	-	4

Marking Scheme

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 15 marks.
3. Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes:

CO1:	Ability of students to implement the fundamental concepts and techniques used in digital electronics along with design of flip flops, registers, counters and their applications as well as the design of digital circuits.
CO2:	Ability of students to be able to quantitatively identify the fundamentals of computers, including number systems, logic gates, logic and arithmetic subsystems, and integrated circuits.
CO3:	Ability of students to analyze logic processes and implement logical operations using combinational logic circuits and design sequential circuits
CO4:	Ability of students to utilize knowledge of different logic families and their characteristics along with the knowledge of different types of memories

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	3	-	-	-	1	1	1	2
CO2	3	3	3	3	3	-	-	-	1	1	1	2
CO3	3	3	3	3	3	-	-	-	1	1	1	3
CO4	3	3	3	3	3	-	-	-	1	1	1	3

Unit I **[14]**

Number Systems and Codes: Decimal, Binary, Octal and Hexadecimal Number systems, Codes- BCD, Gray Code, Excess-3 Code, ASCII, EBCDIC, Conversion between various Codes.

Switching Theory: Boolean Algebra- Postulates and Theorems, De' Morgan's Theorem, Switching Functions Canonical Forms- Simplification of Switching Functions- Karnaugh Map and Quine Mc-Clusky Methods.

Combinational Logic Circuits: Review of basic gates- Universal gates, Adder, Subtractor, Serial Adder, Parallel Adder- Carry Propagate Adder, Carry Look-ahead Adder, Carry Save Adder, Comparators, Parity Generators, Decoder and Encoder, Multiplexer and De-multiplexer, ALU, PLA and PAL.

Unit II **[10]**

Sequential Logic Circuits: Latches and Flip Flops- SR, D, T and MS-JK Flip Flops,

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Asynchronous Inputs.

Counters and Shift Registers: Design of Synchronous and Asynchronous Counters- Binary, BCD, Decade and Up/Down Counters, Shift Registers, Types of Shift Registers, Counters using Shift Registers- Ring Counter and Johnson Counter.

Unit III **[8]**

Integrated circuits: TTL and CMOS logic families and their characteristics. Brief introduction to RAM and ROM

Synchronous Sequential Circuits: State Tables State Equations and State Diagrams, State Reduction and State Assignment, Design of Clocked Sequential Circuits using State Equations.

Unit IV **[6]**

Finite state machine: capabilities and limitations, Mealy and Moore models-minimization of completely specified and incompletely specified sequential machines, Partition techniques and merger chart methods, concept of minimal cover table.

Algorithmic State Machine: Representation of sequential circuits using ASM charts synthesis of output and next state functions, Data path control path partition-based design.

Text Books:

1. Leach and Malvino (2011). *Digital principles and Applications*. Tata McGraw-Hill Education
2. Mano, M. M. (2017). *Digital logic and computer design*. Pearson Education India.
3. Jain, R. P. (2003). *Modern digital electronics*. Tata McGraw-Hill Education.

Reference Books:

1. A Anand Kumar. (2016) *Fundamentals of Digital Logic Circuits*, PHI
2. Taub, H., & Schilling, D. L. (1977). *Digital integrated electronics*. McGraw-Hill College.

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Paper Code: ARD 211	**L**	**T/P**	**Credits**
Subject: Data Structures	4	-	4

Marking Scheme

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 15 marks.
3. Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes:

CO1:	Ability of students to implement the basic knowledge about components and layout of linkages in the assembly of a system/machine in terms of kinematics and dynamics.
CO2:	Ability of students to implement knowledge of the principles for analyzing the assembly with respect to the displacement, velocity, and acceleration at any point in a link of a mechanism.
CO3:	Ability of students to utilize the motion resulting from a specified set of linkages; design few linkage and cam mechanisms for specified output motions.
CO4:	Ability of students to utilize basic concepts of toothed gearing and kinematics of gear trains and the effects of friction in motion transmission and in machine components.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	1	-	-	-	-	-	1	2
CO2	2	3	3	3	1	-	-	-	-	-	1	2
CO3	2	3	3	3	1	-	-	-	-	-	2	3
CO4	3	3	3	3	2	-	-	-	-	-	2	3

