Faculty of Engineering
Savitribai Phule Pune University, Pune
Maharashtra, India



Curriculum
for
Fourth Year of Computer Engineering
(2019 Course)
(With effect from 2022-23)

Third Year of Computer Engineering
(2019 Course)
(With effect from 2022-23)

Prologue

It is with great pleasure and honor that I share the syllabi for Fourth Year of Computer Engineering (2019 Course) on behalf of Board of Studies, Computer Engineering. We, members of BoS are giving our best to streamline the processes and curricula design.

While revising syllabus, honest and sincere efforts are put to tune Computer Engineering program syllabus in tandem with the objectives of Higher Education of India, AICTE, UGC and affiliated University (SPPU) by keeping an eye on the technological advancements and industrial requirements globally.

Syllabus revision is materialized with sincere efforts, active participation, expert opinions and suggestions from domain professionals. Sincere efforts have been put by members of BoS, teachers, alumni, industry experts in framing the draft with guidelines and recommendations.

Case Studies are included in almost all courses. Course instructor is recommended to discuss appropriate related recent technology upgrade Case Studies to encourage students to study from course to the scenario and think through the largest issues: recent trends' utility; developing real world professional skills.

I am sincerely indebted to all the minds and hands who work adroitly to materialize these tasks. I really appreciate your contribution and suggestions in finalizing the contents.

Thanks,

Dr. Varsha H. Patil
Chairman, Board of Studies (Computer Engineering), SPPU, Pune

links for First Year, Second Year and Third Year Computer Engineering Curriculum 2019:

1. http://collegecirculars.unipune.ac.in/sites/documents/Syllabus%202019/Rules%20and%20Regulations%20F.E.%202019%20Patt_10.012020.pdf
2. http://collegecirculars.unipune.ac.in/sites/documents/Syllabus%202019/First%20Year%20Engineering%202019%20Patt-Syllabus_05.072019.pdf
3. http://collegecirculars.unipune.ac.in/sites/documents/Syllabus2020/SE%20Computer%20Engg.%202019%20%20Patt_03.072020.pdf
4. http://collegecirculars.unipune.ac.in/sites/documents/Syllabus2021/Third%20Year%20Engineering%202019%20Pattern_16032022.rar

Savitribai Phule Pune University

Third Year of Computer Engineering (2019 Course)

(With effect from Academic Year 2021-22)

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Savitribai Phule Pune University
Bachelor of Computer Engineering
Program Outcomes (POs)

Learners are expected to know and be able to–

PO1	**Engineering knowledge**	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems.
PO2	**Problem analysis**	Identify, formulate, review research literature, and analyze complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences.
PO3	**Design / Development of Solutions**	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations.
PO4	**Conduct Investigations of Complex Problems**	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice.
PO9	**Individual and Team Work**	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication Skills**	Communicate effectively on complex Engineering activities with the Engineering community, and with society at large, such as, being able to comprehend and make effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project Management and Finance**	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments.
PO12	**Life-long Learning**	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSO)

PSO1 **Professional Skills**- The ability to understand, analyze and develop computer programs in the areas related to algorithms, system software, multimedia, web design, big data analytics, and networking for efficient design of computer-based systems of varying complexities.

PSO2 **Problem-Solving Skills**- The ability to apply standard practices and strategies in software project development using open-ended programming environments to deliver a quality product for business success.

PSO3 **Successful Career and Entrepreneurship**- The ability to employ modern computer languages, environments, and platforms in creating innovative career paths to be an entrepreneur, and a cost for higher studies.

BE Computer Engineering 2019 Course tentative Curriculum structure:

Sri Vidyalaya Pharia Pune University
Final Year of Computer Engineering (2019 Course)
(With effect from Academic Year 2023-24)

Semester VII

Course Code	Course Name	Teaching Scheme (Hours/week)			Examination Scheme and Marks						Credit Scheme			
		Lecture	Practical	Tutorial	Mid-Sem	End-Sem	Term work	Practical	Oral Pr	Total	Lecture	Practical	Tutorial	Total
410241	Design and Analysis of Algorithm	03	-	-	30	70	-	-	-	100	3			3
410242	Machine Learning	03	-	-	30	70	-	-	-	100	3			3
410243	Blockchain Technology	03	-	-	30	70	-	-	-	100	3			3
410244	Elective III	03	-	-	30	70	-	-	-	100	3			3
410245	Elective IV	03	-	-	30	70	-	-	-	100	3			3
410246	Laboratory Practice III	-	04	-	-	-	50	50	-	100	-	2		2
410247	Laboratory Practice IV	-	02	-	-	-	50	-	-	50	-	1		1
410248	Project Stage I	-	02	-	-	-	50	-	-	50	-	2		2
										Total Grade	15	05	-	20
	Total	15	08	-	150	350	150	50	-	700	15	05	-	20
410249	Audit Course 7										Grade			

Elective III	Elective IV
410244(A) Pervasive Computing 410244(B) Multimedia Techniques 410244(C) Cyber Security and Digital Forensics 410244(D) Object Oriented Modeling and Design 410244(E) Digital Signal Processing	410245(A) Information Retrieval 410245(B) GPU Programming and Architecture 410245(C) Mobile Computing 410245(D) Software Testing and Quality Assurance 410245(E) Compilers
Laboratory Practice III: Laboratory assignments Courses- 410241, 410242, 410243	**Laboratory Practice IV:** Laboratory assignments Courses- 410244, 410245

Audit Course 7(AC7) Options:
AC7- I MOOC- Learn New Skills
AC7- II Entrepreneurship Development
AC7- III Behind of Things
AC7- IV 3D Printing
AC7- V Industrial Safety and Environment Consciousness

Savitribai Phule Pune University
Final Year of Computer Engineering (2019 Course)
(With effect from Academic Year 2022-23)

Semester VIII

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit Scheme			
		Lecture	Practical	Tutorial	Mid-Term	End-Term	Term work	Practical	Oral/Pr	Total	Lecture	Practical	Tutorial	Total
410250	High Performance Computing	03	-	-	50	70	-	-	-	100	03			03
410251	Deep Learning	03	-	-	50	70	-	-	-	100	03			03
410252	Elective V	03	-	-	50	70	-	-	-	100	03			03
410253	Elective VI	03	-	-	50	70	-	-	-	100	03			03
410254	Laboratory Practice V	-	02	-	-	-	50	50	-	100		01		01
410255	Laboratory Practice VI	-	02	-	-	-	50	-	-	50		01		01
410256	Project Stage II	-	06	-	-	-	100	-	50	150		06		06
										Total Credit	12	08	-	20
	Total	12	10	-	150	200	200	50	50	700	12	08	-	20
410257	Audit Course II											Grade		

Elective V	Elective VI
410252(A) Natural Language Processing	410253(A) Pattern Recognition
410252(B) Image Processing	410253(B) Soft Computing
410252(C) Software Defined Networks	410253(C) Business Intelligence
410252(D) Advanced Digital Signal Processing	410253(D) Quantum Computing
410252(E) Open Elective	410253(E) Open Elective
Lab Practice V: Laboratory assignments Courses-410250, 410251	**Lab Practice VI:** Laboratory assignments Courses-410252, 410253

Audit Course II(ACS) Options:
ACS- I Usability Engineering
ACS- II Conversational Interfaces
ACS- II Social Media and Analytics
ACS- IV MOOC - Learn New Skills
ACS- V Emotional Intelligence

General Guidelines

1. Every undergraduate program has its own objectives and educational outcomes. These objectives and outcomes are furnished by considering various aspects and impacts of the curriculum. These **Program Outcomes (POs)** are categorically mentioned at the beginning of the curriculum (ref: SBA Manual). There should always be a rationale and a goal behind the inclusion of a course in the curriculum. Course Outcomes though highly rely on the contents of the course, many a times are generic and bundled. The **Course Objectives**, **Course Outcomes** and **CO-PO mappings matrix** justifies the motives, accomplishment and prospect behind learning the course. The Course Objectives, Course Outcomes and CO-PO Mapping Matrix are provided for reference and these are indicative only. The course instructor may modify them as per his or her perspective.

2. **CO and PO Mapping Matrix**(Course Objectives and Program Outcomes) attainment mapping matrix at end of course contents, indicates the correlation levels of 3, 2, 1 and '-'. The notation of 3, 2 and 1 denotes substantially (high), moderately (medium) and slightly (low). The mark '-' indicates that there is no correlation between CO and PO.

3. For each course, contents are divided into six units-I, II, III, IV, V and VI.

4. **Elaborated examples/Case Studies** are included at each unit to explore how the learned topics apply to real world situations and need to be explored so as to assist students to increase their competencies, including the specific skills, building the knowledge to be applicable in any given situation along with an articulation. One or two sample exemplars or case studies are included for each unit; instructor may extend the same with more. **Exemplar/Case Studies** may be assigned as self-study by students and to be excluded from theory examinations.

