VIMAL JYOTHI
ENGINEERING COLLEGE (AUTONOMOUS)

Jyothi Nagar, Chemperi - 670632, Kannur D.T, Kerala

M. Tech - 2024

Discipline: Computer Science and Engineering

SEMESTER 1

SEMESTER S1
ADVANCED MACHINE LEARNING
DISCIPLINE CORE 1

Course Code	**241TCS100**	**CIE Marks**	40
Teaching Hours/Week (L: T:P)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Basic knowledge in Machine learning	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Parameter Estimation and Regression:** Overview of machine learning: supervised, semi-supervised, unsupervised learning, reinforcement learning. Basics of parameter estimation: Maximum Likelihood Estimation (MLE), Maximum a Posteriori Estimation (MAP). Gradient Descent Algorithm, Batch Gradient Descent, Stochastic Gradient Descent. Regression algorithms: least squares linear regression, normal equations and closed form solution, Polynomial regression.	**8**
2	**Regularization techniques and Classification algorithms:** Overfitting, Regularization techniques - LASSO and RIDGE. Classification algorithms: linear and non-linear algorithms, Perceptrons, Logistic regression, Naive Bayes, Decision trees. Neural networks : Concept of Artificial neuron, Feed-Forward Neural Network, Back propagation algorithm.	**9**

3	**Unsupervised learning:** Unsupervised learning: clustering, k-means, Hierarchical clustering, Principal component analysis, Density-based spatial clustering of applications with noise (DBSCAN). Gaussian mixture models: Expectation Maximization (EM) algorithm for Gaussian mixture model.	**8**
4	**Support Vector Machine and Graphical Models:** Support vector machines and kernels: Max margin classification, Nonlinear SVM and the kernel trick, nonlinear decision boundaries, Kernel functions. Basics of graphical models - Bayesian networks, Hidden Markov model - Inference and estimation.	**7**
5	**Evaluation Metrics and Sampling Methods:** Classification Performance Evaluation Metrics: Accuracy, Precision, Precision, Recall, Specificity, False Positive Rate (FPR), F1 Score, Receiver Operator Characteristic (ROC) Curve, AUC. Regression Performance Evaluation Metrics: Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), R Squared/Coefficient of Determination. Clustering Performance Evaluation Metrics: Purity, Jaccard index, Normalized Mutual Information, Clustering Accuracy, Silhouette Coefficient, Dunn's Index. Boosting: AdaBoost, gradient boosting machines. Resampling methods: cross-validation, bootstrap. Ensemble methods: bagging, boosting, random forests Practical aspects in machine learning: data preprocessing, overfitting, accuracy estimation, parameter and model selection Bias-Variance tradeoff.	8

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Micro project/Course based project	Course based task/Seminar/Quiz	Internal Examination-1 (Written)	Total
20	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any five question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Analyze the Machine Learning concepts, classifications of Machine Learning algorithms and basic parameter estimation methods.	**K4**
CO2	Illustrate the concepts of regression and classification techniques	**K3**
CO3	Describe unsupervised learning concepts and dimensionality reduction techniques.	**K3**
CO4	Explain Support Vector Machine concepts and graphical models.	**K3**
CO5	Choose suitable model parameters for different machine learning techniques and to evaluate a model performance.	**K3**
CO6	Design, implement and analyze machine learning solutions for a real-world problem.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Neural Networks for Pattern Recognition	Christopher Bishop	Oxford University Press	1995
2	Machine Learning: A Probabilistic Perspective	Kevin P. Murphy	MIT Press	2012
3	The Elements of Statistical Learning	Trevor Hastie, Robert Tibshirani, Jerome Friedman	Springer	Second edition & 2007
4	Introduction to Machine Learning	Ethem Alpaydin	MIT Press	2nd edition & 2010
5	Machine Learning	Tom Mitchell	McGraw-Hill	1997

SEMESTER S1

ADVANCED DATABASE MANAGEMENT

PROGRAM CORE 1

Course Code	**241TCS001**	**CIE Marks**	40
Teaching Hours/Week (L: T:P)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Query Processing and Optimization :** Review of indexing and Hashing - Overview- Measures of query cost- Algorithms for Selection and Join with cost analysis- Evaluation of expressions- Optimization of RA expressions.	8
2	**Database Security:** Threats to databases, control measures, database security and DBA, Discretionary access control, Mandatory access control (role-based only), SQL injection.	7
3	**Database System Architectures:** Centralized and Client-Server Architectures – Centralized server systems - Server System Architectures - Parallel Systems- - Parallel storage - Data partitioning, replication and indexing in Parallel Databases- Parallel query processing.	9
4	**Distributed System Architecture:** Distributed System architecture- Distributed storage - Distributed file systems – Distributed RDB design- Transparency– Distributed Transactions - Commit Protocols – Concurrency Control - Distributed Query Processing Advanced	10

	indexing Techniques: Bloom filter - Bitmap indices - Indexing spatial data - Hash indices.	
5	**Semi-structured Data:** Semi-structured Data and XML Databases: XML Data Model – XSD – XPath and XQuery – Example Queries. Native XML databases, Object Relational Systems	**6**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Micro project/Course based project	Course based task/Seminar/Quiz	Internal Examination-1 (Written)	Total
20	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any five question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Identify various measures of query processing and optimization.	**K3**
CO2	Analyze and implement security mechanisms to secure a database system.	**K4**
CO3	Apply knowledge and awareness of the different database architectures in different scenarios.	**K3**
CO4	Analyze implementation aspects of distributed systems on database architecture.	**K4**
CO5	Make use of semi structured data, XML and XML queries for data management.	**K3**
CO6	Design, Develop, and Implement innovative ideas on advanced database concepts and techniques.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Database Systems	R. Elmasri, S.B. Navathe	Pearson Education/Addison Wesley	7/e , 2016
2	Database Systems, A Practical Approach to Design, Implementation and Management	Thomas Cannolly and Carolyn Begg	Pearson Education	3/e, 2010
3	Database System Concepts	Henry F Korth, Abraham Silberschatz, S. Sudharshan,	Tata McGraw Hill	7/e,2019
4	Beginning XML	Joe Fawcett, Danny Ayers, Liam R. E. Quin	John Wiley & Sons	5/e, 2012
5	A Semantic Web Primer	Grigoris Antoniou,Frank van Harmelen	The MIT Press,Cambridge, Massachusetts	2003

SEMESTER S1
FOUNDATIONS OF COMPUTER SCIENCE
PROGRAM CORE 2

Course Code	**241TCS002**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Theorem Proving Techniques:** Theorem proving techniques: Direct Proof, Indirect proof - Proof by Contrapositive, Proof by contradiction and Proof by exhausting cases, Principle of mathematical induction, Complete induction and Well-ordering principle. The Pigeonhole principle.	8
2	**Fundamentals of Counting:** The Basics of counting, Addition and multiplication principles, Permutations and Combinations. Countable and uncountable sets, Principle of inclusion and exclusion – applications, derangements.	7
3	**Generating Functions:** Recurrence Relations, Modeling problems with recurrence relations. Generating functions, Solving counting problems using Generating functions, Solving recurrence relations using Generating functions.	7
4	**Probability Theory:** Probability theory – Properties of Probability, Conditional Probability, Independent Events, Bayes Theorem, Mathematical Expectation and Variance of Random variables. Discrete Distributions and its mean and variance- Binomial Distribution,	10

	Bernoulli Distribution , Geometric Distribution, Poisson Distribution. Continuous Distributions and its mean and variance- Uniform and Exponential Distributions, Normal Distribution**.**	
5	**Classic Problems in Probability and Algebraic Structures:** Classic Problems in Probability- Birthday Paradox, The Hat Problem, Coupon Collector Problem. Groups and subgroups, generators for a group, Homomorphism theorems, cosets and normal subgroups, Lagrange's theorem.	**8**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Micro project/Course based project	Course based task/Seminar/Quiz	Internal Examination-1 (Written)	Total
20	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any five question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Apply Direct proof technique, Indirect proof technique and Mathematical Induction to prove various theorems and results.	**K3**
CO2	Solve counting problems using Pigeon hole principle, Principle of Inclusion exclusion, Permutations, Combinations, Cantor's Diagonalization argument and Derangements.	**K3**
CO3	Solve Recurrence relations and counting problems using Generating Functions.	**K3**
CO4	Solve problems on probability using the fundamentals of Probability, Bayes theorem, and Probability Distributions.	**K3**
CO5	Solve problems using concepts in algebraic structures such as Groups, Cosets and Lagrange's Theorem.	**K3**
CO6	Design solutions for various computational problems using the mathematical concepts of computer science and prove the correctness of the solution developed.	**K5**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluation*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Discrete Mathematics and its Applications	Kenneth H. Rosen	McGraw Hill Inc	7/e, 2011
2	Discrete Mathematical Structures with Application to Computer Science	J. P. Tremblay, R. Manohar	Tata McGrawHill	2010
3	Introduction to Probability Models	Sheldon M. Ross	-	-
4	A First Course in Probability	Sheldon M. Ross	-	-
5	An introduction to probability theory and its applications	William Feller	Wiley	1957
6	Randomized Algorithms	Rajeev Motwani and Prabhakar Raghavan	Cambridge University Press	1995

SEMESTER S1

OBJECT ORIENTED SOFTWARE ENGINEERING

PROGRAM ELECTIVE

Course Code	**241ECS100**	**CIE Marks**	40
Teaching Hours/Week (L: T:P)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Classical Paradigm:** System Design Concepts – Project Organization Concepts : Project Organizations , Roles , Tasks and Work Products ,Schedule – Project Communication concepts : Planned Communication , Unplanned Communication ,Communication Mechanism – Project Management Concepts : Tasks and Activities ,Work Products , Work Packages and Roles , Work Breakdown Structure .	**10**
2	**Process Models:** Life cycle models: Sequential Activity Centered Models, Iterative Activity Centered models, Entity Centered models – Unified Process – Iterative and Incremental – Workflow – Agile Processes.	**8**
3	**Analysis:** Requirements Elicitation Concepts – An Overview of Unified Modeling Language –Analysis Concepts : Analysis Object Model and Analysis Dynamic Models – Non-functional requirements – Analysis Patterns – Executable specification.	**7**

4	**Design:** System Design, Architecture – Design Principles - Design Patterns – Dynamic Object Modeling Static Object Modeling – Model based approach vs Document based approach – Interface Specification – Object Constraint Language	8
5	**Implementation, Deployment And Maintenance:** Mapping Design (Models) to Code – Testing - Usability – Deployment – Configuration Management – Maintenance	7

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications	Course based task / Seminar/ Data collection and interpretation	Internal Examination-1 (Written)	Total
15	15	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any five question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course OutCome		Bloom's Knowledge Level (KL)
CO1	Make use of project organization and management concepts and analyze the various tasks carried out.	**K3**
CO2	Identify and select suitable process models for a given problem.	**K3**
CO3	Analyze the requirements of a given software project and produce requirement specifications.	**K4**
CO4	Examine the various designing principles and patterns of a software product.	**K4**
CO5	Build the mapping of product design to code, its testing and maintenance.	**K3**
CO6	Design, analyze object models and dynamic models for a given problem statement.	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluat*e

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Object-Oriented Software Engineering	Bernd Bruegge, Alan H Dutoit	Pearson Education	2nd edition, 2004
2	Applying UML and Patterns	Craig Larman	Pearson Education	3rd edition, 2005
3	Software Engineering	Stephen Schach	McGraw-Hill	7th edition,2007
4	The Unified Software Development Process	Ivar Jacobson, Grady Booch, James Rumbaugh	Pearson Education	1999
5	Agile Software Development	Alistair Cockburn	Pearson Education	2nd edition

SEMESTER S1

ADVANCED DATA MINING

PROGRAM ELECTIVE

Course Code	**241ECS001**	**CIE Marks**	40
Teaching Hours/Week (L: T:P)	3:0:0:	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Data Mining and Knowledge Discovery:** Desirable Properties of Discovered Knowledge – Knowledge representation, Data Mining Functionalities, Motivation and Importance of Data Mining, Classification of Data Mining Systems, Integration of a Data Mining System with a Database or Data Warehouse System, Classification, Clustering, Regression, Data Pre-processing: Data Cleaning, Data Integration and Transformation, normalization, standardization, Data Reduction, Feature vector representation. importance of feature engineering in machine learning; forward selection and backward selection for feature selection; curse of dimensionality; data imputation techniques; No Free Lunch theorem in the context of machine learning, Data Discretization and Concept Hierarchy Generation	6
2	**Data Warehouse and OLAP Technology for Data Mining:** Data warehouses and its Characteristics - Data warehouse Architecture and its Components, Data Warehouse Design Process, Data Warehouse and DBMS, Data marts, Metadata, Data Cube and OLAP, Extraction - Transformation – Loading - Schemas for Multidimensional Database: Stars, Snowflakes and	7

	Fact constellations, OLAP Cube - OLAP Operations - OLAP Server Architecture - Data Warehouse Implementation - From Data Warehousing to Data Mining, Trends in data warehousing.	
3	**Association Pattern Mining:** Mining Frequent Patterns, Associations and Correlations –Mining Methods – Mining Various Kinds of Association Rules – Correlation Analysis – Constraint Based Association Mining, Single Dimensional Boolean Association Rules From Transaction Databases, Multilevel Association Rules from transaction databases – Multidimensional Association Rules from Relational Database and Data Warehouses, Frequent Item Set Generation, Apriori Algorithm, Improved Apriori Algorithm for Association Rules Mining, Methods to improve Apriori, FP Growth Algorithm - Generating association rules from frequent itemset, Compact Representation of Frequent Item set - Maximal Frequent Item Set - Closed Frequent Item Sets. Pattern Evaluation Methods- Relationship Between FP-Growth and Enumeration-Tree Methods From Association Analysis to Correlation Analysis, Lift.	7
4	**Classification and Prediction:** Classification Techniques, Decision Tree - Decision tree Construction, Measures for Selecting the Best Split - Algorithm for Decision tree Induction - CART, Bayesian Belief Networks, Instance-Based Learning, K-Nearest neighbor classification, Accuracy and Error measures, Multiclass Classification, Semi-Supervised Classification, Multi class Learning, Rare class learning, Active Learning, Transfer Learning, Fuzzy Set Approaches for Classification, Rough Set Approaches, Techniques to improve classification accuracy-Ensemble methods, BiasVariance Trade-off, Improving classification accuracy of class imbalanced data.	10
	Cluster Analysis: Desired features of cluster Analysis, Types of data in cluster analysis, Categorization of Major Clustering Methods,	

5	Density-Based Methods, Clustering High Dimensional Data, Constraint Based Cluster Analysis, GA based clustering, Dealing with Large Databases, Probabilistic Model Based Clustering, Clustering with Constraints, Semi supervised clustering, Cluster Ensembles, Quality and validity of cluster analysis methods, Outlier Analysis-Statistical Approaches, Proximity Based Approaches Advanced Mining: Multimedia Data Mining - Text Mining, Graph Mining and Social Network Analytics - Geospatial Data Mining, Temporal Mining, Data Mining Applications - Social Impacts of Data Mining.	10

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications	**Course based task / Seminar/ Data collection and interpretation**	**Internal Examination-1 (Written)**	**Total**
15	**15**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any five question out of seven questions

Part A	**Part B**	**Total**
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course OutCome		Bloom's Knowledge Level (KL)
CO1	Summarize basic concepts of Data mining and Illustrate feature vector representation for a given data collection.	**K2**
CO2	Design Data Warehouse for problems in various domains.	**K3**
CO3	Implement Association Rules for analyzing Transactional databases	**K3**
CO4	Implement major Classification and Clustering Algorithms to a given problem.	**K4**
CO5	To develop Data Mining system and analyze the performance	**K5**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evalua*te

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Machine Learning: A Probabilistic Perspective (MLAPP)	Kevin Murphy	MIT Press	2012
2	Pattern Recognition and Machine Learning (PRML)	Christopher Bishop	Springer	2007
3	Data Mining: Concepts and Techniques	Jiawei Han, Micheline Kamber, Jian Pei	Morgan Kaufmann	2nd Ed, 2005
4	Data Mining	Charu C. Aggarwal	Springer	2015
5	Data Mining: Introductory and Advanced Topics	Margaret H. Dunham	Prentice Hall	1st Ed,2002
6	Data Mining Techniques	Arun K Puari	Universities Press	2001

7	Pattern Classification (PC)	David G. Stork, Peter E. Hart, and Richard O. Duda	Wiley-Blackwell	2000
8	The Elements of Statistical Learning (ESL)	Trevor Hastie, Robert Tibshirani, Jerome Friedman	Springer	2009
9	Introduction to Data Mining with Case Studies	G. K. Gupta	Eastern Economy Edition, Prentice Hall of India	2006
10	Mining the Web: Discovering Knowledge from Hypertext Data	Soumen Chakrabarti	Morghan Kaufmann	1st Ed, 2005
11	Intelligent Data Mining: Techniques and Applications (Studies in Computational Intelligence)	Da Ruan, Guoqing Chen, Etienne E. Kerre, Geert Wets	Springer	1st Ed,2010
12	Intelligent Agents for Data Mining and Information Retrieval	Masoud Mohammadian	Idea Group Publishing	2004
13	Data Mining: Practical Machine Learning Tools and Techniques	I. H. Witten and E. Frank	Morgan Kaufmann	20000
14	Principles of Data Mining	D. Hand, H. Mannila and P. Smyth	Prentice-Hall	2001
15	Google BigQuery: The Definitive Guide: Data Warehousing, Analytics, and Machine Learning	Valliappa Lakshmanan, Jordan Tigani	O'Reilly Media, Inc	2019

SEMESTER S1
CLOUD COMPUTING
PROGRAM ELECTIVE 1

Course Code	**2411ECS002**	**CIE Marks**	40
Teaching Hours/Week (L: T:P)	3-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Basics of Virtual Machines - Process Virtual Machines – System Virtual Machines – Emulation – Interpretation – Binary Translation - Taxonomy of Virtual Machines. Virtualization –Management — Hardware Maximization – Architectures – Virtualization Management – Storage Virtualization – Network Virtualization	**8**
2	Comprehensive Analysis – Resource Pool – Testing Environment –Server Virtualization – Virtual Workloads – Provision -Virtual Machines – Desktop Virtualization – Application Virtualization - Implementation levels of virtualization – virtualization structure – virtualization of CPU-Memory and I/O devices – virtual clusters and Resource Management – Virtualization for data centre automation.	**8**
3	Understanding cloud computing - Cloud Computing – History of Cloud Computing-Advantages and Disadvantages of Cloud Computing- Cloud deployment models-public-private- hybrid-Categories of cloud computing-Everything as a service-Infrastructure-platform-software- A Generic Cloud Architecture Design – Layered cloud Architectural Development – Virtualization Support and Disaster Recovery – Architectural Design Challenges - Public Cloud Platforms –GAE-AWS –	**9**