Unit I **[8]**

Abstract Data Types Abstract Data Types (ADTs) , ADTs and classes , introduction to OOP , classes in Python , inheritance , namespaces , shallow and deep copying. Introduction to analysis of algorithms , asymptotic notations , recursion , analyzing recursive algorithms

Unit II **[10]**

Linear Structures: List ADT , array-based implementations , linked list implementations , singly linked lists , circularly linked lists , doubly linked lists , applications of lists , Stack ADT , Queue ADT , double ended queues

Unit III **[10]**

Sorting And Searching: Bubble sort , selection sort , insertion sort , merge sort , quick sort , linear search , binary search , hashing , hash functions , collision handling , load factors, rehashing, and efficiency

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Unit IV **[12]**

Tree Structures: Tree ADT , Binary Tree ADT , tree traversals , binary search trees , AVL trees , heaps, multiway search trees

Graph Structures: Graph ADT , representations of graph , graph traversals , DAG , topological ordering , shortest paths , minimum spanning trees

Text Books:

1. Gilberg, R. F., & Forouzan, B. A. (2001). *Data structures*: A pseudocode approach with C++. Brooks/Cole Publishing Co..
2. Aho Alfred, V., Hopcroft John, E., Ullman Jeffrey, D., Aho Alfred, V., Bracht Glenn, H., Hopkin Kenneth, D., ... & Johnson, C. A. (1983). *Data structures and algorithms*. USA: Addison-Wesley.

References:

1. Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2022). *Introduction to algorithms*. MIT press.
2. Horowitz, E. (1978). *Fundamentals of computer algorithms*. Galgotia publications.

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DETAILED SYLLABUS FOR 4TH SEMESTER

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Delhi - 110092

Paper Code: ARI 202	**L**	**T/P**	**Credits**
Subject: Internet of Things	4	-	4

Marking Scheme

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 15 marks.
3. Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes:

CO1:	Ability of students to implement the basic knowledge of Internet of things and protocols.
CO2:	Ability of students to implement knowledge of IoT in some of the application areas where IoT can be applied and learn about the middleware for IoT.
CO3:	Ability of students to utilize the concepts of IoT architecture, IoT reference model and overview of IoTivity stack architecture.
CO4:	Ability of students to utilize and implement solid theoretical foundation of the IoT Platform and System Design.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	2	2	1	1	3	2	2	3
CO2	3	3	3	3	2	2	1	1	3	2	2	3
CO3	3	3	3	3	2	2	1	1	3	2	2	3
CO4	3	3	3	3	2	2	1	1	3	2	2	3

Unit I [8]

Introduction to IoT: Meaning of IoT, Importance of IoT, Elements of an IoT ecosystem, Technology drivers, Business drivers, Trends and implications, Overview of Governance, Privacy and Security Issues. Technologies involved in IoT development, Internet web and Networking technologies, Infrastructure, Overview of IoT supported Hardware platforms

Unit II [12]

IoT protocols: Protocol Standardization for IoT, Efforts, M2M and WSN Protocols, Role of M2M in IoT, M2M Value Chains, IoT Value Chains, An emerging industrial structure for IoT, SCADA and RFID Protocols, Issues with IoT Standardization, Unified Data Standards Protocols, IEEE802.15.4–BACNet Protocol, Modbus, KNX, Zigbee, Network layer, APS layer – Security

Unit III [10]

IoT Architecture: IoT Open-source architecture (OIC), OIC Architecture & Design principles

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IoT reference Model and Architecture: Functional View, Information View, Deployment and Operational View, IoT Devices and deployment models, IoTivity: An Open source IoT stack

Overview: IoTivity stack architecture, Resource model and Abstraction

Unit IV **[10]**

Web of things: Web of Things versus Internet of Things, Two Pillars of the Web, Architecture Standardization for WoT, Platform Middleware for WoT, Unified Multitier

WoT Architecture: WoT Portals and Business Intelligence

IoT applications Applications for industry: Future Factory Concepts, Brownfield IoT, Smart Objects, Smart Applications, Study of existing IoT platforms /middleware, IoT- A, Hydra etc.