4. *For each unit contents, the content attainment mapping is indicated with Course Outcome(s). Instructor may revise the same as per their viewpoint.

5. For laboratory courses, set of suggested assignments is provided for reference. Laboratory Instructors may design suitable set of assignments for respective course at their level. Beyond curriculum assignments and mini-project may be included as the part of laboratory work. Inclusion of it will be the value addition for the students and it will satisfy the intellectuals within the group of the learners and will aid in the perspective of the learners.

6. For each laboratory assignment, it is essential for students to draw write-ups(mathematical model, flowchart, algorithm, test cases, mathematical model, Test data set and comparative complexity analysis (as applicable)). Batch size for practical and tutorial may be as per guidelines of authority.

7. For each course, irrespective of the examination head, the instructor should motivate students to read articles/research papers related to recent development and invention in the field.

8. For laboratory, instructions have been included about the conduction and assessment of laboratory work. These guidelines are to be strictly followed.

9. **Term Work** –Term work is continuous assessment that evaluates a student's progress throughout the semester. Term work assessment criteria specify the standards that must be met and the evidences that will be gathered to demonstrate the achievement of course outcomes. Categorical assessment criteria for the term work should establish unambiguous standards of achievement for each course outcome. They should describe what the learner is expected to perform in the laboratories or on the fields to show that the course outcomes have been achieved.

Students' work will be evaluated typically based on the criteria like attentiveness, proficiency in execution of the task, regularity, punctuality, use of referencing, accuracy of language, use of supporting evidence in drawing conclusions, quality of critical thinking and similar performance measuring criteria.

10. Program codes with sample output of all performed assignments are to be submitted as softcopy. Use of DVD or similar media containing students programs maintained by Laboratory In-charge is highly encouraged. For reference one or two journals may be maintained with program prints at Laboratory. As a conscious effort and little contribution towards Green IT and environment awareness, attaching printed papers as part of write-ups and program listing to journal may be avoided. Submission of journal/ term work in the form of softcopy is desirable and appreciated.

Abbreviations

TW: Term Work	TH: Theory	PR: Practical
OR: Oral	Sem: Semester	

SEMESTER VII

Savitribai Phule Pune University

Fourth Year of Computer Engineering (2019 Course)

410241: Design and Analysis of Algorithms

Teaching Scheme:	Credit	Examination Scheme:
TH: 03 Hours/Week	03	In-Sem (Paper): 30 Marks
		End-Sem (Paper): 70 Marks

Prerequisites Courses: Discrete Mathematics (210241), Fundamentals of Data Structures(210242, Data Structures and Algorithms(210252), Theory of Computation (310242)

Companion Course: Laboratory Practice III(410246)

Course Objectives:

- To develop problem solving abilities using mathematical theories
- To apply algorithmic strategies while solving problems
- To analyze performance of different algorithmic strategies in terms of time and space
- To develop time and space efficient algorithms
- To study algorithmic examples in distributed and concurrent environments
- To Understand Multithreaded and Distributed Algorithms

Course Outcomes:

On completion of the course, student will be able to–

CO1: Formulate the problem

CO2: Analyze the asymptotic performance of algorithms

CO3: Decide and **apply** algorithmic strategies to solve given problem

CO4: Find optimal solution by applying various methods

CO5: Analyze and **Apply** Scheduling and Sorting Algorithms

CO6: Solve problems for multi-core or distributed or concurrent environments

Course Contents

Unit I Algorithms and Problem Solving 07 Hours

Algorithm: The Role of Algorithms in Computing – What are algorithms, Algorithms as technology, Evolution of Algorithms, Design of Algorithm, Need of Correctness of Algorithm, Confirming correctness of Algorithm – sample examples, Iterative algorithm design issues.

Problem solving Principles: Classification of problem, problem solving strategies, classification of time complexities (linear, logarithmic etc.)

***Exemplar/Case Studies:** Towers of Hanoi

***Mapping of Course Outcomes for Unit I:** CO1,CO3

Unit II Analysis of Algorithms and Complexity Theory 07 Hours

Analysis: Input size, best case, worst case, average case

Counting: Dominant operations, Growth rate, upper bounds, asymptotic growth, O, Ω, Θ, o and ω notations, polynomial and non-polynomial problem, deterministic and non-deterministic algorithms, P class problems, NP class of problems, Polynomial problem reduction NP complete problems– cotton sweat and 3-SAT and NP hard problem - Hamiltonian cycle.

***Exemplar/Case Studies:** Analysis of iterative and recursive algorithm.

***Mapping of Course Outcomes for Unit II**	CO2

Unit III	Greedy And Dynamic Programming algorithmic Strategy	08 Hours

Greedy strategy: Principle, control abstraction, time analysis of control abstraction, knapsack problem, scheduling algorithms-job scheduling and activity selection problem.
Dynamic Programming: Principle, control abstraction, time analysis of control abstraction, binomialcoefficients, OBST, 0/1 knapsack, Chain Matrix multiplication

***Exemplar/Case Studies**	Rail tracks connecting all the cities.
***Mapping of Course Outcomes for Unit III**	CO3, CO4

Unit IV	Backtracking and Branch-n-Bound	08 Hours

Backtracking: Principle, control abstraction, time analysis of control abstraction, 8-queen problem, graph coloring problem, sum of subsets problem.
Branch-n-Bound: Principle, control abstraction, time analysis of control abstraction, strategies-FIFO,
LIFO and LC approaches, TSP, knapsack problem.

***Exemplar/Case Studies**	Airline Crew Scheduling
***Mapping of Course Outcomes for Unit IV**	CO3, CO4

Unit V	Amortized Analysis	07 Hours

Amortized Analysis: Aggregate Analysis, Accounting Method, Potential Function method, Amortized analysis-binary counter, stack Time-Space tradeoff, Introduction to Tractable and Non-tractable Problems, Introduction to Randomized and Approximate algorithms, Embedded Algorithms: Embedded system scheduling (power optimized scheduling algorithm), sorting algorithm for embedded systems.

***Exemplar/Case Studies**	cutting stock problem
***Mapping of Course Outcomes for Unit V**	CO3, CO5

Unit VI	Multithreaded And Distributed Algorithms	07 Hours

Multithreaded Algorithms – Introduction, Performance measures, Analyzing multithreaded algorithms, Parallel loops, Race conditions.
Problem Solving using Multithreaded Algorithms – Multithreaded matrix multiplication, Multithreadedmerge sort.
Distributed Algorithms – Introduction, Distributed breadth first search, Distributed Minimum Spanning Tree.
String Matching- Introduction, The Naive string matching algorithm, The Rabin-Karp algorithm.

***Exemplar/Case Studies**	Plagiarism detection

***Mapping of Course Outcomes for UnitVI** CO6

Learning Resources

Text Books:

1. Parag Himanshu Dave, Himanshu Bhalchandra Dave, "Design And Analysis of **Algorithms**", Pearson Education, ISBN 81-7758-595-0
2. Gilles Brassard, Paul Bradley, "**Fundamentals of Algorithmics**", PHI, ISBN 978-81-203-1131-2

Reference Books :

1. Michael T. Goodrich, Roberto **Tamassia**, "**Algorithm** Design: **Foundations**," Analysis and Internet **Examples**, Wiley, ISBN 978-81-265-0986-7
2. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, "Introduction to **Algorithms**", **MIT** Press, ISBN 978-0-262-03384-8
3. Horowitz and Sahani, "Fundamentals of Computer Algorithms", University Press, ISBN: 978 817371 6120, 81 7371 6120
4. Rajeev Motwani and Prabhakar Raghavan, "Randomized **Algorithms**" Cambridge University Press, ISBN: 978-0-521-61390-5
5. Dan Gusfield, "Algorithms on Strings, Trees and **Sequences**", Cambridge University Press, ISBN 0-521-67035-7

e-Books :

1. https://www.tutorialspoint.com/design_and_analysis_of_algorithms/design_and_analysis_of_algorithms_tutorial.pdf
2. https://www.ebooks.com/en-in/book/1679384/algorithms-design-techniques-and-analysis-with-alternative/

MOOC Courses links :

- Design and Analysis of Algorithms - https://nptel.ac.in/courses/106106131

8 The CO-PO Mapping Matrix

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	0	0	-	-	-	-	-	-	-	-	-	0
CO2	2	0	-	-	-	-	-	-	-	-	-	2
CO3	3	0	2	-	-	-	-	-	-	-	-	3
CO4	2	0	3	0	-	-	-	-	-	-	-	3
CO5	3	0	4	0	-	-	-	-	-	-	-	3
CO6	2	0	4	0	-	-	-	-	-	-	-	-

Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
410242: Machine Learning

Teaching Scheme:
TH: 03 Hours/Week

Credit
03

Examination Scheme:
In-Sem (Paper): 30 Marks
End-Sem (Paper): 70 Marks

Prerequisite Courses: Data Science and Big Data Analytics(410251)
Companion Course: Laboratory Practice III(410246)

Course Objectives:

- To understand the need for Machine learning
- To explore various data pre-processing methods
- To study and understand classification methods
- To understand the need for multi-class classifiers
- To learn the working of clustering algorithms
- To learn fundamental neural network algorithms

Course Outcomes:
On completion of the course, student will be able to–
CO1: Identify the needs and challenges of machine learning for real time applications
CO2: Apply various data pre-processing techniques to simplify and speed up machine learning algorithms
CO3: Select and apply appropriately supervised machine learning algorithms for real timeapplications
CO4: Implement variants of multi-class classifier and measure its performance
CO5: Compare and contrast different clustering algorithms
CO6: Design a neural network for solving engineering problems

Course Contents

Unit I — Introduction To Machine Learning — 07 Hours

Introduction to Machine Learning, Comparison of Machine learning with traditional programming, ML vs AI vs Data Science.
Types of learning, Supervised, Unsupervised, and semi-supervised, reinforcement learning techniques.Models of Machine learning: Geometric models, Probabilistic Models, Logical Models, Grouping and grading models, Parametric and non-parametric models
Important Elements of Machine Learning- Data formats, Learnability, Statistical learning approaches

***Exemplar/Case Studies**
Suppose you are working for Uber where a task to increase sales is given.Understand the requirements of the client

***Mapping of Course Outcomes for Unit**
CO1

Unit II — Feature Engineering — 07 Hours

Concept of Feature, Preprocessing of data: Normalization and Scaling, Standardization, Managing missing values, Introduction to Dimensionality Reduction: Principal Component Analysis (PCA), Feature Extraction: Kernel PCA, Local Binary Pattern.

Introduction to various Feature Selection Techniques, Sequential Forward Selection, Sequential Backward Selection.

Statistical feature engineering: count-based, Length, Mean, Median, Mode etc. based feature vectorization.

Multidimensional Scaling, Matrix Factorization Techniques.

***Exemplar/CaseStudies**	You are a Data Scientist, and a client comes to you with their data. Client is running a few campaigns from the past few months, but no campaign seems effective. Client provides you the data of customers, product sales and past campaign success. They want to increase their sales and figure out which marketing strategy is working the best for them? Questions for data scientists: 1. What data analysis approach will you follow? 2. What statistical approach do you need to follow? How will you select important features?
***Mapping of Course Outcomes for Unit II**	CO2

Unit III	Supervised Learning : Regression	06 Hours

Bias, Variance, Generalization, Underfitting, Overfitting, Linear regression, Regression: Lasso regression, Ridge regression, Gradient descent algorithm.

Evaluation Metrics: MAE, RMSE, R2

***Exemplar/Case Studies**	Stock market price prediction
***Mapping of Course Outcomes for Unit III**	CO3

Unit IV	Supervised Learning : Classification	08 Hours

Classification: K-nearest neighbour, Support vector machine.

Ensemble Learning: Bagging, Boosting, Random Forest, Adaboost.

Binary-vs-Multiclass Classification, Balanced and Imbalanced Multiclass Classification.

Problems, Variants of Multiclass Classification: One-vs-One and One-vs-All

Evaluation Metrics and Score: Accuracy, Precision, Recall, F-score, Cross-validation, Micro-Average Precision and Recall, Micro-Average F-score, Macro-Average Precision and Recall, Macro-Average F-score.

***Exemplar/Case Studies**	Prediction of Thyroid disorders such as Hyperthyroid, Hypothyroid, Euthyroid-sick, and Euthyroid using multiclass classifier.
***Mapping of Course Outcomes for Unit IV**	CO4

Unit V	Unsupervised Learning	07 Hours

K-Means, K-medoids, Hierarchical, and Density-based Clustering, Spectral Clustering, Outlier analysis: introduction of isolation factor, local outlier factor.

Evaluation metrics and score: elbow method, extrinsic and intrinsic methods.

#Exemplar/Case Studies	Market basket analysis/Customer Segmentation
*Mapping of Course Outcomes for Unit V	CO5

Unit VI	Introduction To Neural Networks	07 Hours

Artificial Neural Networks: Single Layer Neural Network, Multilayer Perceptron, Back Propagation Learning, Functional Link Artificial Neural Network, and Radial Basis Function Network, Activation functions.
Introduction to Recurrent Neural Networks and Convolutional Neural Networks

#Exemplar/Case Studies	Movie Recommendation System
*Mapping of Course Outcomes for Unit VI	CO6

Learning Resources

Text Books:

1. Bishop, Christopher M., and Nasser M. Nasrabadi, "Pattern recognition and machine learning", Vol. 4 No. 4. New York: springer, 2006.
2. Ethem Alpaydin, "Introduction to Machine Learning", PHI 2nd Edition-2013

Reference Books:

1. Tom Mitchell, " Machine learning", McGraw-Hill series in Computer Science, 1997
2. Shalev-Shwartz, Shai, and Shai Ben-David, "Understanding machine learning: From theory to algorithms", Cambridge university press, 2014.
3. Jiawei Han, Micheline Kamber, and Jian Pei, "Data Mining: Concepts and Techniques", Elsevier Publishers Third Edition. ISBN: 9780123814791, 9780123814807
4. Hastie, Trevor, et al., "The elements of statistical learning: data mining, inference, and prediction", Vol. 2. New York: springer, 2009
5. McKinney, "Python for Data Analysis "„O' Reilly media. ISBN : 978-1-449-31979-3
6. Trent hauk, "Scikit-learn", Cookbook , Packt Publishing, ISBN: 9781787286382
7. Goodfellow I., Bengio Y., and Courville, " A Deep Learning", MIT Press, 2016

e-Books:

1. Python Machine Learning : http://www.pu.ac.bd/wp-content/uploads/sites/25/2019/03/207_03_01_Rajeeka_Lamp-Python-for-machine-learning-2015.pdf
2. Foundation of Machine Learning: https://cs.nyu.edu/~mohri/mlbook/
3. Dive into Deep Learning: http://d2l.ai/
4. A brief introduction to machine learning for Engineers: https://arxiv.org/pdf/1709.02840.pdf
5. Feature selection: https://dl.acm.org/doi/pdf/10.1555/944919.944968
6. Introductory Machine Learning Notes: http://faculty.cse.tamu.edu/courses/cpsc/2018/Notes.pdf

MOOC Courses Links:

- Introduction to Machine Learning : https://nptel.ac.in/courses/106/105/
- Introduction to Machine Learning (IIT Madras): https://onlinecourses.nptel.ac.in/noc22_cs29/preview
- Deep learning: https://nptel.ac.in/courses/106/106/

[illegible] CO-PO Mapping Matrix

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
[illegible]	[illegible]			[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
410244: Blockchain Technology

Teaching Scheme:
TH: 03 Hours/Week

Credit:
03

Examination Scheme:
In-Sem (Paper): 30 Marks
End-Sem (Paper): 70 Marks

Prerequisite Courses: Computer Networks and Security(310244)
Companion Course: Laboratory Practice III(410246)

Course Objectives:

- Technology behind Blockchain
- Crypto currency, Bitcoin and Smart contracts
- Different consensus algorithms used in Blockchain
- Real-world applications of Blockchain
- To analyze Blockchain Ethereum Platform using Solidity
- To Describe Blockchain Case Studies

Course Outcomes:

On completion of the course, student will be able to–

CO1: Interpret the fundamentals and basic concepts in Blockchain
CO2: Compare the working of different blockchain platforms
CO3: Use Crypto wallet for cryptocurrency based transactions
CO4: Analyze the importance of blockchain in finding the solutions to the real-world problems.
CO5: Illustrate the Ethereum public block chain platform
CO6: Identify solution where block chain technology can be effectively used and implemented.

Course Content

Unit I — Mathematical Foundation for Blockchain — 06 Hours

Cryptography: Symmetric Key Cryptography and Asymmetric Key Cryptography, Elliptic Curve Cryptography (ECC), Cryptographic Hash Functions: SHA256, Digital Signature Algorithm (DSA), Merkel Trees

***Exemplar/Case Studies:** Compare the Symmetric and Asymmetric Cryptography algorithms

***Mapping of Course Outcomes for Unit I:** CO1

Unit II — Feature Engineering — 07 Hours

History, Centralized Vs. Decentralized Systems, Layers of Blockchain: Application Layer, Execution Layer, Semantic Layer, Propagation Layer, Consensus Layer, Why is Block chain important? Limitations of Centralized Systems, Blockchain Adoption So Far.