	Inter-cloud Resource Management	
4	Introduction to Hadoop Framework – Map Reduce-Input splitting-map and reduce functions-specifying input and output parameters-configuring and running a job –Developing Map Reduce Applications - Design of Hadoop file system –Setting up Hadoop Cluster - Cloud Software Environments –Eucalyptus-Opennebula-Openstack-Nimbus	**8**
5	Cloud Infrastructure security- network, host and application level – aspects of data security-provider data and its security-Identity and access management architecture-IAM practices in the cloud-SaaS-PaaS-IaaS availability in the cloud - Key privacy issues in the cloud –Cloud Security and Trust Management	**7**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	**Course based task/Seminar/Data collection and interpretation**	**Test Paper - I**	**Total**
15	**15**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any five question out of seven questions

Part A	**Part B**	**Total**
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Employ the concepts of storage virtualization, network virtualization and its management.	**K3**
CO2	Apply the concept of virtualization in the cloud computing.	**K3**
CO3	Apply domain knowledge in architecture, infrastructure and delivery models of cloud computing in designing and developing cloud applications.	**K3**
CO4	Develop services using Cloud computing.	**K3**
CO5	Analyse and choose security models appropriate to the cloud environment.	**K4**
CO6	Design, develop and implement cloud based applications.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Cloud and Virtual Data Storage Networking	Greg Schulz	Auerbach Publications	2011
2	Cloud Computing: Web-Based Applications That Change the Way You Work and Collaborate Online	Michael Miller	Que Publishing	August 2008
3	Enterprise Cloud Computing: Technology, Architecture, Applications	GauthamShroff	Cambridge press	2010
4	Information Storage and Management	EMC	Wiley	2nd edition, 2012
5	Distributed and Cloud Computing – From Parallel Processing to the Internet of Things	Kai Hwang, Geoffrey C. Fox, Jack J. Dongarra	Morgan Kaufmann Publishers	2012

SEMESTER S1
WEB SERVICES
PROGRAM ELECTIVE

Course Code	2411ECS003	CIE Marks	40
Teaching Hours/Week (L: T:P)	3-0-0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Web Services:** Web Services Standards Organizations, Service oriented architecture, Advantages of web services over distributed object architecture, SOAP-based web services, RESTful web services. Review of HTTP requests and responses- HTTP as an API, A RESTful example, Use of Servlets for RESTful Web Services.	8
2	**RESTful Web Services: The Service Side** A RESTful service as an HttpServlet, Implementation details. A RESTful Web Service as a JAX-RS Resource- JAX-RS Web Service Using Jersey, Publishing JAX-RS Resources with a Java Application, Publishing JAX-RS Resources with Tomcat, JAX-RS Generation of XML and JSON Responses, Porting the Predictions Web Service to JAX-RS. A RESTful Web Service as Restlet Resources. GraphQL- Introduction to GraphQL, GraphQL Architecture, Basic Queries.	8
3	**RESTful Web Services: The Client Side** A Perl Client Against a Java RESTful Web Service RESTful Clients and WADL Documents- The JAX-RS Client API, JSON for JavaScript Clients- JSONP and Web Services.	8

4	**SOAP-Based Web Services** Introduction and Evolution of SOAP, Architecture of a typical SOAP-based service, Publishing a SOAP-Based Service with a Standalone Web Server RandService- JavaClient Against the RandService, C# Client Against the RandService, A Perl Client Against the RandService. WSDL – WSDL document structure.	**8**
5	**Introduction to React.js, Node.js and Angular.js** Introduction to React and Node-Basic Concepts and Applications, Rendering Elements and Components, Comparison and Purpose of Node.js and React.js, Angular JS Basics-Modules, Creating Components, Directives, Filters, Angular Forms-Services, Single page application and Multipage application, Use case of a real-time single page chat application.	**8**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	Course based task/Seminar/Data collection and interpretation	Test Paper - I	Total
15	**15**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any five question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Illustrate the need of web services in developing applications.	**K2**
CO2	Make use of Server-side and Client-side RESTful web services.	**K4**
CO3	Analyze how web services can be published in standalone web servers.	**K4**
CO4	Employ techniques on creating dynamic web pages.	**K3**
CO5	Utilize emerging technologies in web services.	**K3**
CO6	Design, Develop, Implement and Present innovative ideas on modern web services concepts and techniques.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Java Web Services: Up and Running	Martin Kalin	O'Reilly	2nd Edition, 2013
2	The Road to Learn React	Robin Wieruch	https://www.roadtoreact.com	2022 Edition
3	Beginning Angular JS	Andrew Grantt	Apress	2014
4	ReactJS by Example - Building Modern Web Applications with React	Vipul A M, Prathamesh Sonpatki	PACKT Publishing	2016
5	Node.js Web Development: Server-side web development made easy with Node 14 using practical examples	-	PACKT Publishing	5th Edition, 2020
6	Learning GraphQL	Alex Banks, Eve Porcello	O'Reilly Media	2018

SEMESTER S1
COMPUTATIONAL INTELLIGENCE
PROGRAM ELECTIVE

Course Code	**2411ECS004**	**CIE Marks**	40
Teaching Hours/Week (L: T:P)	3-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Fuzzy Logic** Crisp sets vs fuzzy sets- Operations and properties of Fuzzy sets. Membership functions - Linguistic variables. Operations on fuzzy sets- Fuzzy laws- Operations on fuzzy relations, Fuzzy composition- Max- min, Max – product. Alpha-cut representation.	**9**
2	**Fuzzy Systems** Fuzzy Reasoning – GMP and GMT. Fuzzy Inference System: Defuzzification methods - Fuzzy Controllers -Mamdani FIS, Larsen Model	**7**
3	**Introduction to Genetic Algorithms** Introduction to Genetic Algorithms – Theoretical foundation - GA encoding, decoding - GA operations – Elitism – GA parameters – Convergence. Multi-objective Genetic Algorithm – Pareto Ranking.	**7**
4	**Ant Colony Systems** Swarm intelligent systems - Background Ant colony systems – Biological systems- Development of the ant colony system- - Working - Pheromone updating- Types of ant systems- ACO algorithms for TSP	**8**

5	**Particle Swarm Optimization** Basic Model - Global Best PSO- Local Best PSO- Comparison of 'gbest' to 'lbest'- PSO Algorithm Parameters- Problem Formulation of PSO algorithm- Working. Rate of convergence improvements -Velocity clamping- Inertia weight- Constriction Coefficient- Boundary Conditions- Guaranteed Convergence PSO- Initialization, Stopping Criteria, Iteration Terms and Function Evaluation.	**9**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	Course based task/Seminar/Data collection and interpretation	Test Paper - I	Total
15	15	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any five question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Apply fuzzy logic to handle uncertainty and solve engineering problems.	**K3**
CO2	Apply Fuzzy Logic Inference methods in building intelligent machines.	**K3**
CO3	Design genetic algorithms for optimized solutions in engineering problems.	**K4**
CO4	Analyze the problem scenarios and apply Ant colony system to solve real optimization problems.	**K4**
CO5	Apply PSO algorithm to solve real world problems.	**K3**
CO6	Design, develop and implement solutions based on computational intelligence concepts and techniques.	**K6**

Note:*K1-Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to Soft Computing Neuro-Fuzzy Genetic Algorithms	Samir Roy, Udit Chakraborty	Pearson	2013
2	Artificial Intelligence and Intelligent Systems	N.P. Padhy	Oxford Press, New Delhi	2005
3	Nature-Inspired Optimization Algorithms	Xin-She Yang	Elsevier	First edition, 2014
4	Mathematical Modelling and Applications of Particle Swarm Optimization	Satyobroto Talukder		February 2011
5	An Introduction to Genetic Algorithm	Mitchell Melanie	Prentice Hall	1998
6	Computational Intelligence: An Introduction	Andries Engelbrecht	Wiley	2007
7	Ant Colony Optimization	Marco Dorigo, Thomas Stutzle	Prentice Hall of India, New Delhi	2005

SEMESTER S1
AUTOMATED VERIFICATION
PROGRAM ELECTIVE

Course Code	**241ECS005**	**CIE Marks**	40
Teaching Hours/Week (L: T:P)	3-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction and Basic Concepts** Two approaches to Formal Reasoning, Basic Definitions, Normal forms and their properties, The theoretical point of view, Expressiveness vs. Decidability, Boolean structure in Decision Problems.	**6**
2	**Decision Procedures for Propositional Logic** Propositional Logic, SAT Solvers, Binary Decision Diagrams	**8**
3	**Equality Logic and Uninterpreted Functions** Introduction, Uninterpreted Functions, From Uninterpreted Functions to Equality Logic, Functional Consistency is not enough, Two examples of the use of Uninterpreted Functions.	**7**
4	**Decision Procedures for Equality Logic and Uninterpreted Functions** Congruence Closure, Basic Concepts, Simplification of the formula, A Graph-Based Reduction to Propositional Logic, Equalities and Small Domain Instantiations, Ackermann's vs. Bryant's Reduction.	**8**

5	**Linear Arithmetic** Introduction, The Simplex Algorithm, The Branch and Bound Method, Fourier-Motzkin Variable Elimination, The Omega Test, Preprocessing, Difference Logic.	11

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	Course based task/Seminar/Data collection and interpretation	Test Paper - I	Total
15	15	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any five question out of seven questions

Part A	Part B	Total
● 8 numerical questions with minimum 1 question from each module ● Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	● Contain 7 questions. ● Minimum one question from each module of which student should answer any four. ● Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Use the model-theoretic and proof-theoretic approaches towards formal reasoning.	**K3**
CO2	Demonstrate how decision procedures can be developed for propositional logic using SAT solvers and Binary Decision Diagrams.	**K3**
CO3	Develop methods to prove the validity and satisfiability of formulas using Equality Logic and Uninterpreted Functions.	**K3**
CO4	Illustrate decision procedures using linear arithmetic	**K4**
CO5	Design, develop and implement solutions based on the concepts of automated verification.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Decision Procedures – An Algorithmic Point of View	Daniel Kroening, Ofer Strichman	Springer	2008
2	Principles of Model Checking	Christel Baier, Joost-Pieter Katoen	The MIT Press	2005
3	Logic in Computer Science – Modelling and Reasoning about Systems	Michael Huth, Mark Ryan	Cambridge University Press	First edition, 2014

SEMESTER S1
ADVANCED COMPUTER NETWORKS
PROGRAM ELECTIVE

Course Code	**241ECS006**	**CIE Marks**	40
Teaching Hours/Week (L: T:P)	3-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Elective

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Advanced Internetworking** The Global Internet, Routing Areas, Interdomain Routing -BGP, IP Version 6, Multicast, Multicast Addresses, Multicast Routing -DVMRP-PIM-MSDP, Routing to a mobile node, Mobile IP, TCP and Mobility, Mobile TCP	**8**
2	**Internetwork Quality of Service** QoS Architectural Framework - Integrated Services Architecture – RSVP - Differentiated Services, Multiprotocol Label Switching-Destination-Based Forwarding - Explicit Routing Virtual Private Networks and Tunnels, Performance issues in networks, Delay Tolerant Networking	**8**
3	**Networking Technologies** Wired: DSL, Cable Networks, SONET, ATM, VLAN, Wireless: Satellite Networks, WiMAX.Cellular Networks: Introduction-Wireless links and Network characteristics -CDMA, Cellular Internet access -An overview of cellular network architecture, 3G cellular data networks, 4G LTE Cellular networks - LTE Protocol Stacks -LTE Radio Access Network -Additional LTE functions, 5G Cellular networks, Managing mobility in cellular networks, Wireless and Mobility-Impact on higher level protocols, Personal Area Networks: Bluetooth, Zigbee	**9**

4	**Networking Applications** Multimedia in the Internet: Streaming stored audio/video, Streaming live audio/video, Real time interactive audio/video, Real time Interactive Protocols: RTP- RTCP-SIP-H.323, SCTP Compression: Audio Compression, Image compression- JPEG, Video Compression- MPEG	7
5	**Current Topics in Networking** Overlay Networks: Routing overlays -Resilient overlay networks, Peer-Peer Networks – Bit Torrent- Distributed Hash Tables, Content Distribution networks, Software Defined Networks: Architecture – Control and Data Planes – Open Flow – SDN Controllers, Network Function Virtualization, Data Center Networking	8

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	Course based task/Seminar/Data collection and interpretation	Test Paper - I	Total
15	15	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any five question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Examine the problem of scalability for routing and also identify the challenges in mobile and multicast routing.	**K4**
CO2	Choose the technique that provides the Quality-of-Service needs of a particular application.	**K3**
CO3	Survey various wired and wireless networking technologies including wireless cellular technologies.	**K4**
CO4	Classify the multimedia applications in the Internet and compile the various protocols handling these applications.	**K4**
CO5	Describe examples of current networking trends and identify the technological gaps.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Computer Networks - A Systems Approach	Larry Peterson, Bruce Davie	Morgan Kaufmann	6th edition, 2022
2	Computer Networking: A Top-Down Approach	James F. Kurose, Keith W. Ross	Pearson	8th edition, 2022
3	Mobile Communications	Jochen Schiller	Addison-Wesley	2nd edition, 2003
4	Data and Computer Communications	William Stallings	Pearson	5th edition, 2017
5	Computer Networks	Andrew Tanenbaum, David Wetherall	Pearson	5th edition, 2010
6	Data Communications and Networking	Behrouz A. Forouzan	McGraw Hill	5th edition, 2017
7	SDN – Software Defined Networks	Thomas D. Nadeau, Ken Gray	O'Reilly	2013

SEMESTER S1
PATTERN RECOGNITION
PROGRAM ELECTIVE

Course Code	**241ECS007**	**CIE Marks**	40
Teaching Hours/Week (L: T:P)	3-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Pattern Recognition** Introduction to Pattern Recognition - Basics of pattern recognition systems, various applications, Machine Perception, classification of pattern recognition systems. Design of Pattern recognition system, Pattern recognition Life Cycle. Statistical Pattern Recognition: Review of probability theory, Gaussian distribution. Normal density and discriminant functions.	**7**
2	**Feature selection** Feature selection – Outlier removal – Data normalization – Missing data, The Peaking phenomenon, Feature selection using statistical hypothesis testing- Hypothesis testing basics – Application of t-Test in feature selection. Class separability measures- Divergence-Chernoff bound and Bhattacharya distance-Scatter matrices, Feature subset selection –Scalar feature selection, Feature vector selection.	**10**

3	**Clustering Algorithms** Clustering Algorithms - Unsupervised learning and clustering - Criterion functions for clustering. Cluster validation. Fuzzy clustering algorithms- Point representatives- quadratic surfaces and representatives – hyper plane representatives. Binary morphology clustering algorithms (BMCAs) – Discretization – Morphological operations - Determination of clusters in a discrete binary set- Assignment of feature vectors to clusters – The algorithmic scheme, Boundary detection algorithms	**9**
4	**Dimensionality reduction** Dimensionality reduction: Principal component analysis - its relationship to Eigen analysis. Fisher discriminant analysis - Generalised Eigen analysis. Eigen vectors/Singular vectors as dictionaries. Factor Analysis, Total variability space - a dictionary learning method.Non negative matrix factorisation - a dictionary learning method. Linear discriminant functions: Gradient descent procedures, Perceptron.	**8**
5	**Artificial neural networks and Pattern Classification** Artificial neural networks: Review of Artificial neural network concepts, convolutional neural networks, recurrent neural networks. Non-metric methods for pattern classification: non-numeric data or nominal data. Decision trees: Classification and Regression Trees (CART).	**6**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	Course based task/Seminar/Data collection and interpretation	Test Paper - I	Total
15	**15**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any five question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Apply probability and numerical methods in statistical pattern recognition.	**K3**
CO2	Apply statistical methods in feature selection.	**K3**
CO3	Apply linear algebra and statistical methods in parameter and non-parameter estimation.	**K3**
CO4	Apply the technique of decision trees in pattern recognition.	**K3**
CO5	Analyze the use of deep learning networks and artificial neural networks in pattern recognition.	**K4**
CO6	Design, Develop, Implement and Present innovative ideas in problem solving with various pattern recognition techniques.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Pattern Recognition	S. Theodoridis, K. Koutroumbas	Academic Press	4th Edition, 2009
2	Pattern Recognition and Machine Learning	C. M. Bishop	Springer	2006

3	Pattern Classification	R. O. Duda, P. E. Hart, D. G. Stork	John Wiley	2001
4	The Elements of Statistical Learning	T. Hastie, R. Tibshirani, J. Friedman	Springer	2001

SEMESTER S1
ADVANCED COMPUTER ARCHITECTURE
PROGRAM ELECTIVE

Course Code	**241ECS008**	**CIE Marks**	40
Teaching Hours/Week (L: T:P)	3-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	**Syllabus Description**	**Contact Hours**
1	**Design and Analysis** Principles of computer design, Fallacies and Pitfalls, Instruction Set Principles- Classifying instruction set architecture, Memory addressing, Type and size of operands, Operations in the instruction set, Instruction for control flow, Encoding an instruction set, Role of compiler.	**8**
2	**Memory Hierarchy** Introduction, Cache performance, Basic cache optimizations, Virtual memory–Techniques for fast address translation, Protection via virtual memory, Fallacies and Pitfalls, Case study of Pentium/Linux memory system-Pentium address translation	**8**

3	**Parallelism** Introduction, Pipeline hazards, Static branch prediction and dynamic branch prediction, Implementation of MITS, Basic pipeline of MITS, Implementing the control in MITS pipeline, Dealing with branches in pipeline, Dealing with exceptions, Handling of multi-cycle operations, Maintaining precise exceptions, Case study of MITS R4000 pipeline	**8**
4	**Thread Level Parallelism** Introduction, Centralized Shared-Memory Architectures, Performance of Symmetric Shared-Memory Multiprocessors, Distributed Shared-Memory and Directory-Based Coherence, Synchronization: The Basics, Models of Memory Consistency: An Introduction, Crosscutting Issues, Case study of Sun T1 Multiprocessor.	**8**
5	**Data Level Parallelism** Vector architecture, SIMD instruction set, Extension for multimedia, Graphic Processing Units, Case study Envida GPU instruction set architecture, GPU memory structure, Innovations in GPU architecture, Comparisons between vector architecture and GPUs, Comparisons between multimedia SIMD computers and GPUs, Loop level parallelism, Finding dependencies, Eliminating dependencies.	**8**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	**Course based task/Seminar/Data collection and interpretation**	**Test Paper - I**	**Total**
15	**15**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any five question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Identify and solve the advanced issues in design of computer processors, caches and memory	**K3**
CO2	Analyze the memory hierarchy design, performance improvement techniques and cache optimization techniques	**K4**
CO3	Analyze the working and features of branching and exception handling in pipeline architecture(	**K4**
CO4	Analyze the operation of multiprocessors and thread level parallelism	**K5**
CO5	Demonstrate the concepts of data level parallelism including SIMD and GPU processors	**K3**
CO6	Design, Develop, Implement and Present innovative ideas on advanced computer architecture and techniques	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Computer Architecture- A Quantitative Approach	Hennessy J.L and David A. Patterson	Morgan Kaufmann Publication	Fifth edition, 2002

2	Computer Systems A programmer's perspective	Randal E Bryant and David O'Hallaron	Pearson Education,	2nd edition 2010
3	Advanced Computer Architecture	kaihwang and Naresh Jotwani,	Tata Mcgraw-Hill,	2nd edition 2010
4	Advanced Computer Architecture: A Design Space Approach"	Sima D,Fountain T and Kacsuk P	Pearson Education,	1st edition 1997.

