RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA, BHOPAL

New Scheme Based On AICTE Flexible Curricula

Robotics and Artificial Intelligence, VI Semester

RA 601: Embedded Systems Design

Course Objectives:

The students should be made to:

- Learn the architecture and programming of ARM processor.
- Be familiar with the embedded computing platform design and analysis.
- Be exposed to the basic concepts of real time Operating system.
- Learn the system design techniques and networks for embedded systems
- Learn about some real time operating systems

UNIT I

Definition of embedded system, Role of Embedded Systems in Robotics, embedded systems vs. general computing systems, history of embedded systems, classification, purpose of embedded systems, characteristics and quality attributes of embedded systems, common design metrics, and processor technology: general purpose processor, application specific processor, single purpose processor.

UNIT II

INTRODUCTION TO EMBEDDED COMPUTING AND ARM PROCESSORS Complex systems and micro processors– Embedded system design process –Design example: Model train controller- Instruction sets preliminaries - ARM Processor – CPU: programming input and output- supervisor mode, exceptions and traps – Co-processors- Memory system mechanisms – CPUperformance- CPU power consumption.

UNIT III

RTOS BASED EMBEDDED SYSTEM DESIGN: Operating System Basics, Types of Operating Systems, Tasks, Process and Threads, Multi processing and Multi tasking, Task Scheduling, Implementing Multi-threaded Applications in Robotics.

UNIT IV

EMBEDDED SOFTWARE DEVELOPMENT TOOLS: Host and Target Machines, Linkers/Locators for Embedded Software, Getting Embedded Software into the Target System. Debugging Techniques. Case Studies: Design of Embedded Systems using Microcontrollers – for applications in the area of communication and automotive.Serial Communication: UART, I2C, SPI, CAN Protocol for Robotics Applications

UNIT V

SYSTEM DESIGN TECHNIQUES AND NETWORKS: Design methodologies- Design flows - Requirement Analysis – Specifications-System analysis and architecture design – Quality Assurance techniques- Distributed embedded systems – MPSoCs and shared memory multiprocessors. Participatory Sensing, Industrial IOT and Automotive IOT, Actuator, Sensor data Communication Protocols.

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TEXT BOOKS:

1. Introduction to Embedded Systems - Shibu K.V, Mc Graw Hill.
2. Marilyn Wolf, “Computers as Components - Principles of Embedded Computing System Design”, Third Edition “Morgan Kaufmann Publisher (An imprint from Elsevier), 2012.

REFERENCE BOOKS:

1. Embedded Systems - Raj Kamal, TMH.
2. Embedded System Design - Frank Vahid, Tony Givargis, John Wiley.
3. Embedded Systems – Lyla, Pearson, 2013.
4. An Embedded Software Primer - David E. Simon, Pearson Education.
5. Embedded Microcomputer Systems Real Time Interfacing-Jonathan W.Valvano,Third Edition Cengage Learning, 2012
6. An Introduction to Real-Time Systems- From Design to Networking with C/C++ - Raymond J.A. Buhr, Donald L.Bailey.
7. Embedded Real-Time Systems: Concepts, Design & Programming- Sriram V Iyer, Pankaj GuptaTata Mc Graw Hill, 2004.

Suggested List of Experiments:

1. Study of ARM evaluation system.
2. Interfacing ADC and DAC.
3. Interfacing LED and PWM.
4. Interfacing real time clock and serial port.
5. Interfacing keyboard and LCD.
6. Interfacing EPROM and interrupt.
7. Mailbox.
8. Interrupt performance characteristics of ARM and FPGA.
9. Flashing of LEDS.
10. Interfacing stepper motor and temperature sensor.
11. Implementing ZigBee protocol with ARM.

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New Scheme Based On AICTE Flexible Curricula

Robotics and Artificial Intelligence, VI Semester

RA 602: Deep Learning

COURSE OBJECTIVES:

Introduce deep learning fundamentals and major algorithms, the problem settings, and their applications to solve real world problems.