*Exemplar/Case Studies	Study of a research paper based on Blockchain.
*Mapping of Course Outcomes for Unit II	CO1

Unit III	Blockchain Platforms and Consensus in Blockchain	06 Hours

Types of Blockchain Platforms: Public, Private and Consortium, Bitcoin, Ethereum, Hyperledger IoTA, Corda, R3.
Consensus in Blockchain: Consensus Approach, Consensus Elements, Consensus Algorithms:Proof of Work, Byzantine General problem, Proof of Stake, Proof of Elapsed Time, Proof of Activity, Proof of Burn.

*Exemplar/Case Studies	Compare different consensus algorithms used in Blockchain Technology.
*Mapping of Course Outcomes for Unit III	CO2

Unit IV	Cryptocurrency – Bitcoin, and Token	06 Hours

Introduction, Bitcoin and the Cryptocurrency, Cryptocurrency Basics: Types of Cryptocurrency, Cryptocurrency Usage, Cryptowallets: Metamask, Coinbase, Binance

*Exemplar/Case Studies	Create your own wallet for crypto currency using any of the Blockchain Platforms.
*Mapping of Course Outcomes for Unit IV	CO3

Unit V	Blockchain Ethereum Platform using Solidity	06 Hours

What is Ethereum, Types of Ethereum Networks, EVM (Ethereum Virtual Machine), Introduction to smart contracts, Purpose and types of Smart Contracts, Implementing and deploying smart contracts using Solidity, Swarm (Decentralized Storage Platform), Whisper (Decentralized Messaging Platform)

*Exemplar/Case Studies	Study Truffle Development Environment.
*Mapping of Course Outcomes for Unit V	CO4

Unit VI	Blockchain Case Studies	06 Hours

Prominent Blockchain Applications, Retail, Banking and Financial Services, Government Sector, Healthcare, IOT, Energy and Utilities, Blockchain Integration with other Domains

*Exemplar/Case Studies	Study 2 use cases of Blockchain and write a detailed report on every aspect implemented in the same.
*Mapping of Course Outcomes for Unit VI	CO5, CO6

Learning Resources

Text Books:

1. Martin Quest, "Blockchain Dynamics: A Quick Beginner's Guide on Understanding the Foundations of Bit coin and Other Crypto **currencies**", Create Space Independent Publishing Platform, 13-Mar-2018
2. Imran Bashir, "Mastering Blockchain: Distributed Ledger Technology, Decentralization and Smart Contracts **Explained**", Second Edition, Packt Publishing, 2018
3. Alex Leverington, "Ethereum Programming", Packt Publishing, 2017

Reference Books:

1. Bikramaditya Singhal, Gautam Dhanteja, Priyansu Sekhar Panda, "Beginning Blockchain A**Beginner's** Guide to Building Blockchain Solutions", 2018
2. Chris Dannen, "Introducing Ethereum and Solidity", Foundations of Crypto currency and Blockchain Programming for Beginners
3. Daniel Drescher, "Blockchain Basics", A Non-Technical Introduction in 25Steps
4. Ritesh Modi, "Solidity Programming Essentials", Packt Publishing, 2018
5. Chandramouli Subramanian, Asha A George, Abhilash K A and Meena Karthikeyan, "**Blockchain Technology**", Universities Press, ISBN-9789389211634

e-Books :

1. https://users.cs.fiu.edu/~prabakar/cen5079/Comment/textbooks/Mastering_Blockchain_2nd_Edition.pdf
2. https://www.lopp.net/pdf/princeton_bitcoin_book.pdf
3. https://www.blockchainexpert.uk/book/blockchain-book.pdf

MOOC Courses Links:

1. NPTEL Course on "Introduction to Blockchain Technology & Applications"
   https://nptel.ac.in/courses/106/104/106104220/
2. NPTEL Course on **b**
   https://nptel.ac.in/courses/106/105/106105184/

The CO-PO Mapping Matrix

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	3	-	-	-	-	-	-	-	-	-	-	-
CO3	3	-	2	2	-	-	-	-	-	-	-	-
CO4	3	-	2	-	2	-	-	-	-	-	-	-
CO5	3	3	2	-	-	-	-	-	-	-	-	2
CO6	2	2	2	2	-	-	-	-	-	-	-	-

Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
410244(A): Pervasive Computing

Teaching Scheme:	Credit:	Examination Scheme:
TH: 03 Hours/Week	03	In-Sem (Paper): 30 Marks
		End-Sem (Paper): 70 Marks

Prerequisite Courses: Internet of Things and Embedded Systems(410245A)

Companion Course: Laboratory Practice IV(410247)

Course Objectives:

- To introduce the characteristics, basic concepts and systems issues in pervasivecomputing
- To illustrate smart devices and architectures in pervasive computing
- To introduce intelligent systems and interactions in Pervasive computing
- To identify the trends and latest developments of the technologies in the area
- To Understand Interaction Design – HCI and Wearable Computing Environments
- To identify Security Challenges & Ethics in Pervasive Computing

Course Outcomes:

On completion of the course, student will be able to–

CO1.Demonstrate fundamental concepts in pervasive computing.

CO2.Explain pervasive devices and decide appropriate one as per the need of real timeapplications.

CO3.Classify and analyze context aware systems for their efficiency in different ICT systems.

CO4.Illustrate intelligent systems and generic intelligent interactive applications.

CO5.Design HCI systems in pervasive computing environment.

CO6.Explain the security challenges and know the role of ethics in the context of pervasivecomputing.

Course Content:

Unit I Introduction To Pervasive Computing 07 Hours

Pervasive Computing: History, Principles, Characteristics, Problems/Issues & Challenges, Advantages of Pervasive Computing

Pervasive Computing Applications: Pervasive computing devices and interfaces, Device technology trends, Connecting issues and protocols

#ExemplarCase Studies: Pervasive Computing for Personalized medicine.

Mapping of Course Outcomes for Unit I: CO1

Unit II Smart Computing with Pervasive Computing Devices 07 Hours

Smart Devices: CC1, Smart Environment: CP1 and CC1, Smart Devices: RFCT and HPI, Wearable devices, Application and Requirements, Device Technology and Connectivity, PDA Device characteristics – PDA Based Access Architecture. Voice Enabling Pervasive Computing: Voice Standards, Speech Applications in Pervasive Computing.

#ExemplarCaseStudies: Amazon Alexa

*Mapping of Course Outcomes for Unit II : CO2

Unit III	Context Aware Systems	07 Hours

Introduction, Types of Context, Context Aware Computing and Applications, Modelling Context-Aware Systems, Mobility awareness, spatial awareness, temporal awareness Coordinating and scheduling, ICT system awareness, Middleware Support

*Exemplar/Case Studies: Mobile Shopping Services systems

*Mapping of Course Outcomes for Unit III: CO3

Unit IV	Intelligent Systems and Interaction	07 Hours

Introduction, Basic Concepts, IS Architectures, Semantic KBIS, Classical Logic IS, Soft Computing IS Models, IS System Operations, Interaction Multiplicity, IS Interaction Design, Generic Intelligent Interaction Applications.

*Exemplar/Case Studies: Curious information displays: A motivated reinforcement learning IE application.

*Mapping of Course Outcomes for Unit IV: CO4

Unit V	User Interaction Design – HCI and Wearable Computing	07 Hours

Introduction of Interaction Design, Basics of Interaction Design and its Concepts, Importance of Interaction Design, Difference between Interaction Design and UX, What is HCI? Importance of HCI, Advantages and Disadvantages of HCI, Elements of HCI, HCI Design and Architecture,Define Wearable Computing, Importance of Wearable Computing, Security issues in Wearable Computing, Wearable Computing Architecture and Applications, Wearable Computing Challenges and Opportunities for Privacy Protection.

*Exemplar/Case Studies: Smart Fabric: Textile, Sensory Fabric for Ubiquitous interfaces

*Mapping of Course Outcomes for Unit V: CO5

Unit VI	Security Challenges & Ethics in Pervasive Computing	07 Hours

Security issues in Pervasive Computing, security model, authentication & authorization, access control, secure resource discovery, open issues Pervasive computing security challenges & requirements, Privacy & trust issues, social & user interaction issues, solution for pervasive computing challenges, Role of Ethics in pervasive computing security, Autonomy and Self-determination, Responsibility, legal, moral & social, distributive justice, digital divide and sustainable development

*Exemplar/Case Studies: Pervasive Computing Security Gain Perspect

*Mapping of Course Outcomes for Unit VI: CO6

Learning Resources

Text Books:

1. Stefan Poslad, "Ubiquitous Computing: Smart Devices, Environments and Interactions", Wiley Publications, Student Edition, ISBN 9781265273531.
2. Jochen Burkhardt, Horst Henn, Stefan Hepper, Klaus Rindtorff, Thomas Schaeck, " Pervasive Computing: Technology and Architecture of Mobile Internet Applications", Pearson Education, ISBN 9788177583861.
3. Frank Adelstein, Sandeep K. S. Gupta, Golden G. Richard III, Loren Schwiebert, "Fundamentals of Mobile and Pervasive Computing" McGraw Hill Education, Indian Edition, ISBN 9780070669468.