Textbooks:

1. Zhou, H. (2012). *The internet of things in the cloud*. Boca Raton, FL: CRC press.
2. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds) (2011) *Architecting the Internet of Things*, Springer.
3. Easley, D., & Kleinberg, J. (2010). *Networks, crowds, and markets: Reasoning about a highly connected world*. Cambridge university press.
4. Hersent, O., Boswarthick, D., & Elloumi, O. (2011). *The internet of things: Key applications and protocols*. John Wiley & Sons.

References Books:

1. Bahga, A., & Madisetti, V. (2014). *Internet of Things: A hands-on approach*. Vpt.Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1st Edition, Apress Publications, 2013
2. Pfister, C. (2011). *Getting started with the Internet of things: connecting sensors and microcontrollers to the cloud*." O'Reilly Media, Inc.".

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Paper Code: ARA 204	**L**	**T/P**	**Credits**
Subject: Mechatronic Systems and Applications	4	-	4

Marking Scheme

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 15 marks.
3. Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes:

CO1:	Ability of students to identify, analyze and solve engineering problems related to mechatronics engineering.
CO2:	Ability of students to utilize the various sensors used to measure various physical parameters and implement knowledge of signal conditioning, data acquisition and communication systems used in mechatronics system development
CO3:	Ability of students to utilize understanding of basic functions, structure, concepts, programming and applications of embedded systems
CO4:	Ability of students to practically apply gained theoretical knowledge to design, analyze and implement embedded systems for application in industry automation.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	2	2	2	-	3	2	3	3
CO2	3	3	3	3	2	2	2	-	3	2	3	3
CO3	3	3	3	3	2	2	2	-	3	2	3	3
CO4	3	3	3	3	2	2	2	-	3	2	3	3

Unit I **[12]**

Introduction: Introduction to Mechatronics System, Elements of mechatronics system, mechatronics in manufacturing, product and design, Measurement Systems, Control System, comparison between traditional and mechatronics approach.

Sensors and Transducers: Introduction, Performance terminology, static and dynamic characteristics of transducers, Displacement Measurement: Transducers for displacement, displacement measurement, potentiometer, LVDT. Strain Measurement: Theory of Strain Gauges, Bridge circuit, Strain gauge based load cells and torque sensors, Velocity and Motion: Electromagnetic tachometer, photoelectric tachometer, variable reluctance tachometer, Digital Encoders. Vibration and acceleration: Eddy current type, piezoelectric type; Accelerometer: Principle of working, practical accelerometers, strain gauge based and piezoelectric accelerometers. Pressure Measurement: Elastic pressure transducers viz. Bourdon tubes, diaphragm, bellows and piezoelectric pressure sensors. Flow Measurement: Bernoulli flowmeter, Ultrasonic flowmeter, Magnetic flow meter, Rotameter. Miscellaneous Sensors: Leak detector, Flame detector, Smoke detector, pH sensors, Conductivity sensors, Humidity

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sensors, Potentiometric Biosensors and Proximity sensors. Selection of sensors

Unit II [10]

Mechanical Actuation System: Cams, Gear trains, Ratchet and Pawl, Belt and chain drives, Bearings.

Hydraulic and Pneumatic Actuation System: Introduction to Hydraulic and Pneumatic Systems, Directional Control valves, Flow control valves.

Electrical Actuation System: Electrical systems, Solid State Switches, Solenoids, D.C. motors, A.C. motors, Stepper motors.

Unit III [12]

Microprocessors: Microprocessor systems, Microcontrollers, applications.

Programmable logic controllers: Programmable logic controllers (PLC) Structure, Input / Output Processing, principles of operation, PLC versus computer, Programming Languages, programming using Ladder Diagrams, Logic Functions, Latching, Sequencing, Timers, Internal Relays And Counters, Shift Registers, Master and Jump Controls, Jumps, Data Movement, Code Conversion, Data handling and manipulation, selecting a PLC.