COURSE OUTCOMES: After completing the course student should be able to:

1. Describe in-depth about theories, fundamentals, and techniques in Deep learning.
2. Identify the on-going research in computer vision and multimedia field.
3. Evaluate various deep networks using performance parameters.
4. Design and validate deep neural network as per requirements.

Syllabus

Unit-I

Introduction History of Deep Learning, McCulloch Pitts Neuron, Multilayer Perceptions (MLPs), Representation Power of MLPs, Feed Forward Neural Networks, Representation Learning, GPU implementation, Decomposition – PCA and SVD,data visualization,data preprocessing, data augmentation, normalizing data sets.

Unit -II

Linearity vs non linearity, activation functions like sigmoid, ReLU, etc., weights and bias, loss function, gradient descent, multilayer network, backpropagation, weight initialization, training, testing, unstable gradient problem, auto encoders, batch normalization, dropout, L1 and L2 regularization, momentum, tuning hyper parameters.

Unit III

Convolutional neural network, flattening, subsampling, padding, stride, convolution layer, pooling layer, loss layer, dance layer 1x1 convolution, inception network, input channels, transfer learning, one shot learning, dimension reductions, implementation of CNN like tensor flow, keras etc.Regularization: Dropout, drop Connect, unit pruning, stochastic pooling, artificial data, injecting noise in input, early stopping, Limit Number of parameters, Weight decay etc

Unit IV

Recurrent neural network, Long short-term memory, gated recurrent unit, translation, beam search and width, Bleu score, attention model, Solving the vanishing gradient problem with LSTMs, Encoding and decoding in RNN network,Reinforcement Learning, RL-framework, MDP, Bellman equations, Value Iteration and Policy Iteration, Actor-critic model, Q-learning, SARS

Unit V

Introduction to Deep Generative Models, Generative Adversarial Networks (GANs), Applications of Deep Learning in Object detection, speech/ image recognition, video analysis, NLP, medical science etc.

TEXT BOOKS:

1. Ian Goodfellow, YoshuaBengio and Aaron Courville; Deep Learning, MIT Press.
2. Charu C. Aggarwal "Neural Networks and Deep Learning: A Textbook", Springer.
3. Francois Chollet, "Deep Learning with Python", Manning Publications.

REFERENCE BOOKS:

1. Aurelien Geon, “Hands-On Machine Learning with Scikit-Learn and Tensorflow: Concepts, Tools, and Techniques to Build Intelligent Systems”, O'Reilly.
2. Andreas Muller, "Introduction to Machine Learning with Python: A Guide for Data Scientists", O'Reilly.
3. Adam Gibson, Josh Patterson, "Deep Learning: A Practitioner's Approach", O'Reilly.

SUGGESTED PRACTICALS:

Different problems to be framed to enable students to understand the concept learnt and get hands-on on various tools and software related to the subject. Such assignments are to be framed for ten to twelve lab sessions.

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New Scheme Based On AICTE Flexible Curricula

Robotics and Artificial Intelligence, VI Semester

RA 603 (A) Data Analytics

Unit-I

Data Definitions and Analysis Techniques: Elements, Variables, and Data categorization Levels of Measurement Data management and indexing Introduction to Statistical Concepts: Sampling Distributions, Resampling, Statistical Inference and Descriptive Statistics, Measures of central tendency, Measures of location of dispersions

Unit- II

Advance Data analysis techniques: Statistical hypothesis generation and testing, Chi-Square test, t-Test, Analysis of variance, Correlation analysis, Maximum likelihood test, Regression Modelling, Multivariate Analysis, Bayesian Modelling, Inference and Bayesian Network, Regression analysis.

Unit-III

Data Analytics Steps: Data Pre-Processing, Data Cleaning, Data Transformation, and Data Visualization.

Data Pre-Processing: Understanding the Data, Dealing with Missing Values, Data Formatting, Data Normalization, Data Binning, Importing and Exporting Data in Python, turning categorical variables into quantitative variables in Python.