Reference Books:

1. Sen Loke, "Context Aware Pervasive Systems: Architectures for new Breed of Applications", Taylor and Francis, ISBN 0-8493-7255-0
2. Laurence Yang, Evi Syukur, Seng Loke, "Handbook on Mobile and Ubiquitous Computing : Status and Perspectives", CRC Press, 2013 ISBN 978-1-4398-4811-1
3. M. Hagmi and S. I. Ahamed, "Security in pervasive computing: Current status and open issues", Int. J. Netw. Secur., vol. 3, no. 3, pp. 203–214, 2006.

e-Books::

1. M. Hilty, "Ubiquitous Computing in the Workplace: What School Learns?" no. August, pp. 1–16, 2014, [Online] http://link.springer.com/bookseries/11380.
2. https://ecitsukkur.edu.pk/CS(5.5)P2014/SMZCom/Ubiquitous%20Computing%20Book%20Pervasive%20Computing.pdf
3. http://pervasivecomputing.se/SC01128_2014/material/Wiley-Ubiquitous Computing Smart Devices Environments And Interactions May 2009 eBook.pdf
4. http://media.techtarget.com/searchMobileComputing/downloads/Mobile_and_pervasive_computing_CH06.pdf

MOOC Course Links:

https://www.coursera.org/specializations/mobile-and-pervasive-computing

If the CO-PO Mapping Done:

Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
410244(B): Multimedia Techniques

Teaching Scheme:	Credit	Examination Scheme:
TH: 03 Hours/Week	03	In-Sem (Paper): 30 Marks
		End-Sem (Paper): 70 Marks

Prerequisite Courses: Computer Graphics (210244)

Companion Course: Laboratory Practice IV(410247)

Course Objectives:

- To understand input and output devices, device drivers, control signals and protocols, DSPs
- To study and use standards (e.g., audio, graphics, video)
- To implement applications, media editors, authoring systems, and authoring by studying stream structures, capture, represent, transform, spaces-domains, compression/coding
- To design and develop content-based analysis, indexing, and retrieval of audio, images, animation, and video
- To demonstrate presentation, rendering, synchronization, multi-modal integration, interfaces
- **To Understand IoT architectures and Multimedia Internet of things**

Course Outcomes:

On completion of the course, student will be able to–

CO1: Describe the media and supporting devices commonly associated with multimedia information subsystems

CO2: Demonstrate the use of content-based information analysis in a multimedia information system

CO3: Critique multimedia presentations in terms of their appropriate use of audio, video, graphics, color and other information presentation concepts

CO4: Implement a multimedia application using an authoring system.

CO5: Understanding of technologies for tracking, navigation and gestural control.

CO6: Implement Multimedia Internet of Things Architectures

Course Contents

Unit I — Introduction to multimedia — 07 Hours

What is Multimedia and their Components, History of Multimedia, Hypermedia, WWW, and Internet, Multimedia Tools, Static (text, graphics, and still images), Active (sound, animation, and video, etc.) Multimedia Sharing and Distribution, Multimedia Authoring Tools- Adobe Premiere, Adobe Director, Adobe Flash

***Exemplar/Case Studies:** To study and install open-source multimedia Tools

***Mapping of Course Outcomes for Unit I:** CO1

Unit II — Graphics and Data Representation Techniques — 07 Hours

What are Graphics data types, 1 bit images, 8 bit gray level ,16-bit gray level images, Image data types: Image data types 8 bit & 24-bit color images, Higher bit depth images, Color Lookup tables. File Formats: GIF, JPEG, PNG, TIFF, PSD, APS, AI, INDD, RAW, Windows BMP, Windows WMF,

Netpbm format, EXIF, PTM, Text file format, RTF, TGA Applications Use of text in Multimedia

#Exemplar/Case Studies	To study conversion of image file formats from one to Other
***Mapping of Course Outcomes for Unit II**	CO2

Unit III	Multimedia Representation Techniques	07 Hours

Principal concepts for the analog video: CRT, NTSC Video (National Television System Committee), PAL Video (Phase Alternating Line), SECAM Video (System Electronic Couleur Avec Memoire), Digital Video: Chroma Subsampling, High-Definition TV, Ultra High Definition TV (UHDTV), Component Video: High-Definition Multimedia Interface (HDMI), D3 Video and TV: various cues, Basics of Digital Audio: What is Sound?, Nyquist Theorem, SNR, SQNR, Audio Filtering, Synthetic Sounds, MIDI Overview: Hardware, Structure, Conversion to WAV, Coding of Audio: PCM, DPCM, DM (Delta Modulation)

#Exemplar/Case Studies	Install and use Handbrake (link is https://handbrake.fr/) software to understand the concept of interlaced, deinterlace, noise filters, bitrate, and frame rate for any sample 30 min video, and note down the observations from the output video
***Mapping of Course Outcomes for Unit III**	CO3

Unit IV	Compression Algorithms	07 Hours

Introduction to multimedia – Graphics, Image and Video representations – Fundamental concepts of video, digital audio – Storage requirements of multimedia applications – Need for compression – Types of compression algorithms- lossless compression algorithms RLC, VLC, DBC, AC, lossless image compression, differential coding of Images, lossy compression algorithms-Rate - distortion theory, Quantization ,Transform coding, wavelet based coding, embedded Zerotrees of wavelet coefficients , Image compression standard, JPEG standard, JPEG 2000 standard, LS standard, Bilevel image compression standard, Introduction to video compression - video compression based on motion compensation, Search for motion vectors, MPEG Video coding I , MPEG 1,2,4,7 onwards, Basic Audio Compression Techniques -ADPCM in speech coding, Vocoders, MPEG audio compression

#Exemplar/Case Studies	Implementation of compression algorithms
***Mapping of Course Outcomes for Unit IV**	CO3, CO4

Unit V	Augmented Reality(AR), Virtual Reality (VR) and Mixed Reality (MR)	07 Hours

Basics of Virtual Reality, difference between Virtual Reality and Augmented Reality, Requirement of Augmented Reality, Components and Performance issues in AR, Design and Technological foundations for Immersive Experiences, Input devices – controllers, motion trackers and motion capture technologies for tracking, navigation and gestural control, Output devices – Head Mounted VR Displays, Augmented and Mixed reality glasses, 3D interactive and procedural graphics, Immersive surround sound, Haptic and vibrotactile devices, Best practices in VR, AR and MR Future applications of Immersive Technologies.

VRML Programming Modeling objects and virtual environments Domain Dependent applications: Medical, Visualization, Entertainment, etc.

#Exemplar/Case Studies	Navigation Assistance Systems
***Mapping of Course Outcomes for Unit V**	CO5

Unit VI	Multimedia Internet of Things	07 Hours

IoT and Multimedia IoT Architecture: IoT Architecture, M-IoT Architecture, Multi-Agent Based, AI-Based Software-Defined, Big Data Layered, Applications of M-IoT: Road Management System, Multimedia IoT in Industrial Applications, Health Monitoring

#Exemplar/Case Studies	Traffic Monitoring System
*Mapping of Course Outcomes for Unit VI	CO6

Learning Resources

Text Books:

1. Tay Vaughan, "Multimedia making it work", Tata McGraw-Hill, 2011, ISBN: 978-0-07-174630-4, MHID: 0-07-174630-4, eBook print version of this title: ISBN: 978-0-07-174646-8, MHID: 0-07-174646-8.
2. Ze-Nian Li, Mark S. Drew and Jiang chuan Liu, "Fundamentals of Multimedia", Second Edition, Springer, 2011, ISSN 1868-0941 ISSN 1868-095X (electronic) ISBN 978-3-319-05289-2 ISBN 978-3-319-05290-8 (eBook) DOI 10.1007/978-3-319-05290-8, Pearson Education, 2009

Reference Books:

1. Ali Nauman et al. "Multimedia Internet of Things: A Comprehensive Survey", Special Section on Mobile Multimedia: Methodology and Applications, IEEE Access, Volume 8, 2020
2. Kelly S. Hale (Editor), Kay M. Stanney (Editor), 2014, Handbook of Virtual Environments: Design, Implementation, and Applications, Second Edition (Human Factors and Ergonomics) ISBN-13: 978-1466511842, Amazon

e-Books::

1. https://www.cbse.ac.in/curriculum_secondary_2020/MMS/multimedia/Fundamentals_of_Multimedia.pdf
2. https://cse.sc.edu/~rguan/content/uploads/2022/04/Multimedia.pdf
3. https://www.pearsonhighered.com/assets/samplechapter/0/1/3/5/0135119042.pdf

MOOC Courses Links:

- https://nptel.ac.in/courses/117105083

xxxxx	xx1	xx2	xx3	xx4	xx5	xx6	xx7	xx8	xx9	xx10	xx11
xxx1	1	2	1	1	2	–	1	–	–	–	–	–
xxx2	3	1	3	2	2	–	–	–	–	–	–	–
xxx3	2	1	–	2	3	–	–	–	–	1	–	–
xxx4	3	3	2	2	1	1	1	1	1	1	1	1
xxx5	2	1	2	–	–	–	–	–	–	–	–	–
xxx6	3	3	2	1	2	–	–	–	–	–	–	–

Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
410244(C): Cyber Security and Digital Forensics

Teaching Scheme: TH: 03 Hours/Week	Credits 03	Examination Scheme: In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Prerequisite Courses: Computer Networks and Security(310244), Information Security(310254(A))

Companion Course: 410246: Laboratory Practice IV

Course Objectives:

- To enhance awareness cyber forensics.
- To understand issues in cyber crime and different attacks
- To understand underlying principles and many of the techniques associated with the digital forensic practices
- To know the process and methods of evidence collection
- To analyze and validate forensic data collected.
- To apply digital forensic knowledge to use computer forensic tools and investigation report writing.