SEMESTER S1
NATURAL LANGUAGE PROCESSING AND TEXT MINING
PROGRAM ELECTIVE

Course Code	**241ECS009**	**CIE Marks**	40
Teaching Hours/Week (L: T:P)	3-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction** Natural Language Processing (NLP) - Syntax, semantics, pragmatics, and ambiguity in NLP, Regular Expressions, Text Normalisation, Edit Distance. N-gram Language Models-N-Grams, Evaluating Language Models, Generalisation and Zeros, Smoothing, Kneser-Ney Smoothing, The Web and Stupid Backoff, Perplexity's Relation to Entropy.	**6**
2	**Neural Language Models, Vector Semantics and Embeddings** Neural Networks and Neural Language Models-Units, Feed-Forward Neural Networks, Training Neural Nets, Neural Language Models. Vector Semantics and Embeddings-Lexical Semantics, Vector Semantics, Words and Vectors, Cosine for measuring similarity, TF-IDF: Weighing terms in the vector, Applications of the tf-idf vector model, Word2vec, Visualizing Embeddings, Semantic properties of embeddings, Bias and Embeddings, Evaluating Vector Models.	**8**

3	**Sentiment Classification and Part-of-Speech Tagging** Sentiment Classification –Sentiment classification. Machine Learning for Sentiment Classification - Training the Classifier (Naive Bayes, Logistic Regression, Support Vector Machine, Decision Tree, Random Forest), Optimising for Sentiment Analysis - Other text classification tasks – Evaluation of classification models: Precision, Recall, F-measure, Test sets and Cross-validation, Statistical Significance Testing. Part-of-Speech Tagging-English Word Classes, The Penn Treebank Part-of-Speech Tagset, Part-of-Speech Tagging, HMM Part-of-Speech Tagging, Maximum Entropy Markov Models, Bi-directionality, Part-of Speech Tagging for Morphological Rich Languages. Information Extraction-Named Entity Recognition, Relation Extraction, Extracting Times, Extracting Events and their Times, Template Filling	**10**
4	**Sequence Processing with Recurrent Networks**-Simple Recurrent Neural Networks, Applications of Recurrent Neural Networks, Deep Networks: Stacked and Bidirectional RNNs, Managing Context in RNNs: LSTMs and GRUs, Words, Subwords and Characters Neural Language Models and Generation Revisited, Encoder-Decoder Networks, Attention, Applications of Encoder-Decoder Networks. Case study: Machine translation, Question Answering	**7**
5	**Text Mining** **Document representation** - representing unstructured text documents with appropriate format and structure, automated text mining algorithms **Text Mining:** Text categorization, Text clustering, Topic modeling, Applications - classification, image annotation, collaborative filtering, and hierarchical topical structure modeling. Document summarization - Extraction- based summarization methods Sentiment analysis - concept, sentiment polarity prediction, review mining, aspect identification. Text visualization - introduction to mathematical and programming tools.	**9**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	Course based task/Seminar/Data collection and interpretation	Test Paper - I	Total
15	15	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any five question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Apply different approaches of syntax and semantics in NLP	**K3**
CO2	Employ approaches to generate dialogue and summarisation within NLP	**K3**
CO3	Apply different statistical approaches to machine translation.	**K3**
CO4	Research, analyze and deploy appropriate machine learning techniques in NLP including hidden Markov models and unsupervised methods	**K4**
CO5	Use text mining concepts and methods to model real-world problems and develop technical solutions	**K4**
CO6	Design, develop and implement NLP and text mining methods to solve real world problems	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Speech and Language Processing	Daniel Jurafsky and James H. Martin.	Pearson International edition	2nd edition 2008
2	Foundations of Statistical Natural Language Processing	Manning C, Schuetze H.	MIT Press	1999
3	Natural Language Understanding",	James Allen	Addison-Wesley	2/E, 1994
4	“Mining Text Data”	Charu C. Aggarwal and Cheng Xiang Zhai,	Springer,	2012
5	Text Mining Classification, Clustering, and Applications	Ashok N. Srivastava, Mehran Sahami,	CRC Press	

SEMESTER S1
ADVANCED COMPILER DESIGN
PROGRAM ELECTIVE 2

Course Code	**241ECS010**	**CIE Marks**	40
Teaching Hours/Week (L: T:P)	3-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Overview of compiler design** Introduction - The phases of Compiler - Lexical Analysis - Role of Lexical Analyzer - Specification and Recognition of Tokens - Context Free Grammar – Symbol - Table Structure, Symbol Attributes and Symbol - Table Entries, Local Symbol - Table Management, Global Symbol - Table Structure, Storage Binding and Symbolic Registers, Approaches to Generating Loads and Stores. Intermediate representation – Issues – High level, medium level, low level intermediate languages –MIR, HIR, LIR – ICANfor Intermediate code.	8
2	**Intermediate Representations** The value - number method for constructing DAGs - Addresses and instructions – Quadruples - Triples - Storage organization – Static versus dynamic storage allocation - stack allocation of space -Activation trees - Activation records - Garbage collection - Design goals for Garbage collectors -Reference counting garbage collectors - Introduction to trace - based collection - A basic mark - and-sweep collector. Translation of expressions Translation of expressions – Operations within expressions – Incremental translation – Addressing array elements – Translation of array references Control flow – Boolean expressions – Short - circuit	9

	code – flow – of - control statements – Control flow translation of Boolean expressions – Avoiding redundant Gotos – Boolean values and jumping code – Backpatching – One - passcode generation using back patching – Back patching for Boolean expressions – Flow- of-control statements – Break, continue and Goto statements Translation of switch statements – syntax directed translation of switch statements - intermediate code for procedures	

3	**Code optimization** Principal sources of optimization - causes of redundancy preserving transformations - Global common subexpressions - Copy Propagation - Dead code elimination – Code motion –Upward code motion – Downward code motion – Induction variables and reduction in strength -Introduction to data flow analysis - Loops in Flow graphs – Dominators - Introduction to global data flow analysis - Points and Paths - Reaching definitions - Live variable analysis - Data flow analysis of structured program	**8**
4	**Register allocation and code scheduling** Register allocation and assignment – graph coloring – control flow and low-level optimizations - Inter - procedural analysis and optimization – call graph — register allocation – global References: – Optimization for memory hierarchy. Code Scheduling – Instruction scheduling – peculative scheduling – Software pipelining – trace scheduling –percolation scheduling.	**7**
5	**Parallelism and Case study** Instruction - level parallelism - Instruction pipelines and branch delays – pipelined execution –data dependence – dependencies among memory accesses. Case Studies – Sun Compilers for SPARC–IBMXL Compilers – Alpha compilers – PA – RISC assembly language – COOL – (Classroom Object oriented language) – Compiler testing tools – SPIM	**8**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	Course based task/Seminar/Data collection and interpretation	Test Paper - I	Total
15	15	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any five question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Illustrate lexical rules and grammars for a representative programming language	**K2**
CO2	Construct intermediate code representations and code optimization techniques	**K3**
CO3	Experiment with register allocation strategies and code scheduling	**K3**
CO4	Inspect programming language design, target machine language design and run time environment of compilers	**K4**
CO5	Assess recent trends in compiler design and build a compiler for a hypothetical language	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Advanced Compiler Design and Implementation	Steven S Muchnik,	Morgan Kaufmann publishers Elsevier Science, India, Indian Reprint	2003.
2	Compilers: Principles, Techniques and Tools ,	Alfred V. Aho, Monica S. Lam, Ravi Sethi, and Jeffery D. Ullman.,	Addison Wesley, Boston, MA,	2nd edition 2006
3	Compilers: Principles, Techniques and Tools,	Aho, A. V, Sethi, R. and Ullman, J. D.	Pearson Education	1986.
4	Compiler Construction	D. M. Dhamdhere	Macmillan	(2/e)
5	Engineering a Compiler	Cooper &Torczon	Elsevier	
6	Compiler Construction: Principles and Practice	K C. Louden	Cengage	

SEMESTER S1
BIOINFORMATICS
PROGRAM ELECTIVE

Course Code	**241ECS011**	**CIE Marks**	40
Teaching Hours/Week (L: T:P)	3-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Molecular Biology** Biomolecules-DNA, RNA and proteins-Components and structure. Genome organization. Letter codes for amino acids. Central dogma of molecular Biology. Genetic code. Interatomic forces in proteins, different levels of protein structure, protein domains, motifs.	5
2	**Bioinformatics** Definition and brief history. Bioinformatics vs Computational Biology. Scope and research areas of Bioinformatics. Data archives: Biological Databases-classification and importance; Nucleic acid databases: GenBank, DDBJ, EMB. Protein Sequence Databases: SwissProt, PIR. Derived databases: InterPro, Prosite, Pfam. Structure Databases: RCSB PDB, CATH, SCOP. Bibliographic Databases: PubMed, MEDLINE. Specialized databases. Gateways to archives: Entrez, SRS, ExPASy.	7

3	**Sequence Alignment** Concept of sequence alignment, Gaps in alignment, Scoring matrices: PAM and BLOSUM, Alignment of pairs of sequences: Dot Plot, Dynamic Programming, Alignment algorithms: The Needleman and Wunsch algorithm, Smith-Waterman algorithm. Search for homologous sequences using BLAST and FASTA programs. Statistical significance of database searches. Multiple sequence Alignment: Concept and Algorithms in MSA. Tools: Clustal, Mega.	**10**
4	**Molecular Phylogenetics** Concept and its relation to Multiple Sequence Alignment. Representation of phylogeny. Concept of Outgroup. Gene and Species phylogeny. Phylogenetic tree construction methods: Distance based and Character based. Phylogenetic software's: PHYLIP, MrBayes.	**8**
5	**Protein Structure Prediction and Advanced Bioinformatics** Protein Stability and folding, Ramachandran plot, Homology modelling, Energy minimization, CASP; Protein structure prediction software's: ESyPred3D, Rosetta; PSI-BLAST; Introduction to machine learning techniques: Hidden Markov models, Genetic algorithms and artificial neural networks. Applications of machine learning techniques in multiple sequence alignment, structure prediction and phylogenetic analysis	**10**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	Course based task/Seminar/Data collection and interpretation	Test Paper - I	Total
15	**15**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any five question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Make use of fundamental concepts of molecular biology to provide computational solutions	**K2**
CO2	Utilize bioinformatics tools and databases for retrieving, analysing and understanding biological data	**K3**
CO3	Analyze multiple sequences and find conserved regions.	**K4**
CO4	Find the relationships between species by constructing phylogenetic tree.	**K3**
CO5	Predict unknown protein structures and apply concepts of Machine learning and their applications in Bioinformatics	**K3**
CO6	Design, Develop, Implement and Present innovative ideas on Bioinformatics techniques	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Essential Bioinformatics	Jin Xiong	Cambridge University Press	2006

2	Genomes 3	Brown T. A.	BIOS Scientific Publishers Limited	3rd Edition 2007
3	Biochemistry	Jeremy M. Berg, John L. Tymoczko, Lubert Stryer,	W. H. Freeman	5th Edition 2002
4	Introduction to Bioinformatics,	Arthur Lesk,	Oxford University Press,	5th Edition, 2019.
5	Fundamental concepts of Bioinformatics,	Dan E. Krane	Pearson Education India	3rd Edition,, 2002.
6	Bioinformatics Sequence and Genome Analysis,	David W. Mount,	Cold Spring Press,	2nd Edition, 2004.
7	Bioinformatics: A practical Guide to the Analysis of Genes and Proteins,	Andreas D. Baxevanis, B. F. Francis Ouellette	John Wiley & Sons	2004
8	Microarray Bioinformatics,	Dov Stekel	Cambridge University Press	2003

SEMESTER S1
COMPUTING LAB 1

Course Code	**241LCS008**	**CIE Marks**	100
Teaching Hours/Week (L: T:P)	0-0-2	**ESE Marks**	
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Laboratory 1

SYLLABUS

Syllabus Description
Decision tree (ID3), Naïve bayesian classifier , Bayesian network, Expectation Maximization (EM) algorithm,K-means algorithm, K-nearest neighbor, Regression, Cross validation, Support Vector Machine (SVM), Artificial neural network, Backpropagation algorithm, Recurrent Neural Networks (RNN), Long Short Term Memory (LSTM), Google colab

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Pattern:

Continuous Evaluation	**Final internal assessment**	**Total**
60 marks	**40 marks**	**100**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		**Bloom's Knowledge Level (KL)**
CO1	Apply modern machine learning notions in predictive data analysis	**K3**
CO2	Analyze the range of machine learning algorithms along with their strengths and weaknesses	**K4**
CO3	Design and develop appropriate machine learning models to solve real world problems	**K4**
CO4	Build predictive models from data and analyze their performance	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Lab Report :

All the students attending the Lab should have a Fair Report. The report should contains details of experiment such as Objective, Algorithm/Design, Description, Implementation, Analysis, Results, and Outcome. The report should contain a print out of the respective code with inputs addressing all the aspects of the algorithm described and corresponding outputs. All the experiments noted in the fair report should be verified by the faculty regularly. The fair report, properly certified by the faculty, should be produced during the time of the final assessment.

Experiment List

Experiment No.	Experiment
1	Write a program to demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.
2	Write a program to implement the naïve bayesian classifier for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets.
3	Assuming a set of documents that need to be classified, use the naïve bayesian Classifier model to perform this task. Calculate the accuracy, precision, and recall for your data set.
4	Write a program to construct a Bayesian network considering medical data. Use this model to demonstrate the diagnosis of heart patients using standard Heart Disease Data Set. You can use Python ML library classes/API.
5	Apply EM algorithm to cluster a set of data stored in a .CSV file. Use the same data set for clustering using k-Means algorithm. Compare the results of these two algorithms and comment on the quality of clustering. You can add Python ML library classes/API in the program.
6	Write a program to implement k-Nearest Neighbour algorithm to classify the iris data set. Print both correct and wrong predictions. Python ML library classes can be used for this problem.

7	Implement the non-parametric Locally Weighted Regression algorithm in order to fit data points. Select appropriate data set for your experiment and draw graphs
8	Write a program to implement 5-fold cross validation on a given dataset. Compare the accuracy, precision, recall, and F-score for your data set for different folds.
9	Implement SVM/Softmax classifier for CIFAR-10 dataset: (i) using KNN, (ii) using 3 layer neural network
10	Build an Artificial Neural Network by implementing the Backpropagation algorithm and test the same using appropriate data sets.
11	Image Captioning with Vanilla RNNs
12	Image Captioning with LSTMs.
13	Familiarization of cloud based computing like Google colab.

Reference Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	data mining concepts and techniques	jiawei han, michelin kamber,jian pei	morgan kaufmann	3rd edition
2	pattern recognition and machine learning	christopher m bishop	springer	2006
3	introduction to machine learning	ethem alpaydin	MIT Press	2nd edition 2010
4	data mining and analysis :fundamental concepts and algorithms	Mohammed j zaki and wagner meira	cambridge university press	first south asia edition 2016
5	Deep Learning	goodfellow, bengio y and courville A	MIT Press	2016
6	Neural networks and deep learning	Aggarwal, charu c	springer international publishing AG, part of springer nature	2018

SEMESTER S2

SEMESTER S2
ADVANCED DATA STRUCTURES AND ALGORITHMS
DISCIPLINE CORE 2

Course Code	**242TCS100**	**CIE Marks**	40
Teaching Hours/Week (L: T:P)	3-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Discipline core 2

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Amortized analysis and String matching** Overview of asymptotic notations and complexity analysis, Amortized analysis – aggregate analysis, accounting method, potential method.String matching – introduction, Rabin-Karp algorithm, Knuth-Morris-Pratt algorithm.	**8**
2	**Advanced data structures** Overview of binary heap operations, Binomial tree and heap, Binomial heap operations, Fibonacci heap structure, Fibonacci heap operations, Disjoint set – overview, linked list representation, disjoint set forests.	**9**
3	**Network flow** Network flow properties, examples, residual network, augmenting path, cut of network,maxflow-mincut theorem, Ford-Fulkerson algorithm, Edmonds-Karp algorithm, maximum bipartite matching.	**6**

4	**Probabilistic algorithms** Introduction, types of probabilistic algorithms, Numerical algorithms – Numerical integration, Probabilistic counting, Monte-Carlo algorithms – Verifying matrix multiplication. Number theory fundamentals – modular arithmetic, modular exponentiation, Euler's Theorem and Fermat's Theorem, Primality testing – Miller-Rabin test. Las Vegas algorithms – Probabilistic selection and quick sort.	**8**
5	**Approximation algorithms** Introduction, Vertex-cover problem, Traveling-salesman problem, Set-covering problem,Subset-sum problem.	**6**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Micro project/Course based project	Course based task/Seminar/Quiz	Test paper, 1 no.	Total
20	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any four question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Analyse the relevance of amortized analysis and applications	**K3**
CO2	CIllustrate string matching algorithms	**K3**
CO3	Illustrate advanced data structures like Binomial heap, Fibonacci heap, Disjoint set and string matching algorithms	**K3**
CO4	Illustrate network flow algorithms and applications	**K3**
CO5	Make use of probabilistic algorithms and approximation algorithms in computing	**K3**
CO6	IDesign, develop and implement software using advanced data structures and algorithms	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to Algorithms	T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein	MIT Press	3/e 2009
2	Fundamentals of algorithms	Gilles Brassard and Paul Bratley	Prentice-hall of India Private Limited	2001
3	Randomized Algorithms	Rajeev Motwani, Prabhakar Raghavan	Cambridge University Press	2000
4	The Design and Analysis of Algorithms	Dexter C. Kozen	Springer	
5	Algorithm Design	Jon Kleinberg and Eva Tardos	Pearson Education	2006

SEMESTER S2

ADVANCED OPERATING SYSTEMS

PROGRAM CORE 3

Course Code	**242TCS001**	**CIE Marks**	40
Teaching Hours/Week(L: T:P)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	PROCESS MANAGEMENT AND SCHEDULING Introduction to the Linux kernel, Process Management – Process, Process descriptor and the task structure, Process creation, The Linux implementation of threads, Process termination. Process Scheduling – Multitasking, Linux's process scheduler, Policy, Linux scheduling algorithm, Preemption and context switching, Real-time scheduling policies.	8
2	SYSTEM CALLS AND INTERRUPTS System Calls - Communicating with the Kernel, Syscalls, System call handler, System call implementation, System call context . Interrupts and Interrupt Handlers – Interrupts, Interrupt handlers, Top halves versus bottom halves, Registering an interrupt handler, Writing an interrupt handler, Interrupt context, Interrupt control. Bottom Halves – Task queues, Softirqs, Tasklets, Work queues.	9
3	KERNEL SYNCHRONIZATION Kernel Synchronization – Critical regions and race conditions, Locking, Deadlocks, Contention and scalability. Kernel Synchronization Methods – Atomic operations, Spin locks,Semaphores, Mutexes, Completion variables, BKL: The Big Kernel Lock, Sequential locks, Preemption disabling.	9

4	MEMORY MANAGEMENT AND VIRTUAL FILE SYSTEM Memory Management – Pages, Zones, kmalloc(), kfree(), vmalloc(), Slab layer – design, Per-CPU allocations. The Virtual File system – VFS objects, data structures, relationship and functionalities.	**7**
5	BLOCK I/O LAYER AND PORTABILITY The Block I/O Layer – Buffers and buffer heads, Request queues, I/O schedulers – Types,Scheduler selection. Portability – Word size and data types, Data alignment, Byte order, Time,Processor ordering.	**7**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Micro project/Course based project	Course based task/Seminar/Quiz	Internal Examination-1 (Written)	Total
20	**10**	**10**	

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any four questions out of seven questions.