Unit- IV

Introduction to Hive Architecture, Hive Data types, Hive Query Language, Introduction to Hadoop, Core Hadoop components, Hadoop Eco system, HivePhysical Architecture, Hadoop limitations, Introduction to Pig, Pig on Hadoop, ETL Processing, Execution model of Pig, Operators, functions, Data types of Pig, RDBMS Versus Hadoop, Hadoop Distributed Filesystem, Processing Data with Hadoop, Managing Resources and Application with HadoopYARN, MapReduce programming

Unit -V

Python visualization libraries (matplotlib, pandas, seaborn, ggplot, plotly), Introduction to PowerBI tools, Examples of inspiring (industry) projects- Exercise: create your own visualization of a complex dataset.

Suggested Text books:

(i) Anil Maheshwari, “Data Analytics made accessible,” Amazon Digital Publication, 2014.

(ii) James R. Evans, “Business Analytics: Methods, Models, and Decisions”, Pearson 2012.

(iii) Song, Peter X. K, “Correlated Data Analysis: Modeling, Analytics, and Applications”, Springer-Verlag New York 2007.

Suggested Reference Books:

(i) Glenn J. Myatt, Wayne P. Johnson, “Making Sense of Data I: A Practical Guide to Exploratory Data Analysis and Data Mining”, Wiley 2009.

(ii) Thomas H. Davenport, Jeanne G. Harris and Robert Morison, “Analytics at Work: Smarter Decisions, Better Results”, Harvard Business Press, 2010.

(iii) Rachel Schutt, Cathy O’Neil, “Doing Data Science”, O’REILLY, 2006. Shamanth Kumar Fred Morstatter Huan Liu “Twitter Data Analytics”, Springer-Verlag, 2014.

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New Scheme Based On AICTE Flexible Curricula

Robotics and Artificial Intelligence, VI Semester

RA 603 (B) Mobile and Micro-Robotics

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

- Identify and design a suitable manufacturing process for micro robots.
- Understand the importance of visual perception and recognition for cybernetic view.
- Program a robot for wandering and teleoperation.

Unit-I

Introduction to Mobile Robots - Tasks of mobile robots, robots manufacturers, type of obstacles and challenges, tele-robotics, philosophy of robotics, service robotics, types of environment representation. Ground Robots: Wheeled and Legged Robots, Aerial Robots, Underwater Robots and Surface Robots.

Unit-II

Kinematics and Dynamics of Wheeled Mobile Robots (two, three, four - wheeled robots, omnidirectional and macanum wheeled robots). Sensors for localization: magnetic and optic position sensor, gyroscope, accelerometer, magnetic compass, inclinometer, GNSS and Sensors for navigation: tactile and proximity sensors, ultrasound rangefinder, laser scanner, infrared rangefinder, visual system.

Unit-III

Localization and Mapping in mobile robotics. Motion Control of Mobile Robots (Model and Motion based Controllers): Lyapunov-based Motion Control Designs and Case Studies. Understand the current application and limitations of Mobile Robots. Introduction to Mobile Manipulators and Cooperative Mobile Robots.

Unit-IV

Micro-robotics: Introduction, Task specific definition of micro-robots - Size and Fabrication Technology based definition of micro-robots - Mobility and Functional-based definition of microrobots - Applications for MEMS based micro-robots. Implementation of Micro-robots: Arrayed actuator principles for micro-robotic applications – Micro-robotic actuators.

Unit-V

Design of locomotive micro-robot devices based on arrayed actuators. Micro-robotics devices: Micro- grippers and other micro-tools - Micro-conveyors - Walking MEMS Micro-robots – Multirobot system: Micro-robot powering, Micro-robot communication. Microfabrication and Microassembly: Micro-fabrication principles - Design selection criteria for micromachining - Packaging and Integration aspects – Micro-assembly platforms and manipulators.

Suggested Reference Books:

(i) Roland Siegwart, Illah Reza Nourbakhsh, Davide Sacramuzza, Introduction to Autonomous Mobile Robots, MIT press, 2nd edition, 2011.

(ii) Howie Choset, Kevin Lynch Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, ―Principles of Robot Motion-Theory, Algorithms, and Implementation, MIT Press, Cambridge, 2005.