Course Outcomes: At the end of the course, the student should be able to:

CO1: Analyze threats in order to protect or defend it in cyberspace from cyber-attacks.
CO2: Build appropriate security solutions against cyber-attacks.
CO3:Underline the need of digital forensic and role of digital evidences.
CO4: Explain rules and types of evidence collection.
CO5: Analyze, validate and process crime scenes.
CO6: Identify the methods to generate legal evidence and supporting investigation reports.

Course Contents

Unit I	Introduction to Cyber Security	06 Hours

Introduction and Overview of Cyber Crime, Nature and Scope of Cyber Crime, Types of Cyber Crime: crime against an individual, Crime against property, Cyber extortion, Drug trafficking, cyber terrorism, Need for Information security, Threats to Information Systems, Information Assurance, Cyber Security, and Security Risk Analysis.

*Examples/Case Studies	Data Breach Digest – Perspective & Reality http://securosis.com/assets/publications/Digest
*Mapping of Course Outcome for Unit I	CO1

Unit II	Cyber Crime Issues and Cyber attacks	06 Hours

Unauthorized Access to Computers, Computer Intrusions, Viruses, and Malicious Code, Internet Hacking and Cracking, Virus and worms, Software Piracy, Intellectual Property, Mail Bombs, Exploitation, Stalking and Obscenity in Internet, Cyberstalking: prevention methods, Application security (Database, E-mail) and Internet, Data Security Considerations-Backups, Archival Storage and Disposal of Data, Security Technology-Firewall and VPNs, Hardware protection mechanisms, OS Security.

*Examples/Case Studies	Cyber Stalking types & their cases respectively
*Mapping of Course Outcome for Unit II	CO2

Unit III	Introduction to Digital Forensics	06 Hours

What is Computer Forensics?, Use of Computer Forensics in Law Enforcement, Computer Forensics Assistance to Human Resources/Employment Proceedings, Computer Forensics Services, Benefits of Professional Forensics Methodology, Steps taken by Computer Forensics Specialists, Types of Computer

Forensics Technology: Types of Military Computer Forensic Technology, Types of Law Enforcement — Computer Forensic Technology, Types of Business Computer Forensic Technology Computer Forensics Evidence and Capture: Data Recovery Defined, Data Back-up and Recovery, The Role of Back-up in Data Recovery, The Data-Recovery Solution.	
#Exemplar/Case Studies	Demonstrate practice Linux networking security recovery commands & Study Tools viz: FTK & The Sleuth Kit
***Mapping of Course Outcome for Unit III**	CO3

Unit 4	Evidence Collection and Data Seizure	06 Hours
Why Collect Evidence? Collection Options ,Obstacles, Types of Evidence — The Rules of Evidence, Volatile Evidence, General Procedure, Collection and Archiving, Methods of Collection, Artifacts, Collection Steps, Controlling Contamination: The Chain of Custody Duplication and Preservation of Digital Evidence: Preserving the Digital Crime Scene — Computer Evidence Processing Steps, Legal Aspects of Collecting and Preserving Computer Forensic Evidence Computer Image Verification and Authentication: Special Needs of Evidential Authentication, Practical Consideration, Practical Implementation.		
#Exemplar/Case Studies	Understand how computer forensics works by visiting. http://computer.howstuffworks.com/computer-forensic.htm/printable(23 December 2010)	
***Mapping of Course Outcome for Unit IV**	CO4	

Unit 5	Computer Forensics analysis and validation	06 Hours
Determining what data to collect and analyze, validating forensic data, addressing data-hiding techniques, and performing remote acquisitions Network Forensics: Network forensics overview, performing live acquisitions, developing standard procedures for network forensics, using network tools, examining the honeynet project. Processing Crime and Incident Scenes: Identifying digital evidence, collecting evidence in private-sector incident scenes, processing law enforcement crime scenes, preparing for a search, securing a computer incident or crime scene, mining digital evidence at the scene, storing digital evidence, obtaining a digital hash, reviewing a case		
#Exemplar/Case Studies	Discuss cases under Financial Frauds, Matrimonial Frauds, Job Frauds, Spoofing, and Social media. Then write down safety tips, precautionary measures for the discussed fraud cases.	
***Mapping of Course Outcome for Unit V**	CO5	

Unit 6	Current Computer Forensic tools	06 Hours
Evaluating computer forensic tool needs, computer forensics software tools, computer forensics hardware tools, validating and testing forensics software E-Mail Investigations: Exploring the role of e-mail in investigation, exploring the roles of the client and server in e-mail, investigating e-mail crimes and violations, understanding e-mail servers, using specialized e-mail forensic tools.		
#Exemplar/Case Studies	Install Kali Linux & practice following examples: 1. https://www.youtube.com/watch?time_continue=4&v=MZXZctqlU-w&feature=emb_logo	
***Mapping of Course Outcome for Unit VI**	CO6	

Learning Resources

Text Books:

1. **John R. Vacca**, "Computer Forensics", Computer Crime Investigation Firewall Media, New Delhi.
2. **Nelson, Phillips Enfinger, Steuart**, "Computer Forensics and Investigations", CENGAGE Learning

Reference Books:

1. **Keith J. Jones, Richard Bejtlich, Curtis W. Rose**, "Real Digital Forensics", Addison-

Wesley Pearson Education.

2. Tony Sammes and Brian Jenkinson, "Forensic Compiling", A Tractitioners Guide, Springer International edition.

3. Christopher L.T. Brown, "Computer Evidence Collection & Presentation", Firewall Media.

4. Jesus Mena, "Homeland Security, Techniques & Technologies", Firewall Media.

e books:

1 https://www.pdfdrive.com/computer-forensics-investigating-network-intrusions-and-cyber-crime-e15858265.html

2 https://dokumen.pub/handbook-of-computer-crime-investigation-forensic-tools-and-technology-1stabsped-0121631036-9780121631031.html

3.Massachusetts Institute of Technology Open Courseware: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-858-computer-systems-security-fall-2014/

MOOC Courses Links:

- MIT Open CourseWare: https://ocw.mit.edu/courses/

@The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	-	-	-	-	-	-	-	-	-	2
CO2	1	3	-	-	-	-	-	-	-	-	-	2
CO3	2	3	2	-	-	-	-	-	-	-	-	3
CO4	2	3	3	-	-	-	-	-	-	-	-	3
CO5	2	2	2	2	-	-	-	-	-	-	-	3
CO6	2	3	2	3	-	-	-	-	-	-	-	3



Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
410244(D): Object oriented Modeling and Design

Teaching Scheme:	Credit	Examination Scheme: In-Sem (Paper): 30 Marks
TH: 03 Hours/Week	03	End-Sem (Paper): 70 Marks

Prerequisite Courses: Software Engineering (310241)

Companion Course: Laboratory Practice IV (410247)

Course Objectives:

- Describe the concepts involved in Object-Oriented modelling and their benefits.
- Demonstrate concept of use-case model, sequence model and state chart model for a given problem.
- Explain the merits of the unified process approach to design and build a Software system.
- Translate the requirements into implementation for Object Oriented design.
- Choose an appropriate design pattern to facilitate development procedure. Select suitable design pattern depending on nature of application.
- To describe Designing and Management of Patterns.

Course Outcomes:

On completion of the course, student will be able to—

CO1: Describe the concepts of object-oriented and basic class modelling.
CO2: Draw class diagrams, sequence diagrams and interaction diagrams to solve problems.
CO3: Choose and apply a befitting design pattern for the given problem.
CO4: To Analyze applications, architectural Styles & software control strategies.
CO5: To develop Class design Models & choose Legacy Systems.
CO6:To Understand Design Patterns.