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Illustrate the concepts of process management and process scheduling mechanisms employed in the Linux operating system.	**K3**
CO2	Describe the set of interfaces by which the process running in user space can interact with the system and how the Kernel manages the various interrupts.	**K3**
CO3	Apply various synchronization methods to write race free code.	**K3**
CO4	Demonstrate how the kernel handles memory and implementation of the file system.	**K3**
CO5	Analyze how kernel manages block devices and their requests and identify the issues to be considered in writing portable codes	**K4**
CO6	Design and implement different kernel modules.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Linux Kernel Development	Robert Love	Addison-Wesley	3/e 2010
2	Understanding the Linux Kernel	Daniel Bovet, Marco Cesati	OReilly Media Inc	3/e 2005
3	Linux Kernel Architecture	Wolfgang Mauerer	OReilly Media Inc	
4	Understanding Linux Network Internals	Reilly Christian Benvenuti	OReilly Media Inc.	1/e 2005.
5	Linux Device Drivers	Jonathan Corbet,Alessandro Rubini, Greg Kroah-Hartman	OReilly Media Inc	3/e 2005
6	Operating System Concepts	Silberschatz,Galvin, Gagne		9/e

SEMESTER S2
MINI PROJECT

Course Code	**242PCS100**	**CIE Marks**	100
Teaching Hours/Week(L: T:P:)	0:0:4	**ESE Marks**	
Credits	2	**Exam Hours**	
Prerequisites (if any)	None	**Course Type**	Project

Sl. No	Type of evaluations	Mark	Evaluation criteria
1	Interim evaluation 1	20	
2	Interim evaluation 2	20	
3	Final evaluation by a Committee	35	Will be evaluating the level of completion and demonstration of functionality/ specifications, clarity of presentation, oral examination, work knowledge and involvement
4	Report	15	the committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level(not more than 25%)
5	Supervisor/Guide	10	
		100	

SEMESTER S2
COMPUTING LAB 2

Course Code	**242LCS100**	**CIE Marks**	100
Teaching Hours/Week(L: T:P)	0:0:2	**ESE Marks**	
Credits	2	**Exam Hours**	2 Hrs 30 Min
Prerequisites (if any)	None	**Course Type**	Laboratory 2

SYLLABUS

Syllabus Description
Basic concepts of Big Data, Configuration of Hadoop, Parallel Database, Distributed Database, Semi-structured Data and XML Databases: XML Data Model – XML Schema-DTD-XSD –XPath and XQuery, JDOQL (Java Data Object-based Query Language), No SQL Databases: Key value stores – DynamoDB, Column Based- HBase, Cassandra, Web Page ranking algorithm.

Course Assessment Method (CIE: 60 marks, ESE: 40 marks)

Continuous Internal Evaluation Marks (CIE):

Continuous Evaluation	**Final internal assessment**	**Total**
60	**40**	**100**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	**Bloom's Knowledge Level (KL)**
CO1	Able to perform the distributed processing of large data sets across clusters of computers using simple programming models with the help of Hadoop.	**K3**
CO2	Perform data summarization and ad hoc querying using Hive.	**K6**
CO3	Operates on document databases and techniques using DynamoDB.	**K3**
CO4	Capable of implementing XML and XML queries for data management.	**K6**
CO5	Apply emerging technologies in column store along with Cassandra.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create*

Lab Report:

- All the students attending the Lab should have a Fair Report.
- The report should contain details of experiments such as Objective, Algorithm/Design, Description, Implementation, Analysis, Results, and Outcome.
- The report should contain a print out of the respective code with inputs addressing all the aspects of the algorithm described and corresponding outputs.
- All the experiments noted in the fair report should be verified by the faculty regularly.
- The fair report, properly certified by the faculty, should be produced during the time of the final assessment.

Experiment List

Experiment No.	Experiment
1	Study and Configure Hadoop for Big Data.
2	Study of NoSQL Databases such as Hive/HBase/Cassandra/DynamoDB.
3	Design Data Model using NoSQL Databases such as Hive/HBase/Cassandra/DynamoDB.
4	Implement any one Partitioning technique in Parallel Databases.
5	Implement Two Phase commit protocol in Distributed Databases.
6	Design Persistent Objects using JDO and implement min 10 queries on objects using JDOQL in Object DB NOSQL DATABASE.
7	Create XML, XML schemas, DTD for any database application and implement min 10 queries using XQuery FLOWR expression and XPath.
8	Design database schemas and implement min 10 queries using Hive/ HBase/Cassandra column-based databases.
9	Design database schemas and implement min 10 queries using Dynamo DB key-value based databases.
10	Implement Web Page ranking algorithm.
11	Create a database infrastructure like GitHub backend DB for a project team to collaborate for coding, code review, code commenting and approval, code rejection for changes workflow.

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Hadoop: The Definitive Guide	Tom White	O'Reilly Media	4/e 2015
2	Beginning XML	Joe Fawcett, Danny Ayers, Liam R. E. Quin	John Wiley & Sons	5/e 2012
3	Cassandra: The Definitive Guide	Jeff Carpenter, Eben Hewitt	O'Reilly	3/e 2020
4	DynamoDB Cookbook	Tanmay Deshpande	Packt Publishing	2015

SEMESTER S2

BIG DATA ANALYTICS

PROGRAM ELECTIVE

Course Code	**242ECS100**	**CIE Marks**	40
Teaching Hours/Week(L: T:P: R)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Data Analytics Mathematics for Data Analytics - Descriptive statistics - Measures of central tendency and dispersion, Association of two variables, Probability calculus - probability distributions, Inductive statistics - Point estimation, Interval estimation, Hypothesis Testing - Basic definitions, t-test Introduction To Big Data: Big data characteristics, Features of Big Data, Evolution of Big data, Analyst Perspective on Data Repositories , State of the Practice in Analytics, BI Versus Data Science.	8
2	Introduction to R Review of basic data analytic methods using R : Introduction to R, R graphical user interface-data import and export-attribute and data type. Exploratory data analysis-Visualization, Dirty data, single and multiple variables, data exploration vs presentation. Statistical methods for evaluation-Hypothesis testing, difference of means, Wilcoxon rank sum test, type I and II errors, power and sample size.	8

3	Hadoop & HDFS History of Hadoop, Apache Hadoop, Analysing Data with Unix tools, Analysing Data with Hadoop, Hadoop Streaming, Hadoop Echo System, IBM Big Data Strategy, Introduction to Infosphere BigInsights and Big Sheets. The Design of HDFS, HDFS Concepts, Command Line Interface, Hadoop file system interfaces, Data flow, Data Ingest with Flume and Scoop and Hadoop archives, Hadoop I/O: Compression, Serialization, Avro and File-Based Data structures	**8**
4	Map reduce & Hadoop Ecosystem Anatomy of a Map Reduce Job Run, Failures, Job Scheduling, Shuffle and Sort, Task Execution, Map Reduce Types and Formats, Map Reduce Features. Pig : Introduction to PIG, Execution Modes of Pig, Comparison of Pig with Databases, Grunt, Pig Latin, User Defined Functions, Data Processing operators. Hive : Hive Shell, Hive Services, Hive Metastore, Comparison with Traditional Databases, HiveQL.	**8**
5	Advanced Analytical Theory, Methods and Text Analysis Advanced analytical theory and methods: Time Series Analysis-Overview of Time Series Analysis, Box-Jenkins Methodology ARIMA Model, Autocorrelation Function (ACF), Autoregressive Models, Moving Average Models ARMA and ARIMA Models Building and Evaluating an ARIMA Model, Reasons to Choose and Cautions.	**8**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	Course based task/Seminar/Data collection and interpretation	Internal Examination-1 (Written)	Total
15	**15**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any four question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Illustrate the concept for data analytics using basic mathematics.	**K3**
CO2	Illustrate the concepts of data analytics.	**K3**
CO3	Apply various Big Data Analytics Techniques using R.	**K3**
CO4	Access and Process Data on Distributed File System and to Manage Job Execution in Hadoop Environment.	**K3**
CO5	Analyze the Big Data using Advanced analytical methods such as text analysis.	**K3**
CO6	Design, Develop, Implement and Present innovative ideas on distributed algorithms and techniques.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to Statistics and Data Analysis	Christian Heumann and Michael Schomaker	Springer	2016
2	Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data	David Dietrich, Barry Heller, Biebie Yang	EMC Education Services,John Wiley &Sons, Inc	
3	Data Mining Concepts and Techniques	Jaiwei Han, MichelineKamber	Elsevier.	2006
4	Hadoop: The Definitive Guide	Tom White	O'reily Media	3/e 2012
5	Big Data Analytics	Seema Acharya, Subhashini Chellappan	Wiley	2015

SEMESTER S2
WIRELESS SENSOR NETWORKS
PROGRAM ELECTIVE

Course Code	**242ECS001**	**CIE Marks**	40
Teaching Hours/Week(L: T:P)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Wireless Sensor Networks Motivation, Challenges and Constraints, Applications. Node Architecture – Hardware elements, Sensors and Actuators, Power supply, Energy Consumption of sensor nodes. Challenges in sensor network programming, Operating systems and execution environments-embedded OS, issues, Programming models.	**9**
2	Sensor Network Architecture Sensor network scenarios, Optimization goals and figures of merit Design principles for WSNs, Service interfaces of WSNs. Gateway concepts, WSN- Internet Communication. Discrete time Markov Chain, Performance analysis of IEEE 802.11 DCF using Markov Chain	**7**
3	MAC Protocols for WSNs Characteristics and design goals, low duty cycle protocols and wakeup concepts. Contention based protocols: PAMAS, STEM, T-MAC Schedule based protocols: SMACS, TRAMA Hybrid MAC protocols: Z-MAC Case Studies: S-MAC, 802.15.4, 802.15.6	**8**

4	Routing Protocols for WSNs Introduction, Routing challenges and design issues, Routing Strategies Routing Techniques: Flooding and Gossiping, SPIN, LEACH, PEGASIS, Directed Diffusion, Rumour Routing, Geographic Routing-Forwarding Strategies.	**8**
5	Localization, Coverage and Security in WSNs Localization: approaches-proximity-trilateration and triangulation-scene analysis Coverage and deployment: sensing models, coverage measures, uniform random deployments, coverage determination Security: Security challenges in WSNs, Security attacks in WSNs	**8**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	Course based task/Seminar/Data collection and interpretation	Internal Examination-1 (Written)	Total
15	**15**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any four question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	List the applications, hardware and software components of wireless sensor networks, and the challenges faced in design of sensor networks.	**K4**
CO2	Apply design principles and formulate necessary service interfaces while designing a wireless sensor network	**K3**
CO3	Design MAC protocols for wireless sensor networks taking into account the specific requirements of the network.	**K6**
CO4	Explain localization techniques, coverage problem and security issues in wireless sensor networks	**K5**
CO5	Design energy efficient routing protocols for wireless sensor networks	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Wireless Sensor Networks, Theory and Practice	W. Dargie and C.Poellabauer	Wiley	2010
2	Protocols and Architectures for Wireless Sensor Networks	Holger Karl and Andreas Willig	Wiley	2005
3	Wireless Sensor Networks, Technology, Protocols, and Applications	K. Sohraby, D. Minoli and T. Znati	Wiley-Interscience	2007
4	Adhoc Wireless Networks Architectures and Protocols	C. Siva Ram Murthy and B. S Manoj	Prentice Hall	2004
5	Wireless Sensor Networks An Information Processing Approach	Feng Zhao and Leonidas Guibas	Morgan Kaufman	2005

SEMESTER S2
DEEP LEARNING
PROGRAM ELECTIVE

Course Code	**242ECS002**	**CIE Marks**	40
Teaching Hours/Week(L: T:P)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Deep learning Introduction to deep learning, Deep feed forward network, Training deep models -introduction, setup and initialization issues, Vanishing and exploding gradient problems, Optimization techniques - Gradient Descent (GD), Stochastic GD, GD with momentum, GD with Nesterov momentum, AdaGrad, RMSProp, Adam. Regularization Techniques -L1 and L2 regularization, Early stopping, Dataset augmentation, Parameter tying and sharing, Ensemble methods, Dropout.	9
2	Convolutional Neural Networks Convolutional Neural Networks –Architecture, Convolution and Pooling operation, Motivation, Variants of convolution functions, Structured outputs, Data types, Efficient convolution algorithms, Training a Convolutional Network, Applications of Convolutional Networks, Case study of Convolutional Architectures – AlexNet	9
3	Recurrent neural networks Recurrent neural networks – Computational graphs, RNN design, encoder – decoder sequence to sequence architectures, deep recurrent networks, recursive neural networks, challenges of training Recurrent Networks, gated RNNs LSTM and GRU, Applications of RNNs.	7

4	Graphical Models and Sampling Graphical models - Bayesian network, Markov networks, Inference on chains and factor graphs. Monte Carlo Methods – Basics of Monte Carlo Sampling, Importance sampling, Markov chain Monte Carlo methods(MCMC), Gibbs sampling.	6
5	Advanced Deep learning Topics Autoencoders, Variational AutoEncoder , Deep generative models - Boltzmann machines, Restricted Boltzmann Machines, Deep Belief Networks, Deep Boltzmann Machines, Generative Adversarial Networks, Auto-Regressive Networks. Transfer Learning and Domain Adaptation.	9

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	Course based task/Seminar/Data collection and interpretation	Internal Examination-1 (Written)	Total
15	15	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any four question out of seven questions

Part A	Part B	Total
● 8 numerical questions with minimum 1 question from each module ● Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	● Contain 7 questions. ● Minimum one question from each module of which student should answer any four. ● Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Use the standard regularization and optimization techniques for the effective training of deep neural networks.	**K3**
CO2	Build convolutional Neural Network (CNN) models for different use cases.	**K3**
CO3	Apply the concepts of Recurrent Neural Network (RNN), Long Short Term Memory(LSTM), Gated Recurrent Unit (GRU) for solving problems.	**K3**
CO4	Construct Bayesian networks, Markov networks and apply computational techniques to draw inferences.	**K3**
CO5	Illustrate the concepts of auto encoder, sampling algorithms, deep generative models and transfer learning.	**K3**
CO6	Design, develop, implement and present innovative ideas on deep learning concepts and techniques to solve real-world problems.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Deep Learning	Goodfellow I, Bengio Y, and Courville A	MIT Press	2016
2	Neural Networks and Deep Learning	Aggarwal, Charu C	c Springer International Publishing AG, part of Springer Nature	2018
3	Pattern recognition and machine learning	Christopher M. Bishop	Springer	2006
4	Generative Deep Learning - Teaching Machines to Paint, Write,Compose, and Play.	David Foster	O'Reilly Media, Inc	2019

SEMESTER S2
COMPUTER VISION
PROGRAM ELECTIVE

Course Code	**242ECS003**	**CIE Marks**	40
Teaching Hours/Week(L: T:P)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Image formation and modelling Components of a vision system, Imaging systems, Signal processing for computer vision, Pattern recognition for computer vision, Performance evaluation of algorithms. Image formation and Image model- Camera model and camera calibration- Radiometry- Light in space- Light in surface - Sources, shadows and shading, Multiple images-The Geometry of multiple views- Stereopsis.	7
2	Affine structures Affine structure from motion- Elements of Affine Geometry, Affine structure and motion from two images- Affine structure and motion from multiple images- From Affine to Euclidean images. High level vision- Geometric methods- Model based vision- Obtaining hypothesis by pose consistency, pose clustering and using Invariants, Verification.	8
3	Bayesian Decision Theory Bayesian Decision Theory- Minimum error rate classification Classifiers, discriminant functions, decision surfaces- The normal density and discriminant-functions for the Normal density.	6