Suggested Reference Books:

(i) Atnaik, Srikanta, "Robot Cognition and Navigation: An Experiment with Mobile Robots", Springer-Verlag Berlin and Heidelberg, 2007.

(ii) Spyros G. Tzafestas, “Introduction to Mobile Robot Control”, Elsevier, 2021.

(iii) Margaret E. Jefferies and Wai-Kiang Yeap, "Robotics and Cognitive Approaches to Spatial Mapping", Springer-Verlag Berlin Heidelberg, 2008.

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New Scheme Based On AICTE Flexible Curricula

Robotics and Artificial Intelligence, VI Semester

RA 603 (C) Autonomous Robotics and Telecherics

COURSE OBJECTIVES:

- To understand computability, decidability, and complexity through problem solving.
- To analyse and design abstract model of computation & formal languages
- To understand and conduct mathematical proofs for computation and algorithms

COURSE OUTCOMES:

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

- Learn principles of working of autonomous robots.
- Demonstrating the sensing, perception, and cognition of autonomous robots.
- Understand the anatomy of autonomous robots.

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SYLLABUS:

Unit-I

Introduction to the fundamentals of mobile robotics, basic principles of locomotion, Kinematics and Mobility, Classification of mobile robots, AI for Robot Navigation.

Unit-II

Introduction to modern mobile robots: Swarm robots, cooperative and collaborative robots, mobile manipulators, Current challenges in mobile robotics.

Unit-III

Autonomous Mobile Robots – need and applications, sensing, localisation, mapping, navigation and control. The Basics of Autonomy (Motion, Vision and PID),

Unit-IV

Programming Complex Behaviors (reactive, deliberative, FSM), Robot Navigation (path planning), Robot Navigation (localization), Robot Navigation (mapping), Embedded electronics, kinematics, sensing, perception, and cognition.

Unit-V

Telecheric robots – Concepts of teleoperations, Need and applications of Telecheric robots, Humanoid Robots, Swarm Robotics, Robot Applications and Ethics.

Suggested Text Books:

(i) Nicolas Korell, “Introduction to Autonomous Robots”, MIT Press, 2016.

(ii) (ii) Roland Siegwart, Illah Reza Nourbakhsh, Davide Sacramuzza, Introduction to Autonomous Mobile Robots, MIT press, 2nd edition, 2011.

Suggested Reference Books:

(i) Designing Autonomous Mobile Robots, John M Holland, Elsevier, 2004.

(ii) Autonomous Mobile Robots,Edited by Shuzi Sam Ge, Frank L Lewis, Tylor and Francis, 2006

(iii) Peter Corke, Robotics Vision and Control, Springer 2011.

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Robotics and Artificial Intelligence, VI Semester

RA 604 (A) Theory of Computation

COURSE OUTCOMES After completion of this course, the students would be able to:
CO1.explain the basic concepts of switching and finite automata theory & languages.
CO2.relate practical problems to languages, automata, computability and complexity.
CO3.construct abstract models of computing and check their power to recognize the languages. CO4.analyse the grammar, its types, simplification and normal form.
CO5.interpret rigorously formal mathematical methods to prove properties of languages, grammars and automata.
CO6.develop an overview of how automata theory, languages and computation are applicable in engineering application

Syllabus:

Unit-I

Introduction of Automata Theory: Examples of automata machines, Finite Automata as a language acceptor and translator, Moore machines and mealy machines, composite machine, Conversion from Mealy to Moore and vice versa.

Unit-II

Types of Finite Automata: Non Deterministic Finite Automata (NDFA), Deterministic finite automata machines, conversion of NDFA to DFA, minimization of automata machines, regular expression, Arden's theorem. Meaning of union, intersection, concatenation and closure, 2 way DFA.

Unit-III

Grammars: Types of grammar, context sensitive grammar, and context free grammar, regular grammar. Derivation trees, ambiguity in grammar, simplification of context free grammar, conversion of grammar to automata machine and vice versa, Chomsky hierarchy of grammar, killing null and unit productions. Chomsky normal form and Greibach normal form.