Unit IV [8]

System Models: Mathematical models, Mechanical, Electrical, hydraulic and Thermal Systems, Modelling of dynamic systems.

Design of Mechatronics systems: Stages in designing mechatronics system, Traditional and Mechatronic design.

Case studies of Mechatronics system: Mechatronic approach to design, Boat Auto pilot, Pick and place robots, high speed tilting train, automatic car park system, coin counter, engine management system, automated guided vehicle, autonomous mobile system, antilock brake system control, Auto-Focus Camera, Printer, Domestic Washing Machine, Optical Mark Reader, Bar Code Reader

Text Books:

1. W.Bolton, (2003) *Mechatronics*, Pearson education, second edition, fifth Indian Reprint.
2. Smaili, A., & Mrad, F. (2008). *Mechatronics: Integrated technologies for intelligent machines*. Oxford University Press.
3. Alciatore, D. G. (2007). *Introduction to mechatronics and measurement systems*. Tata McGraw-Hill Education.

Reference Books:

1. R.K Rajput, (2007) *A textbook of mechatronics*, S. Chand & Co.
2. D. A. Bradley, Dawson D., Buru N.C. and. Loader A.J. (1993) *Mechatronics*, Chapman and Hall.
3. Necsulescu, D. S. (2002). *Mechatronics*. Pearson College Division.
4. Kamm, L. J. (1995). *Understanding electro-mechanical engineering: an introduction to mechatronics* (Vol. 3). John Wiley & Sons.
5. Nitaigour Premchand Mahadik, (2003) *Mechatronics*, Tata McGraw-Hill publishing Company Ltd, 2003.

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Paper Code: ARA 206	**L**	**T/P**	**Credits**
Subject: Fundamentals of Automation	4	-	4

Marking Scheme

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 15 marks.
3. Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes:

CO1:	Ability of students to identify suitable automation hardware for the given application.
CO2:	Ability of students to identify potential areas of automation and material handling systems.
CO3:	Ability of students to utilize understanding of Manufacturing systems and Mathematical models of production lines
CO4:	Ability of students to practically implement knowledge of Industrial Automated production lines, work part transfer mechanism and buffer storage analysis for setup of future automated factory

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	2	2	2	1	1	1	3	3
CO2	3	3	3	3	2	2	2	1	1	1	3	3
CO3	3	3	3	3	2	2	2	1	1	1	3	3
CO4	3	3	3	3	2	2	2	1	1	1	3	3

Unit I **[10]**

Concept and scope of automation: Definition of automation, Socio economic impacts of automation, Types of Automation, Low Cost Automation and Automation Strategies, Types of production, Functions of Manufacturing, Organization and Information Processing in Manufacturing, Production concepts and Mathematical Models

Fixed Automation: Automated Flow lines, Methods of Workpart Transport, Transfer Mechanism - Continuous transfer, intermittent transfer and Indexing mechanism, Operator-Paced Free Transfer Machine, Buffer Storage, Control Functions and Automation for Machining Operations, Design and Fabrication Considerations

Automation Application: Home, Library, Electronics Assembly, Mechanical Assembly, Material Removal, Quality Control and Inspection, Material Handling and Storage, Laboratory Automation

Unit II **[10]**

Automated Materials Handling: The material handling function, Types of Material Handling Equipment, Analysis for Material Handling Systems, Design of the System, Conveyor

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Systems, Automated Guided Vehicle Systems.

Automated Storage Systems: Storage System Performance, Automated Storage/Retrieval Systems, Carousel Storage Systems, Work-in-process Storage, Interfacing Handling and Storage with Manufacturing

Automated Manufacturing Systems-Components, Classification and overview of manufacturing systems, Cellular manufacturing, Flexible manufacturing system (FMS), FMS and its planning and implementation, automated assembly system – design and types of automated assembly systems, Analysis of multi station and single station assembly machine.

Unit III **[10]**

Analysis of Automated Flow Lines: General Terminology and Analysis, Analysis of Transfer Lines without Storage, Partial Automation, Automated Flow Lines with Storage Buffers.