4	Introduction to Digital Image Processing Introduction to Digital Image Processing- fundamental steps in Digital Image Processing, relationship between pixels, intensity transformations and spatial filtering: basic intensity transformation functions, histogram processing, spatial filtering, smoothing and sharpening filters Probabilistic Modelling and Fuzzy Image Processing: Introduction of Probabilistic Modelling in Computer Vision, why probabilistic models, Object recognition as probabilistic modelling, Introduction, Fuzzy image understanding, Fuzzy image processing systems, Theoretical components of fuzzy image processing.	**10**
5	Processing on Images Image restoration: noise models, restoration in the presence of noise only, periodic noise reduction. Image compression: fundamentals, compression models and standards, basic compression methods: Huffman coding, arithmetic coding, LZW coding, run-length coding. Image segmentation: point, line and edge detection, thresholding region based segmentation Case Study: Any two applications-Object Recognition with Intelligent Cameras/ Fast 3-D Full Body Scanning for Humans and Other Objects/ Motion Tracking/ Multicolour Classification of Astronomical Objects.	**9**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	**Course based task/Seminar/Data collection and interpretation**	**Internal Examination-1 (Written)**	**Total**
15	**15**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any four question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Apply domain knowledge in vision system, radiometry, shadows, shading, views and Stereopsis for image formation.	**K3**
CO2	Apply affine structures and Geometry for reconstructing images.	**K3**
CO3	Apply Bayesian decision theory for pattern classification.	**K3**
CO4	Analyze the contents of the image using image processing, probabilistic modelling and fuzzy image processing.	**K4**
CO5	Analyze various techniques used for image restoration, compression and segmentation.	**K4**
CO6	Design, develop, implement and present innovative ideas on computer vision concepts and techniques.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Problem solving & programming concepts	Maureen Sprankle, Jim Hubbard	Pearson	9/e, 2011
2	How to Solve It: A New Aspect of Mathematical Method	George Pólya	Princeton University Press	2/e, 2015
3	Creative Problem Solving: An Introduction	Donald Treffinger., Scott Isaksen, Brian Stead-Doval	Prufrock Press	4/e,2005
4	Psychology (Sec. Problem Solving.)	Spielman, R. M., Dumper, K., Jenkins, W., Lacombe, A., Lovett, M., & Perlmutter, M	H5P Edition	1/e, 2021
5	Computational Thinking: A Primer for Programmers and Data Scientists	G Venkatesh Madhavan Mukund	Mylspot Education Services Pvt Ltd	1/e, 2020
6	Computer Arithmetic Algorithms	Koren, Israel	AK Peters/CRC Press	2/e, 2001
7	Python for Everyone	Cay S. Horstmann, Rance D. Necaise	Wiley	3/e, 2024
8	Introduction to Computation and Programming using Python	Guttag John V	PHI	2/e., 2016

SEMESTER - 2

SEMANTIC WEB ARCHITECTURE

PROGRAM ELECTIVE

Course Code	**242ECS004**	**CIE Marks**	40
Teaching Hours/Week(L: T:P)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	ContactHours (40 Hrs)
1	**Introduction to semantic web technology**: Traditional web to semantic web-WWW- First Look at the Semantic Web – meta dataSearch Engine for the Traditional Web- Search Engine for the Semantic Web	**6**
2	**Resource Description Framework** Elements - Resource – Property- Statement -rules of RDF – tools- RDFS core elements-- Syntax and Examples - More about Properties - XML Schema and RDF Schema –Taxonomy and ontology concepts.	**10**
3	**Web ontology language: OWL:** Define classes- set operators –enumerations- defining properties- Symmetric PropertiesTransitive Properties- Functional Properties- Inverse Property- Inverse Functional PropertyValidating OWL ontology- Related Development Tools- Validate OWL Ontology by Using Web Utilities- Using Programming APIs to Understand OWL Ontology.	**9**

4	**Web services and Real world examples:** Web services – web services standards – web services to semantic web services- UDDI. Swoogle- architecture and usage of meta data; FOAF – vocabulary – creating documents – overview of semantic markup – semantic web search engines- Implementation Details.	**10**
5	**Concept of OWL-S** – building blocks of OWL-S- OWL-S Profile OntologyOWL-S Process Ontology- OWL-S Grounding Ontology - mapping OWL-S to UDDI - WSDL.	**5**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Review article based on peer-reviewed publications (min. 10)	Course based task / Seminar/ Data collection and interpretation	Test paper (1 number) with min. 80% of syllabus coverage	Total
15	**15**	**10**	**40**

End Semester Examination Marks (ESE):

In Part A, all questions need to be answered and in Part B, each student can choose any four question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Distinguish between Traditional web Environment and Semantic web Environment and in the behavior of a search engine.	**K2**
CO2	Recognize and Apply the concept of RDF and RDFS and the benefits of Ontology and Taxonomy.	**K3**
CO3	Identify how to use OWL to rewrite the ontology and new features in OWL.	**K4**
CO4	Analyze the Web services like UDDI and Real World Examples like Swoogle and FOAF.	**K4**
CO5	Apply concepts OWL-S for Web service annotation and mapping OWL-S to UDDI.	**K3**
CO6	Design, develop, implement or present innovative ideas on Semantic Web Architecture and techniques.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to the Semantic Web and Semantic web services.	Liyang Yu	Chapman & Hall/CRC, Taylor & Francis Group	1st Edition, 2007
2	Creating the Semantic Web with RDF	Johan Hjelm	Wiley	1st Edition, 2001
3	A Semantic Web Primer	Grigoris Antoniou, Frank van Harmelen	MIT Press	1st Edition, 2004

SEMESTER - 2

PROGRAM ANALYSIS

PROGRAM ELECTIVE

Course Code	**242ECS005**	**CIE Marks**	40
Teaching Hours/Week(L: T:P)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	ContactHours (40 Hrs)
1	Mathematical Foundations for Program Analysis –Revision of Partially Ordered Sets, Lattice, Chains, Fixed Points, Knaster-Tarski Fixed Point Theorem, Galois Connections and their properties, Introduction to Program Analysis.	7
2	Data Flow Analysis / Abstract Interpretation Collecting Semantics, Abstract Interpretation, Join Over all Paths, Abstract Interpretation for Constant propagation, Correctness of Abstract Interpretation, Kildall's algorithm.	8
3	Interprocedural Analysis Call Strings approach, Join OverInterprocedurally Valid Paths, Sharir and Pneuli's approaches to Interprocedural Analysis, Functional Approach.	8
4	Pointer Analysis, PDGs and Slicing Pointer Analysis, Program Dependence Graph, Computing a Program Slice.	9
5	Simply Typed Lambda Calculus Introduction to Lambda Calculus, Type Systems, Algorithms for Type Checking	7

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Review article based on peer-reviewed publications (min. 10)	Course based task / Seminar/ Data collection and interpretation	Test paper (1 number)	Total
15	15	10	40

End Semester Examination Marks (ESE):

In Part A, all questions need to be answered and in Part B, each student can choose any four question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Examine the various mathematical concepts needed for program analysis, including lattice, chains and Galois connections.	**K4**
CO2	Investigate the role of abstract interpretation in static analysis of programs.	**K4**
CO3	Use various methods such as interprocedural analysis, pointer analysis and program slicing for program analysis.	**K4**
CO4	Use simply typed lambda calculus for developing type checking systems.	**K4**

CO5	Design, develop and implement solutions based on the concepts of program analysis.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Nielson, Nielson, and Hankin	Principles of Program Analysis	Springer-Verlag	
3	Gary A. Kildall	A unified approach to global program optimization	In POPL '73: Proceedings of the 1st ACM SIGACT-SIGPLAN symposium	1973
4	Patrick Cousot and Radhia Cousot	Abstract interpretation: a unified lattice model for static analysis of programs by construction or approximation of fixpoints	In POPL '77: Proceedings of the 4th ACM SIGACT-SIGPLAN symposium	1977
5	Anders Moller and Michael I. Schwartzbach	Static Program Analysis		
6	Micha Sharir and Amir Pnueli	Two approaches to interprocedural data-flow analysis	In Program Flow Analysis, Ed. Muchnik and Jones	1981
7	Tom Reps, Susan Horwitz, and Mooly Sagiv	Precise interprocedural dataflow analysis via graph reachability	In POPL ’95	
8	Manuvir Das, Sorin Lerner, and Mark Seigle	ESP: path-sensitive program verification in polynomial time	ACM SIGPLAN Notices	2002
9	Thomas Reps and Wuu Yang	The Semantics of Program Slicing	University of Wisconsin – Madison	
10	S. Horwitz, T. Reps, and D. Binkley	Interprocedural slicing using dependence graphs	Wisconsin – Madison	

11	Jeanne Ferrante, Karl J. Ottenstein, and Joe D. Warren	The program dependence graph and its use in optimization	ACM Transactions on Programming Languages and Systems	1987
12	Karl J. Ottenstein and Linda M. Ottenstein	The program dependence graph in a software development environment		
13	Benjamin C. Pierce	Types and Programming Languages		
14	L. Damas and R. Milner	Principal type-schemes for functional programs	In POPL '82	

SEMESTER - 2

BLOCKCHAIN TECHNOLOGY AND IOT

PROGRAM ELECTIVE

Course Code	**242ECS006**	**CIE Marks**	40
Teaching Hours/Week(L: T:P)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	ContactHours (40 Hrs)
1	Introduction to IoT Sensor basics, sensing and actuation, basics of networking - wired, wireless, MANET, PAN, wireless and wired protocols, Communication protocols - IEEE standards, 5G era, sensor communications, connectivity challenges, fading and attenuations.	**10**
2	IoT Architecture and Programming basic architectures, Data processing mechanisms, scalability issues and visualization issues, analytic basics, utility of cloud computing, fog computing, edge computing, Raspberry Pi and Arduino programming, Applications- IoT for industrial automation (Industry 4.0).	**10**

3	Introduction to Blockchain Blockchain concepts, evolution, structure and characteristics, benefits and challenges, Blockchain as public ledgers - Transactions, Elements of Cryptography - Cryptographic Hash functions, Merkle Tree.	**6**
4	Blockchain architecture and Use Cases Design methodology for Blockchain applications, Blockchain application templates, Blockchain application development, Ethereum, Solidity,Bitcoin, Sample use cases from Industries,Business problems.	**6**
5	Smart Contracts and Decentralized Applications (DApps) Smart contract smart contract examples, structure of a contract, smart contract examples, smart contract patterns, implementing Dapps, Ethereum Dapps, case studies related to Dapps.	**7**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Review article based on peer-reviewed publications (min. 10)	**Course based task / Seminar/ Data collection and interpretation**	**Test paper (1 number) with min. 80% of syllabus coverage**	**Total**
15	**15**	**10**	**40**

End Semester Examination Marks (ESE):

In Part A, all questions need to be answered and in Part B, each student can choose any four question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Analyze various protocols for IoT.	**K4**
CO2	Design IoT based applications using Arduino or Raspberry PI boards.	**K3**
CO3	Identify the need of blockchains to find the solution to the real-world problems.	**K4**
CO4	Recognize the underlying technology of transactions, blocks, proof-of-work, and consensus building.	**K4**
CO5	Design and implement new ways of using blockchain for real time applications.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	The Internet of Things: Enabling Technologies, Platforms, and Use Cases	Pethuru Raj, Anupama C. Raman	CRC Press	First
2	The Internet of Things in the Cloud: A Middleware Perspective	Honbu Zhou	CRC Press	First
3	Internet of Things: A Hands-on Approach	Arshdeep Bahga, Vijay Madisetti	Universities Press	First
4	Fog for 5G and IoT (Information and Communication Technology Series)	Mung Chiang, Bharath Balasubramanian, Flavio Bonomi	Wiley series	First
5	Blockchain Applications: A Hands-on Approach	Bahga A., Madisetti V.	VPT	
6	Beginning Blockchain: A Beginner's Guide to Building Blockchain Solutions	Bikramaditya Singhal, Gautam Dhameja, Priyansu Sekhar Panda	Apress	First
7	Blockchain: A Practical Guide to Developing Business, Law, and Technology Solutions	Joseph J. Bambara, Paul R. Allen	McGraw Hill	
8	Blockchain Enabled Applications	Vikram Dhillon, David Metcalf, Max Hooper	Apress	
9	The Business Blockchain: Promise, Practice, and Application of the Next Internet Technology	William Mougayar	Wiley	
10	Blockchain Science: Distributed Ledger Technology	Roger Wattenhofer	Inverted Forest Publishing	3rd

SEMESTER - 2
SOCIAL NETWORK ANALYSIS
PROGRAM ELECTIVE

Course Code	**242ECS007**	**CIE Marks**	40
Teaching Hours/Week(L: T:P)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours (40 Hrs)
1	**Introduction** : Introduction to Social Network Data Analytics: Introduction, Online Social Networks: Research Issues, Research Topics in Social Networks. Statistical Properties of Social Networks: Preliminaries, Static Properties, Dynamic Properties. Random Walks in Social Networks and their Applications: Random Walks on Graphs: Background, Application in Computer Vision, Text Analysis, Collaborative Filtering.	**8**
2	**Evolution in Social Networks**: Framework, Challenges of Social Network Streams, Incremental Mining for Community Tracing, Tracing Smoothly Evolving Communities. Models and Algorithms for Social Influence Analysis: Influence Related Statistics, Social Similarity and Influence. Privacy in Social Networks: Privacy breaches in social networks, Privacy-preserving mechanisms.	**8**

3	**Visualizing Social Networks**: A Taxonomy of Visualizing Social Networks: A Taxonomy of Visualizations. Data Mining in Social Media: Methods for Social Media, Ethnography and Netnography, Event Maps. Text Mining in Social Networks: Keyword Search, Classification and Clustering Algorithms, Transfer Learning in Heterogeneous Networks.	**8**
4	Mining Communities : Aggregating and reasoning with social network data, Advanced Representations - Extracting evolution of Web Community from a Series of Web Archive -Detecting Communities in Social Networks - Evaluating Communities – Core Methods for Community Detection & Mining - Applications of Community Mining Algorithms - Node Classification in Social Networks	**8**
5	Multimedia Information Networks in Social Media Multimedia Information Networks in Social Media: Links from Semantics, Links from Community Media. Network of Personal Photo Albums, Geographical Information, Inference Methods. Social Tagging and Applications: Tags: Why What, Tagging System Design, Tag analysis, Visualization of Tags, Applications of Tags.	**8**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Review article based on peer-reviewed publications (min. 10)	**Course based task / Seminar/ Data collection and interpretation**	**Test paper (1 number) with min. 80% of syllabus coverage**	**Total**
15	**15**	**10**	**40**

End Semester Examination Marks (ESE):

In Part A, all questions need to be answered and in Part B, each student can choose any four question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the concepts and properties of social networks.	K2
CO2	Analyze the concepts of evolution and privacy in social networks.	K4
CO3	Model and visualize social networks.	K4
CO4	Mine the behaviour of users in the Social Networks.	K4
CO5	Use Multimedia Information Networks in Social Media.	K4
CO6	Design, Develop, Implement and Present innovative ideas on Social network analysis concepts and techniques.	K6

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Social Network Data Analytics	Charu C. Aggarwal	Springer	
2	Social Networks and the Semantic Web	Peter Mika	Springer	2007
3	Handbook of Social Network Technologies and Applications	Borko Furht	Springer	2010
4	Web Mining and Social Networking: Techniques and Applications	Guandong Xu, Yanchun Zhang, Lin L	Springer	2011

SEMESTER - 2
MODERN DATABASE MANAGEMENT
PROGRAM ELECTIVE

Course Code	**242ECS008**	**CIE Marks**	40
Teaching Hours/Week(L: T:P)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)		**Course Type**	Theory

Course Objectives:

This course provides an exposure to the concepts and techniques in modern data management. Different types of NoSQL databases, their architecture and use cases are discussed in this course. A better understanding of data management is provided through MongoDB, Cassandra and Neo4J databases. This course helps the learners to develop applications that manage data efficiently with the help of suitable data models and techniques.

SYLLABUS

Module No.	Syllabus Description	ContactHours (40 Hrs)
1	NoSQL Databases Review of Distributed Databases- Fragmentation, Replication, Transparencies in design, CAP theorem- BASE transactions and eventual consistency, consistent hashing, object versioning & vector clocks, Consensus algorithms, Logging & Snapshots, Properties of NoSQL databases, Types of NoSQL Databases.	**8**
2	Document based databases MongoDB- Documents- JSON & BSON format, representing relationships, CRUD operations, Indexing, Aggregation, Sharding architecture and Replication strategies, consistency and locking.	**10**

3	Spatial Databases Types of Spatial Data and Queries- Point and Region Data- Queries, Spatial Indexing: Space Filling Curves- Z ordering, Quad Trees, R-Trees, Geospatial queries & geospatial indexes in MongoDB.	**8**
4	Column databases Column family, Cassandra Architecture-Gossiping, Snitches, Rings and Tokens, Virtual Nodes, Replication Strategies, Consistency, Hinted handoff, Lightweight Transactions, Bloom filter, Compaction; Fault tolerance, Caching, SSTable & MemTable, Cassandra Query Language	**8**
5	Graph Databases Neo4j- Introduction, Example graphs, Data Modeling, Traversal, Indexing, Features, operations, Cypher Queries- Create, Match clause.	**6**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Review article based on peer-reviewed publications (min. 10)	Course based task / Seminar/ Data collection and interpretation	Test paper (1 number) with min. 80% of syllabus coverage	Total
15	**15**	**10**	**40**

End Semester Examination Marks (ESE):

n Part A, all questions need to be answered and in Part B, each student can choose any four question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Analyze issues and solutions in modern databases.	K2
CO2	Employ and operate on document databases and techniques.	K3
CO3	Apply spatial database concepts to efficiently organise and retrieve spatial data.	K3
CO4	Research, analyze and use emerging technologies in column store.	K4
CO5	Practice techniques in Graph database.	K4
CO6	Design, Develop, Implement and Present innovative ideas on modern database concepts and techniques.	K6

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Next Generation Databases: NoSQL, NewSQL, and Big Data	Guy Harrison	Apress	2016
2	Database Systems: A Practical Approach to Design, Implementation and Management	Thomas Cannolly, Carolyn Begg	Pearson Education	6/e 2015
3	Database System Concepts	Henry F. Korth, Abraham Silberschatz, S. Sudharshan	Tata McGraw Hill	7/e 2019
4	NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence	Pramod Sadalage, Martin Fowler	Addison-Wesley	2012

5	MongoDB: The Definitive Guide	Shannon Bradshaw, Eoin Brazil, Kristina Chodorow	O'Reilly	3/e 2019
6	Graph Databases	Ian Robinson, Jim Webber, Emil Eifrem	O'Reilly	2013
7	Cassandra: The Definitive Guide	Jeff Carpenter, Eben Hewitt	O'Reilly	3/e2020
8	NoSQL for Mere Mortals	Dan Sullivan	Addison-Wesley	2015
9	Database Internals: A Deep Dive into How Distributed Data Systems Work	Alex Petrov	O'Reilly	2019
10	Seven Databases in Seven Weeks: A Guide to Modern Databases and the NoSQL Movement	Luc Perkins, Eric Redmond, Jim Wilson	O'Reilly	2/e 2018
11	Learning Neo4j 3.x	Jérôme Baton, Rik Van Bruggen	Packt	2/e 2017
12	Neo4j in Action	Aleksa Vukotic, Nicki Watt	Manning Publications	2015
13	Spatial Databases: A Tour	Shashi Shekhar, Sanjay Chawla	Pearson Education	Indian Edition, First Impression 2009
14	Web Resource: Neo4j Operations Manual		Neo4j Documentation	