Unit-IV

Push down Automata: example of PDA, deterministic and non-deterministic PDA, conversion of PDA into context free grammar and vice versa, CFG equivalent to PDA, Petrinet model.

Unit-V

Turing Machine: Techniques for construction. Universal Turing machine Multitape, multihead and multidimensional Turing machine, N-P complete problems. Decidability and Recursively Enumerable Languages, decidability, decidable languages, undecidable languages, Halting problem of Turing machine & the post correspondence problem.

RECOMMENDED BOOKS

- Introduction to Automata Theory Language & Computation, Hopcroft& Ullman, Narosa Publication.
- Element of the Theory Computation, Lewis &Christors, Pearson.
- Theory of Computation, Chandrasekhar & Mishra, PHI.
- Theory of Computation, Wood, Harper & Row.
- Introduction to Computing Theory, Daniel I-A Cohen, Wiley.

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Robotics and Artificial Intelligence, VI Semester

RA 604 (B) Intelligent Manufacturing

Course Outcomes: After completion of the course, the students will be able to:

- Summarize the concepts of computer integrated manufacturing systems and manufacturing communication systems.
- Identify various components of knowledge based systems.
- Demonstrate the concepts of artificial intelligence and automated process planning.
- Select the manufacturing equipment using knowledge based system for equipment selection.
- Apply various methods to solve group technology problems and demonstrate the structure for knowledge based system for group technology

Syllabus:

Unit-I:

Computer Integrated Manufacturing Systems Structure and functional areas of CIM system, - CAD, CAPP, CAM, CAQC, ASRS. Advantages of CIM.

Unit-II:

Manufacturing Communication Systems - MAP/TOP, OSI Model, Data Redundancy, Top- down and Bottom-up Approach, Volume of Information. Intelligent Manufacturing System Components, System Architecture and Data Flow, System Operation.

Unit-III:

Basic Components of Knowledge Based Systems, Knowledge Representation, Comparison of Knowledge Representation Schemes, Interference Engine, Knowledge Acquisition. Automated Process Planning - Variant Approach, Generative Approach,

Unit-IV:

Expert Systems for Process Planning, Feature Recognition, Phases of Process planning. Knowledge Based System for Equipment Selection (KBSES) - Manufacturing system design. Equipment Selection Problem, Modeling the Manufacturing Equipment Selection Problem, Problem Solving approach in KBSES, Structure of the KRSES.

Unit-V:

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

Suggested Text Books:

(i) Andrew Kusiak, “Intelligent Manufacturing Systems”, Prentice Hall, 1990.
(ii) Pat Langley, “Computational Intelligence and Intelligent Systems”, 2006.

Suggested Reference Books:

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

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Robotics and Artificial Intelligence, VI Semester

RA 604 (C) Cognitive Robotics

Course Objectives:

1. To understand the main types of cognitive (vision, motor control, language, social skills) robots and their driving requirements (engineering operations, navigation, cooperation)
2. To understand advanced methods for creating highly capable cognitive robots
3. To dive into the recent literature, and collectively synthesize, clearly explain and evaluate the state of the art in cognitive robotics
4. To apply one or more core reasoning methods to create a simple agent that is driven by goals or rewards

Course Outcomes:

After the completion of the course, student will be able to:

1. Understand how our psychology and neuroscience understanding of behavior and intelligence informs the design of robotics models and applications
2. Compare, select and apply different machine learning methods for intelligent behavior in robots.
3. Analyse the methods and software/hardware technologies for robotics research and applications.
4. Discuss the state of the art in cognitive and intelligent robotics models, and how this informs the design of future robot applications.

Unit-I

Introduction- Intelligent System Design and Cognition Development Thinking, Cognition, and Intelligence, Defining Intelligence - Embodiment and Its Implications, Synthetic Methodology for Intelligence. Cybernetic View of Robot Cognition and PerceptionIntroduction to the Model of Cognition, Visual Perception, Visual Recognition, Machine Learning, and Robot Cognition.

Unit II

Intelligent System Design, Cognition Development and control Properties of Complete Agents, Agent Design Principle, Developmental Robot Design, Matching brain and Body Dynamics, Artificial Neural Networks (ANN), Fuzzy Logic, Genetic Algorithms and Other Nature Inspired Methods, Optimal Control using ANN.