Course Contents

Unit I — Introduction To Modeling — 06 Hours

What is Object Orientation? What is OO development? OO themes; Evidence for usefulness of OO development; OO modeling history. Modeling as Design Technique: Modeling; abstraction; The three models. Class Modeling: Object and class concepts; Link and associations concepts; Generalization and inheritance; A sample class model; Navigation of class models; Practical tips.

*Exemplar/Case Studies	Case Study of ATM System
*Mapping of Course Outcomes for Unit I	CO1

Unit II — Advanced Class Modeling and State Modeling — 06 Hours

Advanced object and class concepts; Association ends; N-ary associations; Aggregation; Abstract classes; Multiple inheritance; Metadata; Reification; Constraints; Derived data; Packages; Practical tips. State Modeling: Events, States, Transitions and Conditions; State diagrams; State diagram behavior; Practical tips.

*Exemplar/Case Studies	Case Study of Train Reservation System
*Mapping of Course Outcomes for Unit II	CO2

Unit III	Advanced State Modeling and Interaction Modeling	06 Hours

Advanced State Modeling: Nested state diagrams, Nested states, Signal generalization, Concurrency: A sample state model, Relation of class and state models, Practical tips.Interaction Modeling: Use case models, Sequence models, Activity models. Use case relationships, Procedural sequence models, Special constructs for activity models.

*Exemplar/Case Studies	Case Study of Coffee Vending Machine
*Mapping of Course Outcomes for Unit III	CO2, CO3

Unit IV	User Application Analysis - System Design	06 Hours

Application Analysis: Application interaction model, Application class model, Application state model, Adding operations. Overview of system design: Estimating performance, Making a issue plan, Breaking a system in to sub-systems, Identifying concurrency, Allocation of sub-systems, Management of data storage, Handling global resources,
Choosing a software control strategy, Handling boundary conditions, Setting the trade-off priorities, Common architectural styles. Architecture of the ATM system as the example

*Exemplar/Case Studies	Case System of ATM System
*Mapping of Course Outcomes for Unit IV	CO3, CO4

Unit V	Class Design ,Implementation Modeling, Legacy Systems	06 Hours

Class Design: Overview of class design, Bridging the gap, Realizing use cases, Designing algorithms, Refining attributes, Designing associations, Refactoring: Design optimization, Reification of behavior, Adjustment of inheritance, Organizing a class design, ATM example. Implementation Modeling: Overview of implementation, Fine-tuning classes, Fine-tuning generalizations, Realizing associations, Testing. Legacy Systems: Reverse engineering, Building the class models, Building the interaction model, Building the state model, Reverse engineering tips, Wrapping, Maintenance.

*Exemplar/Case Studies	Case study of College Library System
*Mapping of Course Outcomes for Unit V	CO4, CO5

Unit VI	Design Patterns	06 Hours

What is a pattern and what makes a pattern? Pattern categories, Relationships between patterns, Pattern descriptions.Communication Patterns: Forwarder-Receiver, Client-Dispatcher-Server, Publisher-Subscriber.
Management Patterns: Command processor, View handler. Idioms: Introduction, what can idioms provide? Idiom and style, When to find idioms, Counted Pointer example.

*Exemplar/Case Studies	Design Pattern for Any suitable System
*Mapping of Course Outcomes for Unit XI	CO6

Learning Resources

Text Books:

1. Michael Blaha, James Rumbaugh, "Object-Oriented Modeling and Design with UML", 2nd Edition, Pearson Education, 2005
2. Frank Buschmann, Regine Meunier, Hans Rohnert, Peter Sommerlad, Michael Stal, "Pattern-Oriented Software Architecture, A System of Patterns", Volume 1, John Wiley and Sons, 2007

Reference Books:

1. Grady Booch et al, "Object-Oriented Analysis and Design with Applications", 3rd Edition, Pearson Education, 2007
2. Brahma Dathan, Sarnath Ramnath, "Object-Oriented Analysis, Design, and Implementation", UniversitiesPress, 2009
3. Hans-Erik Eriksson, Magnus Penker, Brian Lyons, David Fado, " UML 2 Toolkit", Wiley-Dreamtech India, 2004
4. Simon Bennett, Steve McRobb and Ray Farmer, " UML 2 Toolkit, Object-Oriented Systems Analysis and Design Using UML, 2nd Edition, Tata McGraw-Hill, 2002.

e-Books :

1. Object Oriented Modeling and Design - https://www.pdfdrive.com/object-oriented-design-and-modeling-d13014868.html
2. https://www.gopalancollege.com/gopalancollege/material/computer-science/semester-VI/object-oriented-modeling-and-design-(OCS7).pdf

MOOC Lectures Links:

- https://nptel.ac.in/courses/106/105153/

Mapping CO-PO Mapping Matrix

course	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
co1	2	2	2	2	2	2	—	—	—	—	—	—
co2	2	2	2	2	2	2	—	—	—	—	—	—
co3	2	2	2	2	2	2	—	—	—	—	—	—
co4	2	2	2	2	2	2	—	—	—	—	—	—
co5	2	2	2	2	2	2	—	—	—	—	—	—
co6	2	2	2	2	2	2	—	—	—	—	—	—

Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
410244(E): Digital Signal Processing

Teaching Scheme:	Credit	Examination Scheme:
TH: 03 Hours/Week	03	In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Prerequisite Courses: Engineering Mathematics III(207003)
Companion Course: Laboratory Practice IV(410254)

Course Objectives:

- To Study and understand representation and properties of signals and systems
- To learn methodology to analyze signals and systems
- To study transformed domain representation of signals and systems
- To explore Design and analysis of Discrete Time (DT) signals and systems
- To Understand Design of filters as DT systems
- To get acquainted with the DSP Processors and DSP applications

Course Outcomes:

On completion of the course, student will be able to–

CO1: Understand the mathematical models and representations of DT Signals and Systems
CO2: Apply different transforms like Fourier and Z-Transform from applications point of view.
CO3: Understand the design and implementation of DT systems as DT filters with filter structures and different transforms.
CO4: Demonstrate the knowledge of signals and systems for design and analysis of systems
CO5: Apply knowledge and use the signal transforms for digital processing applications
CO6:To understand Filtering and Different Filter Structures.

Course Content

Unit I Signals and Systems 08 Hours

Continuous time (CT), Discrete time (DT) and Digital signals, Basic DT signals and Operations, Discrete time Systems, Properties of DT Systems and Classification, Linear Time Invariant (LTI) Systems, Impulse response, Linear convolution, Linear constant coefficient difference equations, FIR and IIR systems, Periodic Sampling, Relationship between Analog and DT frequencies, Aliasing, Sampling Theorem, A to D conversion Process, Sampling, quantization and encoding

*Exemplar/Case Studies: Audio/Music Sampling

*Mapping of Course Outcomes for Unit I: CO1

Unit II Frequency Domain Representation of Signal 08 Hours

Introduction to Fourier Series, Representation of DT signal by Fourier Transform (FT), Properties of FT: Linearity, periodicity, time shifting, frequency shifting, time reversal, differentiation, convolution theorem, windowing, Discrete Discrete Fourier Transform (DFT), DFT and FT, IDFT, Twiddle factor, DFT as linear transformation matrix, Properties of DFT, circular shifting, Circular Convolution, DFT as Linear filtering, overlap save and add, DFT spectral

leakage

#Exemplar/Case Studies	Spectral Analysis using FFT
***Mapping of Course Outcomes for Unit II**	CO1

Unit III	Fast Fourier Transform (FFT) and Z-Transform(ZT)	08 Hours

Effective computation of DFT, Radix-2 FFT algorithms: DIT FFT, DIF FFT, Inverse DFT using FFT, Z-transform (ZT), ZT and FT, ZT and DFT, ROC and its properties, ZT Properties, convolution, initial value theorem, Rational ZT, Pole Zero Plot, Behavior of causal DT signals, Inverse Z Transform (IZT): power series method, partial fraction expansion (PFE) , Residue method.

#Exemplar/Case Studies	Discrete Hilbert Algorithm
***Mapping of Course Outcomes for Unit III**	CO2

Unit IV	Analysis of DT – LTI Systems	08 Hours

System function H(z), H(z) in terms of Nth order general difference equation, all poll and all zero systems, Analysis of LTI system using H(Z), Unilateral Z-transform: solution of difference equation, Impulse and Step response from difference equation, Pole zero plot of H(Z) and difference equation, Frequency response of system, Frequency response from pole-zero plot using Simple geometric construction.

#Exemplar/Case Studies	Sehai Algorithm
***Mapping of Course Outcomes for Unit IV**	CO3

Unit V	Digital Filter Design	08 Hours

Concept of filtering, Ideal filters and approximations, specifications, FIR and IIR filters, Linear phase response, FIR filter Design: Fourier Series method, Windowing method, Gibbs Phenomenon, desirable features of windows, Different window sequences and its analysis, Design examples IIR filter design: Introduction, Mapping of S-plane to Z-plane: Impulse Invariance method, Bilinear Z transformation (BLT) method, Frequency Warping, Pre-warping, Design examples, Comparison of IIR and FIR Filters.