SEMESTER - 2
DISTRIBUTED ALGORITHMS
PROGRAM ELECTIVE

Course Code	**242ECS009**	**CIE Marks**	40
Teaching Hours/Week(L: T:P)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)		**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	ContactHours (40 Hrs)
1	Synchronous distributed computing system Synchronous distributed computing system, Leader Election in a Synchronous Ring, LCR algorithm, HS algorithm, Time Slice Algorithm, Variable Speeds Algorithm, Lower Bound for Comparison-Based Algorithms.	**8**
2	Algorithms in General Synchronous Networks Algorithms in General Synchronous Networks. Leader election in a General Network - Simple Flooding Algorithm, Basic Breadth- First Search Algorithm, Bellman-Ford algorithm, Minimum Spanning Tree, Maximal Independent Set, LubyMIS algorithm.	**8**
3	Distributed Consensus Distributed Consensus, Distributed Consensus with Link Failures – The coordinated Attack Problem- Deterministic version, Randomized version. Distributed Consensus with Process Failures and Process Failures. Algorithms for stopping Failures, Algorithms for Byzantine Failure. Byzantine agreement in general graphs. Weak Byzantine agreement. Consensus Problems-K Agreement, Approximate Agreement, Commit Problem.	**8**

4	Asynchronous distributed computing system Asynchronous distributed computing system, Asynchronous Network Model - Send/Receive systems, Broadcast systems, Multicast systems. Asynchronous Network algorithms- Peterson Leader-Election Algorithm, Local Synchronizer, Safe Synchronizer.	**7**
5	Asynchronous Shared Memory Systems Asynchronous Shared Memory Systems, Environment Model, Shared Variable Types. Mutual Exclusion - Asynchronous Shared Memory Model, Dijkstra's Mutual Exclusion Algorithm. Resource Allocation - Nonexistence of Symmetric Dining Philosophers Algorithms, Right-Left Dining Philosophers Algorithm, Mutual exclusion and Consensus, Relationship between shared memory and network models.	**9**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Review article based on peer-reviewed publications (min. 10)	Course based task / Seminar/ Data collection and interpretation	Test paper (1 number) with min. 80% of syllabus coverage	Total
15	**15**	**10**	**40**

End Semester Examination Marks (ESE):

In Part A, all questions need to be answered and in Part B, each student can choose any four question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the working of problem domain in synchronous distributed computing system	K2
CO2	Develop algorithms for synchronous distributed computing system	K3
CO3	Examine the consensus problem in a distributed computing system.	K3
CO4	Illustrate the use of different communication models in asynchronous distributed computing systems	K3
CO5	Develop algorithms for various resource allocation problems in Asynchronous distributed computing systems.	K3
CO6	Design, Develop, Implement and Present innovative ideas on distributed algorithms and techniques.	K6

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Distributed Algorithms	Nancy A. Lynch	Morgan Kaufmann Publishers, Inc.	1996
2	Elements of Distributed Algorithms: Modeling and Analysis with Petri Nets	Wolfgang Reisig	Springer-Verlag	1st Edition, 1998
3	Introduction to Distributed Algorithms	Tel Gerard	Cambridge University Press	2nd Edition, 2000
4	An Introduction to Distributed Algorithms	Valmir C. Barbosa	MIT Press	1996
5	Distributed Operating Systems and Algorithm Analysis	Randy Chow, Theodore Johnson	Pearson Education	2009

SEMESTER S2
CYBER FORENSICS AND INFORMATION SECURITY
PROGRAM ELECTIVE

Course Code	**242ECS010**	**CIE Marks**	40
Teaching Hours/Week(L: T:P)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours (44 Hrs)
1	**Introduction to Computer Forensics** : Computer Forensics Fundamentals, Types of Computer Forensics Technology – Types of Computer Forensics Systems-Data Recovery and Evidence Collection– Forensic duplication and preservation of DE, Understanding Computer Investigation.	**8**
2	**Evidence Data Gathering :** Data Acquisition. - Data Recovery- Evidence Collection and Data Seizure - Duplication and Preservation of Digital Evidence.	**11**
3	**Investigations :** Network Traffic , Web Attacks, Router Forensics, DoS Attacks and Internet Crime.	**6**
4	**Evidence Data Analysis :** Discovery of Electronic Evidence - Identification of Data - Determining and Validating Forensics Data – Data Hiding Techniques – Performing Remote Acquisition– Cell Phone and Mobile Devices Forensics-Processing Crime and Incident Scenes.	**7**

5	**Forensics Tools and Case Studies :** Working with Windows and DOS Systems. - Understanding File systems, Exploring Microsoft file structures, Examining NTFS disks, Understanding whole disk encryption, windows registry, Microsoft start-up tasks. Current Computer Forensics Tools: Software/ Hardware Tools. Computer forensics investigation – A case study	8

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications	Course based task / Seminar/ Data collection and interpretation	Internal Examination-1 (Written)	Total
15	15	10	40

End Semester Examination Marks (ESE):

In Part A, all questions need to be answered and in Part B, each student can choose any four question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Apply forensics technologies, data recovery , evidence collection and handling different forensics issues.	**K3**
CO2	Solve the issues of Data Acquisition and Data Recovery.	**K3**
CO3	Investigate network intrusions and attacks.	**K4**
CO4	Validating Forensics data and process crime, incident scene.	**K4**
CO5	Exploring file structures and perform forensics investigation.	**K4**
CO6	Design, Develop, Implement and Present innovative ideas on different digital forensic investigation model.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	"Computer Forensics"	John R.Vacca	Cengage Learning, India Edition	2nd Edition, 2005
2	"Internet Cryptography"	Richard E.Smith	Pearson Education	3rd Edition, 2008
3	"Computer Forensics and Cyber Crime": An Introduction"	Marjie T.Britz	Prentice Hall	3rd Edition, 2013
4	"Internet Security: Cryptographic Principles", "Algorithms and protocols"	Man Young Rhee	Wiley Publications	1st Edition 2003.
5	Computer Forensics and Investigations"	Nelson, Phillips, Enfinger, Steuart	Cengage Learning, India Edition	4th Edition, 2008

SEMESTER S2
SOFTWARE TESTING
PROGRAM ELECTIVE

Course Code	**242ECS011**	**CIE Marks**	40
Teaching Hours/Week(L: T:P)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)		**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours (44 Hrs)
1	**Testing Fundamentals:** Introduction, black box testing, white box testing, static black box testing, dynamic black box testing, static white box testing, dynamic white box testing.	**7**
2	**Introduction to JUnit :** Introduction to Unit Testing in Java, Test Class, Test Method, Assertions, JUnit Life Cycle API, Test Execution, JUnit Test Framework.	**8**
3	**Introduction to Selenium :** Introduction, Selenium methods, Verification Point in Selenium, Shared UI Maps, Using functions, Using a configuration file, Data Driven Testing, UI Objects, Debugging, Exception Handling, Reporting, Batch Execution, Continuous Integration with Jenkins.	**8**
4	**Coverage Guided Fuzzing Using American Fuzzy Lop (AFL) :** Basic test input generation, AFL as a grey box fuzzer, Characteristics of retained test cases, vulnerability detection, Measuring the code coverage, AFL algorithm.	**7**
5	**Bounded Model Checking with CBMC :** Principles of BMC, The CBMC tool, Applications of BMC, CBMC Hands on.	**7**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications	Course based task / Seminar/ Data collection and interpretation	Internal Examination- 1 (Written)	Total
15	15	10	40

End Semester Examination Marks (ESE):

In Part A, all questions need to be answered and in Part B, each student can choose any four question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain various concepts in software testing including black box testing and white box testing.	**K2**
CO2	Develop test cases in JUnit to verify the behavior of independent components of a program.	**K5**
CO3	Use Selenium to automate tests across web browsers to verify that the application behaves as expected.	**K5**
CO4	Use American Fuzzy Lop (AFL) to efficiently increase the coverage of test cases and to automatically discover clean, interesting test cases that trigger new internal states in the targeted binary.	**K4**

CO5	Perform bounded model checking for C programs using the tool CBMC.	**K5**
CO6	Design, develop and implement solutions based on the concepts of software testing.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Software Testing	Ron Patton	Sams Publishing, Pearson Education,	2nd Edition, 2007
2	Java unit Testing with JUnit 5	Shekhar Gulati and Rahul Sharma	Apress	3rd Edition, 2008
3	Test Automation Using Selenium WebDriver with java	Navneesh Garg	AdactIn Group Pty Ltd	3rd Edition, 2014

SEMESTER S2
PYTHON FOR MACHINE LEARNING
PROGRAM ELECTIVE

Course Code	**242ECS012**	**CIE Marks**	40
Teaching Hours/Week (L: T:P)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Basic knowledge in Computational Problem Solving.	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Programming Environment and Python Basics:** Getting started with Python programming – Interactive shell, IDLE, iPython Notebooks, Detecting and correcting syntax errors, How Python works. The software development process – A case study. Basic coding skills – strings, assignment, and comments, Numeric data types and character sets, Expressions, Using inbuilt functions and modules. Control statements – Iteration with for/while loop, Formatting text for output, A case study, Selection structure, Conditional iteration with while, A case study, Testing control statements, Lazy evaluation.	**8**

2	**Building Python Programs:** Strings and text files – Accessing characters, substrings, Data encryption, Strings and number system, String methods, Text files. A case study on text analysis. Design with Functions – Functions as Abstraction Mechanisms, Problem solving with top-down design, Design with recursive functions, Managing a program's namespace, Higher-Order Functions. Lists - Basic list Operations and functions, List of lists, Slicing, Searching and sorting list, List comprehension. Work with tuples. Sets. Work with dates and times, A case study with lists. Dictionaries - Dictionary functions, dictionary literals, adding and removing keys, accessing and replacing values, traversing dictionaries, reverse lookup. Case Study – Data Structure Selection.	**9**
3	**Graphics:** Graphics – Terminal-based programs, Simple Graphics using Turtle. Operations, 2D Shapes, Colors and RGB Systems, A case study Image Processing – Basic image processing with inbuilt functions. Graphical User Interfaces – Event-driven programming, Coding simple GUI-based programs: Windows, Labels, Displaying images. Input text entry, Popup dialog boxes, Command buttons, A case study.	**8**
4	**Object Oriented Programming:** Design with classes - Objects and Classes, Methods, Instance variables, Constructor, Accessor and Mutator, Data-Modeling Examples, Structuring classes with inheritance and polymorphism. Abstract classes, Interfaces, Exceptions-Handle a single exception. handle multiple exceptions.	**7**

5	**Data Processing:** The os and sys modules, NumPy - Basics, Creating arrays, Arithmetic, Slicing, Matrix Operations, Random numbers. Plotting and visualization. Matplotlib - Basic plot, Ticks, Labels, and Legends. Working with CSV files. – Pandas - Reading, Manipulating, and Processing Data. Introduction to Micro services using Flask.	8

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	Course based task/Seminar/Data collection and interpretation	Internal Examination-1 (Written)	Total
15	15	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any five question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Write, test and debug Python programs.	**K3**
CO2	Illustrate uses of conditional (if, if-else and if-elif-else) and iterative (while and for) statements in Python programs.	**K3**
CO3	Develop programs by utilizing the Python programming constructs such as Lists,Tuples, Sets and Dictionaries.	**K3**
CO4	Develop graphical user interface for solutions using Python libraries.	**K3**
CO5	Implement Object Oriented programs with exception handling.	**K3**
CO5	Write programs in Python to process data stored in files by utilizing Numpy, Matplotlib, and Pandas.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Python : First Programs, 2/e	Kenneth A Lambert.	Cengage Publishing,	2016
2	Python for Data Analysis	Wes McKinney,	Shroff / O'Reilly Publishers	2017
3	Flask: Building Python web services	Jack Stouffer, Shalabh Aggarwal, Gareth Dwyer,	PACKT Publishing Limited,	S2018
4	Introduction to Machine Learning	Ethem Alpaydin	MIT Press	2nd edition & 2010
5	Learn Python 3 The Hard Way	Zed A Shaw	Addison-Wesley	2017

SEMESTER S2

DEEP LEARNING FOR COMPUTER VISION

PROGRAM ELECTIVE

Course Code	**242ECS013**	**CIE Marks**	40
Teaching Hours/Week (L: T:P)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Completion of a basic course in Machine Learning.	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction and Overview:** Image Representation, Linear Filtering, Correlation, Convolution, Edge Detection, From Edges to Blobs and Corners, Scale Space, Image Pyramids and Filter Banks SIFT and Variants.	7
2	**Neural Networks:** A Review Feedforward Neural Networks and Backpropagation, Gradient Descent and Variants Regularization in Neural Networks, Improving Training of Neural Networks **Convolutional Neural Networks for Image Classification:** An Introduction, Backpropagation in CNNs, CNN Architecture for Image Classification.	7
3	**Evolution of CNN Architectures:** VGG, Inception, ResNets, ResNet Variants, MobileNet, EfficientNet, Finetuning CNNs, Visualizing CNNs. **CNNs for Object Detection and Segmentation:**CNNs for Object Detection: Two-stage Models,Single-stage Models,	9

	CNNs for Segmentation.	
4	**Recurrent Neural Networks and their use in Vision:** Recurrent Neural Networks: Introduction, Backpropagation in RNNs, LSTMs and GRUs, Video Understanding using CNNs and RNNs. **Attention Models and Transformers:** Attention in Vision Models: An Introduction Soft and Hard Attention: Image Captioning, Self-Attention and Transformers. **Vision Transformers and Applications:** From Transformers to Vision Transformers, Transformers for Detection ,Transformers for Segmentation.	**9**
5	**Deep Generative Models: GANs and VAEs:** Deep Generative Models: An Introduction, Generative Adversarial Networks, GAN Hacks and Improvements, Variational Autoencoders and Disentanglement. **Introduction to Diffusion Models:** DDPMs, Classifier and Classifier-Free Diffusion Guidance, Text-conditioned Diffusion Models, Under the Hood: Sampling, Prediction Space, Noise Schedules, Architectures.	**8**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	**Course based task/Seminar/Data collection and interpretation**	**Internal Examination-1 (Written)**	**Total**
15	**15**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any five question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand image representation, filtering, edge detection, and advanced features like scale space and SIFT.	K3
CO2	Design and fine-tune CNNs for classification, detection, and segmentation tasks.	K3
CO3	Apply RNNs, LSTMs, and GRUs for video and sequential data understanding.	K6
CO4	Implement GANs, VAEs, and diffusion models for generative tasks.	K6
CO5	Solve advanced vision problems using cutting-edge architectures and techniques.	K6

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Computer Vision: Algorithms and Applications, 2nd ed.	Richard Szeliski	Springer	2011
2	Pattern Recognition and Machine Learning	Bishop, Christopher M	Springer	2006
3	Neural Networks for Pattern Recognition	Bishop, Christopher	New York, NY: Oxford University Press	1995
4	Computer Vision: Models, Learning, and Inference	Simon J. D. Prince	Cambridge University Press	2012

SEMESTER S2

STATISTICAL MACHINE LEARNING

PROGRAM ELECTIVE

Course Code	**242ECS014**	**CIE Marks**	40
Teaching Hours/Week (L: T:P)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Familiarity with machine learning concepts and basic statistics	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction -** Introduction to Statistical Learning, Variance and bias trade-off, Model evaluation. Linear Regression - Linear regression review, Model assessment, Some practical issues. supervised and unsupervised learning, loss functions, train and test errors, bias-variance tradeoff, model complexity and overfitting, linear regression, k- nearest neighbors. Statistical Inference: Maximum Likelihood Estimators, Bayes Estimator, Method of Moments.	**8**
2	**Regression:** linear regression, model selection, ridge and Lasso. Basis function models : Basis expansions, smoothing splines, additive models, backfitting, sparse additive models	**9**
3	**Classification:** Gaussian discriminant analysis, linear discriminant analysis, logistic regression. Resampling methods: cross-validation, bootstrap.	**8**

4	**Support vector machines and kernels :** perceptron algorithm, Max margin classification, separating hyper- planes, the kernel trick, nonlinear decision boundaries, Tree-based methods: classification and regression trees, bagging, random forests.	7
5	**Boosting:** AdaBoost, gradient boosting machines. Unsupervised learning: principal component analysis, k- means, Gaussian mixtures and the EM algorithm.	8

Course Assessment Method(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	Course based task/Seminar/Data collection and interpretation	Internal Examination-1 (Written)	Total
15	15	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any five question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	60

Course Outcomes (COs)

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Formulate appropriate models for empirical data	**K3**
CO2	Estimate the parameters of a statistical model	**K3**
CO3	Interpret the fit of a model to data	**K3**
CO4	Justify the choice of a model/technique to analyze empirical data	**K3**
CO5	Explain the mathematical/statistical mechanisms of most common machine learning algorithms	**K3**

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Elements of Statistical Learning	T. Hastie, R. Tibshirani, J Friedman,	Springer	2009
2	Machine Learning: a Probabilistic Perspective,	K. Murphy	MIT Press	2012
3	Pattern Recognition and Machine Learning,	C. Bishop	Springer	2007

SEMESTER S2

PRINCIPLES OF DATA SCIENCE

PROGRAM ELECTIVE

Course Code	**242ECS015**	**CIE Marks**	40
Teaching Hours/Week (L: T: P)	3:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Familiarity with Data preprocessing and machine learning concepts	**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Data Science -** A brief introduction to data – structured, unstructured, semi-structured, data sets & patterns, Brief history of Data Science, Introduction to Data Science, Importance of Data Science, Differences between AI, ML, DL, Data Science & Data Analytics, Real world applications of data science, Steps in data science process. Simple case study based on real life applications such as - Market research case, tracking disease outbreaks, business predictions, (for example, Rating a product design) etc., Ethical and privacy implications of Data Science. Tools and Skills Needed – brief introduction of platforms, tools, frameworks, languages, databases and libraries, Current trends & major research challenges in data science.	**8**
2	**Data Mining & Preprocessing:** Data Mining, Kinds of data - mining, Data Preprocessing. An Overview - Data Quality, Need to preprocess the data. Major Tasks in Data Preprocessing.	**9**