Automated Assembly Systems: Design for Automated Assembly, Types of Automated Assembly Systems, Vibratory bowl feeder and Non vibratory bowl feeder, Part Orienting Systems, Feed tracks, Escapements and part placing mechanism, Analysis of Multi-station Assembly Machines, Analysis of a Single Station Assembly Machine

Unit IV **[10]**

Automated Inspection and Testing: Inspection and testing, Statistical Quality Control, Automated Inspection Principles and Methods, Sensor Technologies for Automated Inspection, Coordinate Measuring Machines, Other Contact Inspection Methods, Machine Vision, Other optical Inspection Methods.

Modeling Automated Manufacturing Systems: Role of Performance Modeling, Performance Measures,

Performance Modeling Tools: Simulation Models, Analytical Models.

The Future Automated Factory: Trends in Manufacturing, The Future Automated Factory, Human Workers in the Future Automated Factory, The social impact.

Text Books:

1. Groover, M. P. (2016). *Automation, production systems, and computer-integrated manufacturing*. Pearson Education India.
2. Asfahl, R. (1992). *Robots and Manufacturing Automation*, John Wiley&Son.
3. Chang, Y. W., Zhu, K., Wu, G. M., Wong, D. F., & Wong, C. K. (1985). An Introduction to Automated. In *Process Planning, Prentice-Hall International Series in Industrial and Systems Engineering*.

Reference Books:

1. Viswanadham, N., & Narahari, Y. (2015). *Performance modeling of automated systems*. PHI Learning Pvt. Ltd.
2. Stephen J. Derby, (2004) *Design of Automatic Machinery*, Special Indian Edition, Marcel Decker, New York, Yesdee publishing Pvt. Ltd, Chennai.

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Paper Code: ARI 208	**L**	**T/P**	**Credits**
Subject: Control Systems	4	-	4

Marking Scheme

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 15 marks.
3. Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes:

CO1:	Ability of students to utilize concepts of control system components and mathematical modeling of electrical system, mechanical system, etc.
CO2:	Ability of students to identify and implement the concept of time response and frequency response of the system.
CO3:	Ability of students to utilize understanding of different plots such as Bode plot, Nyquist plot, Root locus method and Polar plot and implement them for robot applications
CO4:	Ability of students to practically implement knowledge on joint space and task space control schemes in robots.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	2	-	-	-	1	1	-	3
CO2	3	3	3	3	2	-	-	-	1	1	-	3
CO3	3	3	3	3	-	-	-	-	1	1	-	3
CO4	3	3	3	3	-	-	-	-	1	1	-	3

Unit I **[10]**

Introduction to Control System:
Elements of control systems, concept of open loop and closed loop systems, Examples and application of open loop and closed loop systems. Concept of feedback and Automatic control, Effects of feedback. Transfer function of electrical, mechanical (translational and rotational) System. Force Voltage and Force Current analogies.
Transfer function model of AC & DC servomotor, potentiometer & tacho-generator. Block diagram reduction technique and signal flow graph, Mason's rule, Signal flow graph of electrical network. Conversion of BDR to SFG and vice versa.

Unit II **[10]**

Time Domain Analysis: Time domain analysis of a standard second order closed loop system. Concept of un-damped natural frequency, damping, overshoot, rise time and settling time. Dependence of time domain performance parameters on natural frequency and damping ratio. Step and Impulse response of first and second order systems. Effects of Pole and Zeros

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on transient response. Stability by pole location. Routh-Hurwitz criteria and applications. Error Analysis: Steady state errors in control systems due to step, ramp and parabolic inputs. Concepts of system types and error constants. Root locus Techniques: Definition and properties of root locus, rules for plotting root locus, stability analysis using root locus.

Frequency Domain Analysis:

Polar plots, Bode plot, stability in frequency domain, Nyquist plots. Nyquist stability criterion. Gain margin and phase margin via Nyquist diagram and Bode plots.