Unit III

Map Building Introduction, constructing a 2D World Map, Data Structure for Map Building, Explanation of the Algorithm, An Illustration of Procedure Map BuildingIntroduction, Representation of the Robot's Environment, Review of configuration spaces, Visibility Graphs, Voronoi diagrams, Potential Fields and Cell Decomposition, planning with moving obstacles, Probabilistic Roadmaps, rapidly exploring random trees, Execution of the Quad tree-Based Path Planner Program.

Unit IV

Problem Definition, Mathematical Basis, Examples: SLAM in Landmark Worlds, Taxonomy of the SLAM Problem, Extended Kalman filter, Graph-Based Optimization Techniques, ParticleMethods Relation of Paradigms.

Unit V

Robot Programming methods Python Robot Programming Methods-:Go-to-Goal Behavior, Avoid-Obstacles Behavior, Hybrid Automata (Behavior State Machine),Follow-Wall Behavior. A Complete Program for autonomous mobile robot, Contemporary issues.

Text Book(s)

Patnaik, Srikanta, "Robot Cognition and Navigation - An Experiment with Mobile Robots", Springer Verlag Berlin and Heidelberg, 2007

Howie Choset, Kevin Lynch Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, “Principles of Robot Motion-Theory, Algorithms, and Implementation”, MIT Press, Cambridge, 2005.
David Vernon, “Artificial Cognitive Systems: A Primer” ,The MIT Press, 1st Edition,2014.

Reference Books

Hooman Somani, “Cognitive Robotics”, CRC Press, 2015
Jared Kroff, “Cognitive Robotics: Intelligent Robotic Systems”, Wilford Press, 2016
https://www.toptal.com/robotics/programming-a-robot-an-introductory-tutorial

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Robotics and Artificial Intelligence, VI Semester

RA 605: Data Analytics Lab

Course Outcomes: After completion of the course students should be able to

1. Understand the basic of data analytics using concepts of statistics and probability.
2. Understand the needs of data processing techniques.
3. Implement the data analytics techniques using R, MATLAB and Python.
4. Apply the data analytics techniques in real life applications.

Unit-I Basics of data analytic framework, data per-processing, Statistics, probability, Probability Distribution, Bayes' Theorem, Central Limit theorem, Data Exploration & preparation, Concepts of Correlation, Regression, Covariance, Outliers, Data visualization.

Unit-II: Introduction to R as a data analytics tool.

Unit -III : Introduction to MATLAB as a data analytics tool.

Unit -IV : Introduction to python as a data analytics tool.

Unit – V: Case studies.

List of experiments should cover above all the five units.

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New Scheme Based On AICTE Flexible Curricula

Robotics and Artificial Intelligence, VI Semester

RA 606: Theory of Computation Lab

COURSE OUTCOMES:

After completion of this lab course, the students would be able to:

CO1: judge various computational models.

CO2: construct abstract models of computing.

CO3: justify the power of abstract models in computing to recognize the languages.

CO4: demonstrate analytical thinking and intuition for problem solving in the related areas.

CO5: discuss the limitations of computation in problemsolving.

CO6: follow set of rules for syntax verification.

LIST OF EXPERIMENTS

1. Design a Program for creating machine that accepts three consecutive one.
2. Design a Program for creating machine that accepts the string always ending with 101.
3. Design a Program for Mode 3 Machine
4. Design a program for accepting decimal number divisible by 2.
5. Design a program for creating a machine which accepts string having equal no. of 1's and 0's.
6. Design a program for creating a machine which count number of 1's and 0's in a given string.
7. Design a Program to find 2's complement of a given binary number.
8. Design a Program which will increment the given binary number by 1.
9. Design a Program to convert NDFA to DFA.
10. Design a Program to create PDA machine that accept the well-formed parenthesis.
11. Design a PDA to accept WCWR where w is any string and WR is reverse of that string and C is a Special symbol.
12. Design a Turing machine that's accepts the following language a n b n c n where n>0.