	Data cleaning - Missing Values Noisy Data, Data Cleaning as a Process, Data Integration, Data Reduction, Data transformation and Data Discretization. Introduction to Data Visualization.	
3	**Classification Models:** Classification - Basic Concepts, Decision Tree Induction, Bayes Classification Methods- Naıve Bayesian Classification, Rule-Based Classification. Classification Advanced Methods - Bayesian Belief Networks, Classification by Back propagation, A Multilayer Feed-Forward Neural Network, Back propagation, Support Vector Machines, Lazy Learners, K-Nearest-Neighbour Classifiers, Case-Based Reasoning.	**8**
4	**Association Mining and Cluster Analysis :** Mining Frequent Patterns, Associations, and Correlations. Basic Concepts Frequent Itemset Mining Methods, Apriori Algorithm, Generating Association Rules from Frequent Itemsets Cluster Analysis, Partitioning Methods, Hierarchical Methods, Agglomerative versus Divisive Hierarchical Clustering, Distance Measures in Algorithmic Methods. Density-Based Methods - DBSCAN.	**7**
5	**Evaluation:** Evaluating model performance-Confusion matrices, Precision and recall, Sensitivity and specificity, F-measure, ROC curves, Cross validation, K-fold cross validation, Bootstrap sampling. Improving model performance - Bagging, Boosting, Random forests.	**8**

Course Assessment Method(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	**Course based task/Seminar/Data collection and interpretation**	**Internal Examination -1 (Written)**	**Total**
15	**15**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any five question out of seven questions

Part A	Part B	Total
• 8 numerical questions with minimum 1 question from each module • Answer all questions, each carrying 4 marks **(8x4 =32 Marks)**	• Contain 7 questions. • Minimum one question from each module of which student should answer any four. • Each question can carry 7 marks. **(4x7 = 28 marks)**	**60**

Course Outcomes (COs)

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Recall the fundamental concepts and applications of data science, and make inferences on key important points.	K3
CO2	Identify the concepts in data mining and analyze the different steps in data preprocessing.	K3
CO3	Illustrate the concepts of classification methods.	K3
CO4	Perform association mining and analyze clusters using different methods.	K3
CO5	Evaluate & improve the performance of machine learning classification models.	K3

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Data Science	Sanjeev J. Wagh, Manisha S. Bhende, and Anuradha D. Thakare	CRC press	
2	Data mining Concepts and Techniques	Jiawei Han, Michelin Kamber, Jian Pei	Morgan Kaufmann Publishers	Third Edition, 2012
3	Machine Learning with R	Brett Lantz	PackT publishing	Second edition, 2015

SEMESTER III

SEMESTER S3
ACADEMIC WRITING
AUDIT COURSE

Course Code	**243AGE100**	**CIE Marks**	40
Teaching Hours/Week(L: T: P)	3:0:0	**ESE Marks**	60
Credits		**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)		**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours (44 Hrs)
1	Fundamentals of Academic writing from a reader's perspective: acronyms,synonyms, pronouns, disconnected phrases, background ghettos, abusive detailing, cryptic captions, long sentences : all that take their toll on reader's memory.	6
2	Fluid reading & reading energy consumption: setting expectations and laying Progression tracks; Reading energy consumption	6
3	How to write the Title, abstract, introduction ; Structure the writing with headings & subheadings	6
4	Visuals: Resources, Skills, and Methods; Conclusion; References;Bibliography; Grammar in technical writing	6
5	Techniques of writing: An extended abstract, a project proposal, a research paper, a technical report.	6

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Course based task	Seminar/Quiz	Internal Examination- 1 (Written)	Total
15	15	10	40

End Semester Examination Marks (ESE):

The examination will be conducted by the College	
Part A	**Total**
• The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Vive. • Each question can carry 12 marks.	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome	
CO1	Understand the principles of scientific/ academic writing
CO2	Analyse the technique of scientific writing from the reader's perspective
CO3	Apply the concepts of setting expectations and laying the progression tracks
CO4	Evaluate the merits of a title, abstract , introduction, conclusion and structuring of a research paper
CO5	Justify the need using a project proposal or a technical report
CO6	Prepare a review paper, an extended abstract and a project proposal

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	SCIENTIFIC WRITING 2.0 A Reader and Writer's Guide	Jean-Luc Lebrun	World ScientiFic Publishing Co. Pte. Ltd	2011
2	How to Write and Publish a ScientiFic Paper	Barbara Gastel and Robert A.Day	Greenwood publishers	2016
3	Grammar, Punctuation, and Capitalisation; a handbook for technical writers and editors.		www.sti.nasa.gov/publish/sp7084.pdf www.sti.nasa.gov/sp7084/contents.html	
4	Everything You Wanted to Know About Making Tables and Figures		http://abacus.bates.edu/%7Eganderso/biology/resources/writing/HTWtableVigs.html	

SEMESTER S3
ADVANCED ENGINEERING MATERIALS
AUDIT COURSE

Course Code	**243AGE001**	**CIE Marks**	40
Teaching Hours/Week(L: T:P)	3:0:0	**ESE Marks**	60
Credits		**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)		**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours (44 Hrs)
1	Requirements / needs of advanced materials. Classification of materials, Importance of materials selection, Criteria for selection of materials; motivation for selection, cost basis and service requirements. Relationship between materials selection and processing.	**5**
2	Classification of non-metallic materials. Polymer, Ceramics: Properties, processing and applications. Nanocomposites - Polymer nanocomposites (PNCs), Processing and characterisation techniques – properties and potential applications	**7**
3	Functionally graded materials (FGMs), Potential Applications of FGMs, classification of FGMs, processing techniques. limitations of FGMs.	**6**
4	Smart Materials: Introduction, smart material types - pyroelectric sensors, piezoelectric materials, electrostrictors and magnetostrictors, shape memory alloys – associated energy stimulus and response forms, applications	**5**

5	High Temperature Materials: super alloys – main classes, high temperature properties of superalloys, applications. Energy Materials: materials for batteries.	**7**

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Course based task	Seminar/Quiz	Internal Examination- 1 (Written)	Total
15	**15**	**10**	**40**

End Semester Examination Marks (ESE):

The examination will be conducted by the College	
Part A	**Total**
• The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. • Each question can carry 12 marks.	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome
CO1	Analyse the requirement and find appropriate solution for use of materials
CO2	Differentiate the properties of polymers, ceramics and composite materials.
CO3	Recognize basic concepts and properties of functional materials.
CO4	Comprehend smart and shape memory materials for various applications.
CO5	Appraise materials used for high temperature, energy production and storage applications.

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6-Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	DeGarmo et al, "Materials and Processes in Manufacturing"	Wiley		10th Edition, 2008.
2	Physical Metallurgy and Advanced Materials	R.E. Smallman and A.H.W. Ngan	Butterworth-Heinemann	Seventh Edition, 2007
3	"Functional Materials: A chemist's perspective"	Vijayamohanan K. Pillai and Meera Parthasarathy	Universities Press	2012
4	Smart Materials and Structures	M.V. Gandhi, B.S. Thompson	Chapman & Hall	1992
5	Materials for High Temperature Engineering Applications (Engineering Materials)	G. W. Meetham and M. H. Van de Voorde	Springer	1st Edition, 2000
6	"Smart Structures Theory"	Inderjit Chopra,Jayant Sirohi	Cambridge University Press	2013

SEMESTER 3
FORENSIC ENGINEERING
AUDIT COURSE

Course Code	**243AGE002**	**CIE Marks**	**40**
Teaching Hours/Week (L: T:P:R)	**3:0:0:0**	**ESE Marks**	**60**
Credits	**—--**	**Exam Hours**	**2 Hrs. 30 Min.**
Prerequisites (if any)	**—---**	**Course Type**	**Theory**

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Forensic Engineering :**Forensic Engineering-Definition, Investigation Pyramid, Eyewitness Information, Role in Legal System,Scientific Method-Applying scientific methods in Forensic Engineering-Engineer as expert Witness-Scientific methods and legal system ,Qualification of Forensic Engineer-Technical- Knowledge-Oral-written-Communication-other skills-Personality Characteristics,Ethics and professional responsibilities.	6
2	**Forensic Engineering Workflow and Investigation Methods:** Forensic Engineering Workflow-Team &nplanning-preliminary onsite investigation. Sampling-selection of sample-collection- packing-sealing of samples.Source and type of evidence - Paper documentation- digital documentation-electronic data. Physical Evidence-Collection of photograph-cataloguing -Recognizing the Evidence-organizing-Evidence Analysis -Reporting,Investigation Methods- Cause and Causal mechanism analysis-Time and event sequence-STEP method. Human Factors, Human errors - Analysis of Operative Instruction and working Procedures	6

3	**Physical Product Failure & Analytical Methods:** Introduction to typical Forensic Engineering Toolbox-NDT, Crack detection and human eye -Hardness testing- and Destructive testing Methods with case studies ,Indirect stress strain Analysis-Brittle lacquer technique, Contact Radiography-Metallography-EDAX method,Forensic Optical Microscopy-Examination- Magnification-USB Microscopy -Wifi Enabled microscopy -Reflected microscopy,Novel Tools and System -Contour Method-Flash Thermography- Thermographic signal reconstruction (TSR)-Electromagnetically induced acoustic Emission (EMAE)-Pulsed Eddy Current (PEA)-Theory only	6
4	**Cyber Forensic , Civil ,Electrical Accidents & Standards:** Basics of Digital & Cyber forensics: Technical concepts; labs and tools; collecting evidence Operating System Forensic basics with - Windows, Linux -Mobile Forensic-Anti forensics-Malware- Web attack forensics with Email Crimes-Cyber Laws, Different types of Forensic accident investigations- Civil Engineering - Structural - Road accidents -Fire accidents - Water related accidents-Electrical accidents and Investigation methods,Protocol for forensic Investigations-Standard guides-scope significance - use -procedures- reports. Standards – ASTM standards -FMV Standards - SAE Standards -Relevant Standards -NFPA Standards - International Standards	6
5	**Engineer in the Courtroom Criminal Cases:**Role of an Engineering Expert-Report-pre trial meetings-Alternative Dispute resolution-Single joint expert. Engineer in the courtroom,Criminal Cases-Introduction-Counterfeit coins-fraudulent road accidents-Fraudulent Insurance claims.Cyber Crimes and Cases- SIM Swapping -ATM Cloning-MicrosoftInternal Spam-Intellectual property cases.	6

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Course based task	Seminar/Quiz	Internal Examination-1 (Written)	Total
15	15	10	40

End Semester Examination Marks (ESE)

The examination will be conducted by the College	
Part A	**Total**
• The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. • Each question can carry 12 marks.	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	**Bloom's Knowledge Level (KL)**
CO1	**Identify the fundamental aspects of forensic Engineering**	**K1**
CO2	**Apply forensic Engineering in Practical workflow and Investigation**	**K3**
CO3	**Apply methods and analysis in Forensic Investigation**	**K2**
CO4	**Develop practical strategies and standards of Investigation**	**K6**
CO5	**Create an awareness in criminal cases and create Engineering expertise in court room on forensic Engineering**	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Forensic EngineeringThe Art &Craft of a failure detective	Colin R Gagg,	Taylor & Francis Publishing,	2020
2	Luca Marmo Principles of Forensic Engineering Applied to Industria	Luca Fiorentini	Wiley	2019

	Accidents			
3	Forensic Engineering Fundamentals	Harold Franck, Darren Franck	Taylor & Francis publishing	2013
4	Forensic Engineering Investigation	Randall K Noon	CRC press limited	2001
5	Forensic Engineering: Damage assessment for residential and commercial structures	Stephen E Petty	CRC press	2nd edition , 2017
6	Guideliness for forensic Engineering practice	Joshua B Kardon	Guideliness for forensic Engineering practice	2012
7	Engineering standards for forensic Applications	Richard W. Mclay and Robert N. Anderson	Academic Press	1st edition 2018
8	Forensic Engineering (Advanced forensic Science)	Max M Houck	Academic press	1st edition 2017
9	Practical Cyber Forensics. An Incident-based Approach to ForensicInvestigations	Niranjan Reddy	Apress	2019
10	Forensic Materials Engineering Case Studies	Peter Rhys Lewis, Ken Reynolds, Colin Gagg	CRC Press	2003

SEMESTER S3
DATA SCIENCE FOR ENGINEERS
AUDIT COURSE

Course Code	**243AGE003**	**CIE Marks**	40
Teaching Hours/Week(L: T:P)	3:0:0	**ESE Marks**	60
Credits		**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)		**Course Type**	Theory

SYLLABUS

Module No.	Syllabus Description	ContactHours (44 Hrs)
1	**Statistics for Data science** Probability: Basic concepts of probability, conditional probability, total probability, independent events, Bayes' theorem, random variable, Population, Sample, Population Mean, Sample Mean, Population Distribution, Sample Distribution and sampling Distribution, Mean, Mode, Median, Range, Measure of Dispersion, Variance, Standard Deviation, Gaussian/Normal Distribution, covariance, correlation	6
2	**Linear Algebra** Vectors and their properties, Sum and difference of Vectors, distance between Vectors, Matrices,Inverse of Matrix, Determinant of Matrix, Trace of a Matrix, Dot Product, Eigen Values, Eigen Vectors, Single Value Decomposition	6
3	**Hypothesis Testing** Understanding Hypothesis Testing, Null and Alternate Hypothesis, Non-directional Hypothesis, Directional Hypothesis Critical Value Method, P-Value Method, Types of Errors-Type1 Error,Type2 Error, Types of Hypothesis Test Z Test, Chi-Square.	6

4	**Exploratory Data Analysis** Data Collection –Public and Private Data, Data Cleaning-Fixing Rows and Columns, Missing Values, Standardizing values, invalid values, filtering data, Data-Integration,Data-Reduction,Data Transformation	6
5	**Machine Learning and Python for Data Science** Python Data structures-List, Tuple, Set, Dictionary, Pandas, Numpy, Scipy, Matplotlib, Machine Learning Supervised Machine Learning, Unsupervised Machine Learning,Regression, Classification, Naïve-Bayes	6

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Course based task	Seminar/Quiz	Internal Examination- 1 (Written)	Total
15	15	10	40

End Semester Examination Marks (ESE):

The examination will be conducted by the respective College	
Part A	**Total**
• The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Vive. • Each question can carry 12 marks.	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome	
CO1	Study Data Science Concepts and statistics
CO2	Demonstrate Understanding of Mathematical Foundations needed for Data Science
CO3	Understand Exploratory analysis and Data Visualization and Preprocessing on given dataset
CO4	Implement Models such as Naive Bayes, K-Nearest Neighbors, Linear and Logistic Regression
CO5	Build real time data science applications and test use cases

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Python Data Science Handbook. Essential Tools for Working with Data	Jake VanderPlas	O'Reilly Media	2016
2	Practical Statistics for Data Scientists:	Peter Bruce, Andrew Bruce	O'Reilly Media	2017
3	Practical Linear Algebra for Data Science	Mike X Cohen	O'Reilly Media	2022
4	Data Science from Scratch	Joel Grus	O'Reilly Media	2015
5	Hands-On Exploratory Data Analysis with Python	Suresh Kumar Mukhiya, Usman Ahmed	Packt Publishing	2020

SEMESTER 3
DESIGN THINKING
AUDIT COURSE

Course Code	**242AGE004**	**CIE Marks**	**40**
Teaching Hours/Week (L: T:P)	**3:0:0**	**ESE Marks**	**60**
Credits	**--**	**Exam Hours**	**2 Hrs. 30 Min.**
Prerequisites (if any)	**-**	**Course Type**	**Theory**

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Design process:** Traditional design, Design Thinking Approach, Introduction to Design Thinking, History and evolution of Design Thinking, Role of design thinking in the human-centred design process. Design space, Design Thinking in a Team Environment, Team formation.	7
2	**Design Thinking Stages:** Empathize, Define, Ideate, Prototype and Test. The importance of empathy, Building a user-centred mindset. Problem statement formulation, User needs and pain points, establishing target specifications, Setting the final specifications.	7
3	Generating Ideas, Brainstorming techniques, Application of Aesthetics and Ergonomics in Design. Bio-mimicry, Conceptualization, Visual thinking, Drawing/Sketching, Presenting ideas.	7

4	Use of prototyping, Types of prototypes, Rapid prototyping techniques, User testing and feedback collection, Iterative prototyping, testing to gauge risk and market interest	5
5	Entrepreneurship/business ideas, Patents and Intellectual Property, Agility in design, Ethical considerations in design. Overcoming common implementation challenges	4

Course Assessment M (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Course based task	Seminar/Quiz	Internal Examination-1 (Written)	Total
15	**15**	**10**	**40**

End Semester Examination Marks (ESE)

The examination will be conducted by the College	
Part A	**Total**
• The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Vive. • Each question can carry 12 marks.	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Identify and frame design challenges effectively.	**K2**
CO2	Generate creative ideas through brainstorming and ideation	**K3**
CO3	Iterate on designs based on user insights	**K2**
CO4	Apply Design Thinking to real-world problems and projects.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Design Thinking: Understand – Improve – Apply	Christoph Meinel,Larry Leifer and Hasso Plattner	Springer Berlin,Heidelberg	2011
2	Design Thinking: Integrating Innovation, Customer Experience, and Brand Value	Thomas Lockwood and Edgar Papke	Allworth Press	2009
3	Design Your Thinking	Pavan Soni	Penguin Random House India PrivateLimited	2020
4	Design Thinking : A Guide to Creative Problem Solving forEveryone	Andrew Pressman	Taylor & Francis	2018
5	Design Thinking Techniques an Approaches	N Siva Prasad	Ane Books Pvt. Ltd	2023

SEMESTER 3
FUNCTIONAL PROGRAMMING IN HASKELL
AUDIT COURSE

Course Code	**243AGE005**	**CIE Marks**	**40**
Teaching Hours/Week (L: T:P)	**3:0:0**	**ESE Marks**	**60**
Credits	**—**	**Exam Hours**	**2 Hrs. 30 Min.**
Prerequisites (if any)	**—-**	**Course Type**	**Theory**

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Functional Programming**: Programming language paradigms, imperative style programming, comparison of programming paradigms. Functional programming, Functions - Mathematical concepts and terminology, Lambda calculus, Function definitions, programs as functions, Functional programming Languages. Haskell basics, GHCi interpreter	5
2	**Programming in Haskell:** Expressions and evaluation, Lazy evaluation, let expressions, scopes. Basic data types in Haskell, operators, infix operators, associativity and precedence, Arithmetic functions. types, definitions, currying and uncurrying, type abstraction. Function definitions, pattern matching, guards, anonymous functions, higher order functions. Recursion, Programming exercises..	6
3	**Data types: tuples and lists:** Tuples , Lists: building lists, decomposing lists, functions on lists, builtin functions on lists, primitive and general recursion over lists, infinite lists.Strings: functions on strings Polymorphism and overloading,	7

	conditional polymorphism	
4	Type classes, Algebraic data types, Modules, Recursive data types.User defined data types, Records, Stacks, Queues, Binary trees, Constructors, Destructors	6
5	Functor, Applicative functor, Monad Programming with actions: Functions vs actions, Basics of input / output, the do notation, interacting with the command line and lazy I/O, File I/O.	6

Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Course based task	Seminar/Quiz	Internal Examination-1 (Written)	Total
15	**15**	**10**	**40**

End Semester Examination Marks (ESE)

The examination will be conducted by the College	
Part A	**Total**
• The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Vive. • Each question can carry 12 marks.	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the functional programming paradigm which is based on the mathematics of lambda calculus.	**K2**
CO2	Develop Haskell programs using functions, guards and recursive functions	**K3**
CO3	Apply the concept of tuples, lists and strings in Haskell programming	**K3**
CO4	Apply the concept of algebraic data types, abstract data types, modules, recursive data types and user defined data types in Haskell programming	**K3**
CO5	Develop Haskell programs with files for reading input and storing output	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to functional programming using Haskell	Richard Bird	second edition, Prentice hall series in computer science	-
2	Real World Haskell	Bryan O'Sullivan, Don Stewart, and John Goerzen		-
3	Thinking Functionally with Haskell	Richard Bird	Cambridge University Press	2014
4	Haskell: The Craft of Functional Programming	Simon Thompson	Addison-Wesley,	3rd Edition, 2011

5	Notes on Functional Programming with Haskell	H. Conrad Cunningham	-	2014
6	Programming in Haskell	Graham Hutton	Cambridge University Press	2nd Edition, 2016
7	Practical Haskell: A Real-World Guide to Functional Programming	Alejandro Serrano Mena	Apress,	3rd Edition, 2022
8	Learn You a Haskell for Great Good!: A Beginner's Guide	Miran Lipovaca	No Starch Press	2011

INTERNSHIP

A student shall opt for carrying out the Internship at an Industry/Research Organization or at another institute of higher learning and repute (Academia). The organization for Internship shall be selected/decided by the students on their own with prior approval from the faculty advisor/respective PG Programme Coordinator/Guide/Supervisor. Every student shall be assigned an internship Supervisor/Guide at the beginning of the Internship. The training shall be related to their specialization after the second semester for a minimum duration of six to eight weeks. On completion of the course, the student is expected to be able to develop skills in facing and solving the problems experiencing in the related field.