Unit III **[10]**

State Variable Analysis

Introduction to state variable, General state space representation, State space representation of Electrical and Mechanical systems. Conversion between state space and transfer function. Alternative representations in state space: (Phase variable, canonical, parallel & cascade).

Similarity transformations, diagonalizing a system matrix. Laplace Transform solution of state equation, stability in state space, pole placement topology, controller design by pole placement topology in phase variable form, controllability, controllability matrix, controllability by inspection, alternative approach to controller design, controller design by transformation.

Introduction to Observer / estimator, observability, observability matrix, observability by inspection, observer design by pole placement, alternative approach to Observer design. Steady state error design using integral control.

Unit IV **[10]**

Introduction to the Compensator:

Basic concept of compensator design, requirement, cascade compensator, feedback compensator, gain compensation, lag, lead and lag-lead compensator, proportional, derivative, integral Compensation, physical realization of compensator with passive and active components, basic block diagrams of a compensated closed loop control system.

Textbooks: -

1. Nise N. (2004). *Control system engineering*.2nd edition
2. Kuo B. C. (1995) *Digital Control Systems*. Oxford series. 2nd Edition
3. Wilkie J., Johnson M., Katebi R. (2002). *Control Engineering: An Introductory Course*. Palgrave MacMillan.

Reference Books: -

1. Dorf R.C., (1998). *Modern control Engineering*.SH Bishop, & Wesley edition, Eighth Edition.
2. J. J. Azzo, Houpis C. H., Sheldon S. N., Dekkar M. (2003). *Linear Control system Analysis and design with MATLAB*. ISBN 0824740386

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Paper Code: ARI 210	**L**	**T/P**	**Credits**
Subject: Electrical Machines and Drives	3	-	3

Marking Scheme

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 15 marks.
3. Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes:

CO1:	Ability of students to utilize concepts of abstract data types.
CO2:	Ability of students to design, implement, and analyze linear data structures, such as lists, queues, and stacks, according to the needs of different applications.
CO3:	Ability of students to design, implement, and analyze efficient tree structures to meet requirements such as searching, indexing, and sorting.
CO4:	Ability of students to practically implement knowledge gained for computing graph problems and implement efficient graph algorithms to solve them.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	3	1	-	-	3	1	2	3
CO2	3	3	3	3	3	1	-	-	3	1	2	3
CO3	3	3	3	3	3	1	-	-	3	1	2	3
CO4	3	3	3	3	3	1	-	-	3	1	2	3

UNIT I **[10]**

Fractional Horsepower Motors: Single Phase Induction Motor: Double revolving field theory, equivalent circuit, no load and blocked rotor tests, starting methods, split phase Induction motor- capacitor start, two value capacitor motor. Introduction and applications of single-phase AC series motor, universal motor, AC servo motor, stepper motor, permanent magnet AC motors.

Stepper Motors: Principle of operation, characteristics and analysis of variable reluctance, permanent magnet and hybrid stepper motors, torque equation, drive circuits and switching diagrams, Open-Loop Control of Stepper Motor, Microprocessor-Based Control of Stepper Motor.

UNIT II **[10]**

Switched Reluctance Motors: Construction, principle of operation, torque production, modes of operation, drive circuits, microprocessor-based control of SRM and sensor less control.

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Permanent Magnet Machines: Construction, working principle, torque equation, equivalent circuit, performance characteristics and applications of permanent magnet brushed DC motors (PMBDC), PMBLDC Motors, permanent magnet synchronous motors, reluctance motors, synchronous reluctance motors. DC and AC tacho generators.

Special Electrical Machines: Construction, principle of operation, characteristics and analysis of fractional horse power universal motor, hysteresis motor. Construction, principle of operation of Linear Induction Motors and applications.

UNIT III **[10]**

Dynamics of Electric Drives: Types of loads, quadrant diagram of speed time characteristics, Basic and modified characteristics of dc and ac motors, equalization of load, steady state stability, calculation of time and energy loss, control of electric drives, modes of operation, speed control and drive classifications, closed loop control of drives, selection of motor power rating, class of duty, thermal considerations.

UNIT IV **[10]**

DC Motor Drives: DC motor speed control, Methods of armature control, field weakening, semiconductor-controlled drives, starting, braking, transient analysis, controlled rectifier fed dc drives, chopper-controlled dc drives.

Induction Motor Drives: Three phase induction motor starting, braking, transient analysis, speed control from stator and rotor sides, stator voltage control, variable frequency control from voltage sources and current sources, static rotor resistance control, slip power recovery, static Scherbius and static Kramer drive.

Textbooks:

1. Nagrath I. J., Kothari D. P. (2011). *Electric Machines*. McGraw-Hill Education. 3rd edition.
2. A Fitzgerald A., Kingsley C., Umans S. (2002). *Electric Machinery*. Tata McGraw Hill Education, 6th edition.
3. Venkatratnam K. (2014). *Special Electrical Machines*. Universities Press 2014

References Books:

1. Mohan N. (2012). *Electrical Machines and Drives*. Wiley India Publication
2. Sen P. C. (2002). *Principles of Electrical Machines and Power Electronics*. John Wiley.
3. E.G. Janardanan E. G. (2014). *Special Electrical Machines*. PHI, 2014.

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Paper Code: ABS 212	**L**	**T/P**	**Credits**
Subject: Convex Optimization	3	-	3

Marking Scheme

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 15 marks.
3. Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes:

CO1:	Ability of students to translate the problem given in descriptive form into a mathematical model.
CO2:	Ability of students to examine and evaluate various optimization problems according to their characteristics.
CO3:	Ability of students to adopt scientific approach for analyzing problems and making decisions.
CO4:	Ability of students to practically implement knowledge gained from various optimization methods for solving linear and nonlinear mathematical models.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	2	-	-	-	-	-	-	3
CO2	3	3	3	3	2	-	-	-	-	-	-	3
CO3	3	3	3	3	2	-	-	-	-	-	-	3
CO4	3	3	3	3	2	-	-	-	-	-	-	3

Unit I **[10]**

Linear programming: Fundamental theorem of linear programming, Simplex methods, Method of artificial variables, Degeneracy and Cycling, Simplex tableau in the condensed form, Duality, Complementary slackness conditions, Dual simplex method.

Unit II **[10]**

Transportation and assignment problems: Transportation problem, Balanced transportation problem, Unbalanced transportation problem, Assignment problem, Hungarian method for assignment problem, Dual interpretation of Hungarian method.

Unit III **[10]**

Optimality conditions and duality in non-linear programming : Convex functions and their properties, convex optimization problems, feasible directions and linearizing cone, Basic constraint qualification, Lagrangian and Lagrange multipliers, Karush-Kuhn-Tucker necessary/sufficient conditions, Duality in nonlinear programming.

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Unit IV [10]

Un-constraints optimization problems: Basic scheme and certain desirable properties, line search method for unimodal functions, the Steepest decent method, Newton's method, modified Newton's method, Conjugate gradient method.

Text Books

1. Chandra, S., & Jayadeva, M. A. (2009). *Numerical Optimization with Applications*, Alpha Science International.
2. Bertsekas, D. P. (1997). *Nonlinear programming. Journal of the Operational Research Society*, *48*(3), 334-334.
3. Chvátal, V. (1983). *Linear Programming WH Freeman and Company. New York*, 13-26.
4. Chong, E. K., & Zak, S. H. (2004). *An introduction to optimization*. John Wiley & Sons.

Reference Books

1. Fletcher, R. (2013). *Practical methods of optimization*. John Wiley & Sons.
2. D. Luenberger, *Linear and nonlinear programming*, 2nd Edition, 1984, Kluwer Academic Publisher, New York
3. Mangasarian, O. L. (1994). *Nonlinear programming*. Society for Industrial and Applied Mathematics.
4. Nocedal, J., & Wright, S. J. (Eds.). (1999). *Numerical optimization*. New York, NY: Springer New York.
5. Ruszczynski, A. (2011). *Nonlinear optimization*. Princeton university press.
6. Sundaram, R. K. (1996). *A first course in optimization theory*. Cambridge university press.

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