Objectives

- Exposure to the industrial environment, which cannot be simulated in the classroom and hence creating competent professionals for the industry.
- Provide possible opportunities to learn understand and sharpen the real time technical / managerial skills required at the job.
- Exposure to the current technological developments relevant to the subject area of training.
- Create conducive conditions with quest for knowledge and its applicability on the job.
- Understand the social, environmental, economic and administrative considerations that influence the working environment.
- Expose students to the engineer's responsibilities and ethics.

Benefits of Internship

Benefits to Students

- An opportunity to get hired by the Industry/ organization.
- Practical experience in an organizational setting & Industry environment.
- Excellent opportunity to see how the theoretical aspects learned in classes are integrated into the practical world. On-floor experience provides much more professional experience which is often worth more than classroom teaching.
- Helps them decide if the industry and the profession is the best career option to pursue
- Opportunity to learn new skills and supplement knowledge.
- Opportunity to practice communication and teamwork skills.
- Opportunity to learn strategies like time management, multi-tasking etc in an industrial setup.
- Makes a valuable addition to their resume.
- Enhances their candidacy for higher education/placement.
- Creating network and social circle and developing relationships with industry people.
- Provides opportunity to evaluate the organization before committing to a full time position.

Benefits to the Institute

- Build industry academia relations.
- Makes the placement process easier.
- Improve institutional credibility & branding.
- Helps in retention of the students.
- Curriculum revision can be made based on feedback from Industry/students.
- Improvement in teaching learning process.

Benefits to the Industry

- Availability of ready to contribute candidates for employment.

- Year round source of highly motivated pre-professionals.
- Students bring new perspectives to problem solving.
- Visibility of the organization is increased on campus
- candidate's availability for temporary or seasonal positions and projects.
- Freedom for industrial staff to pursue more creative projects.
- Availability of flexible, cost-effective workforce not requiring a long-term
- employer commitment.
- Proven, cost-effective way to recruit and evaluate potential employees.
- Enhancement of employer's image in the community by contributing to the educational enterprise.

Guidelines

- All the students need to go for internship for minimum duration of 6 to 8 weeks.
- Students can take mini projects, assignments, case studies by discussing it with concerned authority from industry and can work on it during internship.
- All students should compulsorily follow the rules and regulations as laid by industry.
- Every student should take prior permissions from concerned industrial authority if they want to use any drawings, photographs or any other document from industry.
- Student should follow all ethical practices and SOP of industry.
- Students have to take necessary health and safety precautions as laid by the industry.
- Student should contact his /her Guide/Supervisor from college on weekly basis to communicate the progress.
- Each student has to maintain a diary/log book
- After completion of internship, students are required to submit
    - oReport of work done
    - o Internship certificate copy
    - o Feedback from employer / internship mentor
    - o Stipend proof (in case of paid internship).

Total Marks 100: The marks awarded for the Internship will be on the basis of (i) Evaluation done by the Industry (ii) Students diary (iii) Internship Report and (iv) Comprehensive Viva Voce.

Continuous Internal Evaluation: 50 marks

Student's diary - 25 Marks

Evaluation done by the industry - 25 Marks

Student's Diary/ Daily Log: The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily training diary the day to day account of the observations,impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily training diary should be signed after every day by the supervisor/ in charge of the section where the student has been working. The diary should also be shown to the Faculty Mentor visiting the industry from time to time and got ratified on the day of his visit. Student's diary will be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary
- Adequacy & quality of information recorded
- Drawings, design, sketches and data recorded
- Thought process and recording techniques used
- Organization of the information.

The format of student's diary

Name of the Organization/Section:
Name and Address of the Section Head:
Name and Address of the Supervisor:
Name and address of the student:
Internship Duration: From ..... To .....
Brief description about the nature of internship:
Day

Day	Brief write up about the Activities carried out: Such as design, sketches, result observed, issues identified, data recorded, etc.
1	
2	
3	

Signature of Industry Supervisor Signature of Section Head/HR Manager

Office Seal

Attendance Sheet

Name of the Organization/Section:
Name and Address of the Section Head:
Name and Address of the Supervisor:
Name and address of the student:
Internship Duration: From ..... To .....

Month & Year	1	2	3	4	5	6	7	8	9	20	…….
Month & Year											
Month & Year											

Signature of Industry Supervisor Signature of Section Head/HR Manager

Office Seal

Note:

- Student's Diary shall be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training.
- Attendance Sheet should remain affixed in daily training diary. Do not remove or tear it off.
- Student shall sign in the attendance column. Do not mark 'P'.
- Holidays should be marked in red ink in the attendance column. Absent should be marked as 'A' in red ink

Evaluation done by the Industry (Marks 25)

Format for Supervisor Evaluation of Intern

Student Name : …….. Date: …….
Supervisor Name :..... Designation:.....
Company/Organization : …….
Internship Address: ……..
Dates of Internship: From…… To……..
Please evaluate intern by indicating the frequency with which you observed the following parameters:

Parameters Marks	Needs improvement (0 – 0.25) mark)	Satisfactory (0.25 – 0.50) mark)	Good (0.75 mark)	Excellent (1 mark)
Behavior				
Performs in a dependable Manner				
Cooperates with coworkers and supervisor				
Shows interest in work				
Learns quickly				
Shows initiative				
Produces high quality work				
Accepts responsibility				
Accepts criticism				
Demonstrates organizational skills				
Uses technical				

knowledge and expertise				
Shows good judgment				
Demonstrates creativity/originality				
Analyzes problems effectively				
Is self-reliant				
Communicates well				
Writes effectively				
Has a professional attitude				
Gives a professional appearance				
Is punctual				
Uses time effectively				

Overall performance of student
Intern (Tick one) : Needs improvement (0 - 0.50 mark) / Satisfactory (0.50 – 1.0 mark) /
Good (1.5 mark) / Excellent (2.0 mark)

Additional comments, if any (2 marks) :

Signature of Industry Supervisor Signature of Section Head/HR Manager

Office Seal

End Semester Evaluation (External Evaluation)

Internship Report	Viva Voce	Total
25	25	50

Internship Report: After completion of the internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period and should be submitted to the faculty Supervisor. The student may contact Industrial Supervisor/ Faculty Mentor for assigning special topics and problems and should prepare the final report on the assigned topics. Daily diary will also help to a great extent in writing the industrial report since much of the information has already been incorporated by the student into the daily diary. The training report should be signed by the Internship Supervisor, Programme Coordinator and Faculty Mentor.

The Internship report (25 Marks) will be evaluated on the basis of following criteria:

- Originality
- Adequacy and purposeful write-up
- Organization, format, drawings, sketches, style, language etc.
- Variety and relevance of learning experience
- Practical applications, relationships with basic theory and concepts taught in the course

Viva Voce (25 Marks) will be done by a committee comprising Faculty Supervisor, PG Programme Coordinator and an external expert (from Industry or research/academic Institute). This committee will be evaluating the internship report also.

RESEARCH PROJECT/DISSERTATION

Research Project: Students choosing track 2 shall carry out the research project in their parent Institution only under the guidance of a supervisor assigned by the DLAC.

Dissertation: All categories of students in track 1 are to carry out the dissertation in the Institute they are studying or can work either in any CSIR/Industrial R&D organization/any other reputed Institute which have facilities for dissertation work in the area proposed

Mark Distribution:
Phase 1: Total marks: 100, only CIA

SEMESTER - IV

DISSERTATION PHASE II

Course Code	**244PBT100**	**CIA Marks**	**100**
Teaching Hours/Week (L: T:P:R)	**0:0:24:0**	**ESE Marks**	**100**
Credits	**16**	**Exam Hours**	**—-**
Prerequisites (if any)	**—-**	**Course Type**	**Project Work**

SYLLABUS:

DETAILS	HOURS
1. Literature study/survey of published literature on the assigned topic 2. Topic Selection and Proposal 3. Formulation of objectives 4. Research and Planning 5. Formulation of work plan and task allocation. 6. Execution 7. Documentation and Reporting 8. Project Showcase reflecting on the project experience and lessons learned	200

Course Assessment Method :(CIA:100)

The evaluation committee comprises

1- Project Coordinator(s)

2- A Senior faculty member

3- Supervisor of the student

Continuous Internal Assessment(CIA):

Zeroth evaluation by the Evaluation Committee	Interim evaluation by the Evaluation Committee	Final evaluation by the Evaluation Committee	Project progress evaluation by supervisor	Total
—-	30	50	20	100

Evaluation by the supervisor

The guide/supervisor shall monitor the progress being carried out by the student on a regular basis. In case it is found that progress is unsatisfactory it shall be reported to the Department **Evaluation Committee for necessary action**.

Student's Diary/ Log book: The main purpose of writing diary/log book is to cultivate the habit of documenting and to encourage the students to search for details. The activity diary shall be signed after every week by the supervisor.

End Semester Evaluation (ESE) Total Marks: 100

The evaluation committee comprises

1- Project Coordinator(s)

2- An external expert (from Industry or research/academic institute)

3- Supervisor of the student

End Semester Evaluation (ESE):

Innovation and Originality	Implementation and Execution	Project Documentation	Presentation and Defence	Publication of the work either in a conference or in a journal	Total
10	20	25	40	5	100

Pattern (ESE):

1. Innovation and Originality :

Assessment of the uniqueness and innovation demonstrated in the project work.

Original contributions, if any, to the field or problem area.

2. Implementation and Execution :

Evaluation of the actual implementation or execution of the project, including:

Quality of work done

Demonstrated skills and techniques applied

Adherence to project timelines and milestones

3. Project Documentation:

Comprehensive project report evaluation including:

Introduction and problem statement

Literature review

Methodology and approach

Results and analysis

Conclusion and recommendations

References and citations

Details of the publications

Plagiarism certificate

The Plagiarism level in the project report shall be less than 25%.

4. Presentation and Defence:

Oral presentation of the project to a panel of examiners, including:

Clarity and effectiveness of the presentation

Ability to explain the project objectives, methodologies, and findings

Handling questions and providing satisfactory answers during the defence

5. Publication of the work either in a conference or in a journal.

Dissertation outside the Institute:

For doing dissertation outside the Institution, the following conditions are to be met:

i. They have completed successfully the course work prescribed in the approved curriculum up to the second semester.

ii. The student has to get prior approval from the DLAC and CLAC.

iii. Facilities required for doing the dissertation shall be available in the Organization/Industry (A certificate stating the facilities available in the proposed organization and the time period for which the facilities shall be made available to the student, issued by a competent authority from the Organization/Industry shall be submitted by the student along with the application).

iv. They should have an external as well as an internal supervisor. The internal supervisor should belong to the parent institution and the external supervisor should be Scientists or Engineers from the Institution/Industry/ R&D organization with which the student is associated for doing the dissertation work. The external supervisor shall be with a minimum post graduate degree in the related area.

v. The student has to furnish his /her monthly progress as well as attendance report signed by the external supervisor and submit the same to the concerned internal supervisor.

vi. The external supervisor is to be preferably present during all the stages of evaluation of the dissertation.

SEMESTER S1

RESEARCH METHODOLOGY AND IPR

Course Code	**241RGE100**	**CIE Marks**	40
TeachingHours/Week (L: T:P)	2:0:0:	**ESE Marks**	60
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)		**Course Type**	Theory

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

CO 1	Approach research projects with enthusiasm and creativity.
CO 2	Conduct literature survey and define research problem
CO 3	Adopt suitable methodologies for solution of the problem
CO 4	Deliver well-structured technical presentations and write technical reports.
CO 5	Publish/Patent research outcome.

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Course based task: 15 marks

Some sample course based tasks that can be performed by the student given below. o

Conduct a group discussion based on the good practices in research.

o *Conduct literature survey on a suitable research topic and prepare a report based on this.*

Seminar: 15 marks

Test paper: 10 marks

End Semester Examination Pattern:

Total Marks: 60

The examination will be conducted by the respective college with the question provided by the University. The examination will be for 150 minutes and contain two parts; Part A and Part B. Part A will contain 6 short answer questions with 1 question each from modules 1 to 4, and 2 questions from module 5. Each question carries 5 marks. Part B will contain only 1 question based on a research article from the respective discipline and carries 30 marks. The students are to answer the questions based on that research article.

Sample question for part B is given below:

PART B			
7		Read the given article and write a report that addresses the following issues (The article given can be specific to the discipline concerned)	**Marks**
	a	What is the main research problem addressed?	**4**
	b	Identify the type of research	**4**
	c	Discuss the short comings in literature review if any?	**4**
	d	Discuss the significance of the study	**6**
	e	Discuss appropriateness of the methodology used for the study	**6**
	f	Summarize the important results and contributions by the authors	**6**

Syllabus and Course Plan

No	**Topic**	**No. of Lectures**
1	**Introduction**	
1.1	Meaning and significance of research, Skills, habits and attitudes for research, Types of research,	1
1.2	Characteristics of good research, Research process	1
1.3	Motivation for research: Motivational talks on research: "You and Your Research"- Richard Hamming	1
1.4	Thinking skills: Levels and styles of thinking, common-sense and scientific thinking, examples, logical thinking, division into sub problems, verbalization, awareness of scale.	1

1.5	Creativity: Some definitions, illustrations from day to day life, intelligence versus creativity, creative process, requirements for creativity	1
2	**Literature survey Problem definition**	
2.1	Information gathering – reading, searching and documentation; types of literature. Journal index and impact factor.	1
2.2	Integration of research literature and identification of research gaps	1
2.3	Attributes and sources of research problems; problem formulation, Research question, multiple approaches to a problem	1
2.4	Problem solving strategies – reformulation or rephrasing, techniques of representation, Importance of graphical representation; examples.	1
2.5	Analytical and analogical reasoning, examples; Creative problem solving using Triz, Prescriptions for developing creativity and problem solving.	1
3	**Experimental and modelling skills**	
3.1	Scientific method; role of hypothesis in experiment; units and dimensions; dependent and independent variables; control in experiment	1
3.2	precision and accuracy; need for precision; definition, detection, estimation and reduction of random errors; statistical treatment of data; definition, detection and elimination of systematic errors;	1
3.3	Design of experiments; experimental logic; documentation	1
3.4	Types of models; stages in modelling; curve fitting; the role of approximations; problem representation; logical reasoning; mathematical skills;	1
3.5	Continuum/meso/micro scale approaches for numerical simulation;	1

	Two case studies illustrating experimental and modelling skills.	
4	**Effective communication - oral and written**	
4.1	Examples illustrating the importance of effective communication; stages and dimensions of a communication process.	1
4.2	Oral communication –verbal and non-verbal, casual, formal and informal communication; interactive communication; listening; form, content and delivery; various contexts for speaking conference, seminar etc.	1
4.3	Guidelines for preparation of good presentation slides.	1
4.4	Written communication - form, content and language; layout, typography and illustrations; nomenclature, reference and citation styles, contexts for writing – paper, thesis, reports etc. Tools for document preparation-LaTeX.	1
4.5	Common errors in typing and documentation	1
5	**Publication and Patents**	
5.1	Relative importance of various forms of publication; Choice of journal and reviewing process, Stages in the realization of a paper.	1
5.2	Research metrics-Journal level, Article level and Author level, Plagiarism and research ethics	1
5.3	Introduction to IPR, Concepts of IPR, Types of IPR	1
5.4	Common rules of IPR practices, Types and Features of IPR Agreement, Trademark	1
5.5	Patents- Concept, Objectives and benefits, features, Patent process – steps and procedures	2

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	How to get a PhD - a handbook for PhD students and their supervisors	E. M. Phillips and D. S. Pugh	Viva books Pvt Ltd	-
2	Practical physics	G. L. Squires	Cambridge University Press	
3	Handbook of Science Communication	Antony Wilson, Jane Gregory, Steve Miller, Shirley Earl	Overseas Press India Pvt Ltd, New Delhi	st edition 2005
4	Research Methodology	C. R. Kothari	New Age International	2004
5	Research Methodology	Panneerselvam	Prentice Hall of India, New Delhi,	2012
6	Practical Research: Planning and Design	Leedy P. D	McMillan Publishing Co.	
7	How to Write and Publish a Scientific Paper	Day R. A	Cambridge University Press	1989
8	Elements of Style	William Strunk Jr	Fingerprint Publishing	2020
9	Advice to Young Scientist	Peter Medawar	loan Foundation Series	1979
10	Letters to a Young Scientist	E.O.Wilson	Liveright	2014
11	You and Your Research	R. Hamming	Talk at Bell Labs	1986