#Exemplar/Case Studies	Realization of an Analogue Second-order Differentiator
***Mapping of Course Outcomes for Unit V**	CO3

Unit VI	Filter Structures and DSP Processors	08 Hours

Filter Structures for FIR Systems: direct form, cascade form, structures for linear phase FIR Systems, Examples, Filter structures for IIR Systems: direct form, cascade form, parallel form, Examples DSP Processors: ADSP 21XX Features, comparison with conventional processor, Basic Functional Block diagram, SHARC DSP Processor Introduction to OMAP (Open Multimedia Application Platform)

#Exemplar/Case Studies	Architectures and Design techniques for energy efficient embedded DSP

and multimedia processing

***Mapping of Course Outcomes for Unit VI**	**CO6**

Learning Resources

Text Books:

1. Proakis J, Manolakis D, "Digital Signal Processing", 4th Edition, Pearson Education, ISBN9788131710005
2. Oppenheimer A, Schafer R, Buck J, "Discrete time Signal Processing", 2nd Edition, PearsonEducation, ISBN 9788131704929

Reference Books:

1. Mitra S., "Digital Signal Processing: A Computer Based Approach", Tata McGraw-Hill,1998, ISBN 0-07-044705-5
2. Mcclellan E. C., Jervis B. W., "Digital Signal Processing: A Practical Approach ", Pearson Education, 2002, , ISBN-13: 978-0201596199,ISBN-10: 0201596199
3. S. Salivahanan, A. Vallavaraj, C. Gnanapriya, "Digital Signal Processing", McGraw-Hill,ISBN 0-07-463996-X
4. S. Poornachandra, B. Sankala, "Digital Signal Processing",3rd Edition, McGraw-Hill, ISBN-13:978-07-067279-6

e-Books :

1. An Introduction to Digital Signal Processing: A Focus on Implementation https://www.sleepublishers.com/pdf/ebook/BP_E9788792982032.pdf

MOOC Courses Links:

- **Digital signal Processing Introduction- https://nptel.ac.in/courses/117102060**

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	1	1	-	-	-	-	-	-	-
CO2	3	3	2	2	3	-	-	-	-	-	-	-
CO3	1	2	2	2	1	-	-	-	-	-	-	-
CO4	3	3	2	3	3	-	-	-	-	-	-	-
CO5	3	2	3	2	2	-	-	-	-	-	-	-
CO6	2	2	2	2	2	-	-	-	-	-	-	-

Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
Elective V
410245(A): Information Retrieval

Teaching Scheme:
TH: 04 Hours/Week

Credit:
04

Examination Scheme:
In-Sem (Paper): 30 Marks
End-Sem (Paper): 70 Marks

Prerequisite Courses: Database Management Systems(310241)

Companion Course: Laboratory Practice IV(410247)

Course Objectives:

- To study basic concepts of Information Retrieval.
- To study concepts of Indexing for Information Retrieval.
- To analyze the performance of information retrieval using advanced techniques such asclassification, clustering, and filtering over multimedia.
- To provide comprehensive details about various Evaluation methods.
- To understand the changes necessary to translate a Basic IR system into large scale search service system.
- To understand Parallel Information retrieval and Web structures.

Course Outcomes:

On completion of the course, student will be able to–

CO1:Implement the concept of Information Retrieval
CO2:Generate quality information out of retrieval information
CO3:Apply techniques such as classification, clustering, and filtering over multimedia to analyzethe information
CO4:Evaluate and analyze retrieved information
CO5:Understand the data in various Application and Extensions of information retrieval
CO6: Understand Parallel information retrieving and web structure.

Course Contents

Unit I — Introduction , Basic techniques, & Tokens — 07 Hours

Introduction: The IR System, The Software Architecture Of The IR System.

Basic IR Models: Boolean Model, TF-IDF (Term Frequency/Inverse Document Frequency) Weighting, Vector Model, Probabilistic Model and Latent Semantic Indexing Model.

Basic Tokenizing: Simple Tokenizing, Stop Word Removal and Stemming.

Exemplar/Case Studies: A Case Study Of Osmania Divisional Library Which Aims At Finding TheCauses And Solutions To The Problems Of Information Retrieval Methods By The Library.

Mapping of Course Outcomes for Unit I: CO 1

Unit II — Basic Retrieval Indices and Query Processing — 07 Hours

Static Inverted Indices :Inverted Index Construction, Index Components and Index Life Cycle, The Dictionary : Sort-based dictionary ,Hash-based dictionary, Interleaving Dictionary and Postings Lists.

Index Construction: Different types of Index Construction, In-Memory Index Construction, Sort-Based Index Construction, Merge-Based Index Construction, Disk-Based Index Construction)

Other types of Indices

Query Processing : Query Processing for Ranked Retrieval : Document-at-a-Time Query Processing, Term-at-a-Time Query Processing, Precomputing Score Contributions, Impact Ordering)

Query optimization, Lightweight Structure : Generalized Conjunction Lists, Operators, Implementation & Examples

***Examples/Case Studies**	Match the search statement with the stored database
***Mapping of Course Outcomes for Unit II**	CO2

Unit III Index Compression and Dynamic Inverted Indices **07 Hours**

General-Purpose Data Compression,

Data Compression : Modeling and Coding, Huffman Coding, Arithmetic Coding, Symbolwise Text Compression

Compressing Postings Lists:

Nonparametric Gap Compression, Parametric Gap Compression, Context-Aware Compression Methods, Index Compression for High Query Performance, Compression Effectiveness, Decoding Performance, Document Reordering

Dynamic Inverted Indices:

Incremental Index Updates, Contiguous Inverted Lists, Noncontiguous Inverted,

Document Deletions: Invalidation List, Garbage Collection, Document Modifications.

***Examples/Case Studies**	Translating Short Sequences with NMT : A Case Study in English-to-Hindi
***Mapping of Course Outcomes for Unit III**	CO2

Unit IV Probabilistic Retrieval and Language Modeling & Related Methods, Categorization & Filtering **07 Hours**

Probabilistic Retrieval: Modeling Relevance, The Binary Independence Model, Term Frequency, Document Length:BM25, Relevance Feedback, Field Weights

Language Modeling and Related Methods: Generating Queries from Documents, Language Models and Smoothing, Ranking with Language Models, Divergence from Randomness, Passage Retrieval and Ranking

Categorization and Filtering: Detailed Examples, Classification, Linear, Similarity- Based, Probabilistic Classifiers, Generalized Linear Models, Information-Theoretic Models

E-Mail on the Move: Categorization, Filtering, and Alerting on Mobile Devices with the of Mail Prototype

***Examples/Case Studies**	E-Mail on the Move: Study of Email Categorization, Filtering, and Alerting on Mobile Devices

*Mapping of Course Outcomes for Unit IV	CO3

Unit V	Measuring Effectiveness and Measuring Efficiency	07 Hours

Measuring Effectiveness – Traditional effectiveness measure, The Text Retrieval Conference (TREC), Using statistics in evaluation, Minimizing adjudication Effort, Nontraditional effectiveness measures

Measuring Efficiency – Efficiency criteria, Query Scheduling, Caching, Introduction to Redis and Memcached

*Exemplar/Case Studies	Study of API Handling
*Mapping of Course Outcomes for Unit V	CO 4

Unit VI	Parallel Information retrieval, Web Search	07 Hours

Parallel Information retrieval - Parallel Query Processing, MapReduce

Web Search- The structure of the web, Quiver and Users, Static ranking, Dynamic ranking, Evaluation web search, Web Crawlers, Web crawler libraries, Python Scrapy, BeautifulSoup

*Exemplar/Case Studies	Study of Google Map / Facebook information retrieval
*Mapping of Course Outcomes for Unit VI	CO 5 , CO6

Learning Resources

Text Books:

1. S. Buttcher, C. Clarke and G. Cormack, "Information Retrieval: Implementing and Evaluating Search **Engines**" MIT Press, 2010, ISBN: 0-400-70029-4.
2. C. Manning, P. Raghavan, and H. Schütze, "Introduction to Information Retrieval", Cambridge University Press, 2008, -13: 9780521865715.
3. Ricardo Baeza , Yates and Berthier Ribeiro Neto, "Modern Information Retrieval: The Concepts and Technology behind **Search**", **2nd** Edition, ACM Press Books 2011.
4. Bruce Croft, Donald Metzler and Trevor Strohman, "Search Engines: Information Retrieval in **Practice**", **1st Edition Addison** Wesley, 2009, ISBN: 9780135756524

Reference Books:

1. C.J. Rijsbergen, "Information Retrieval", (http://www.dcs.gla.ac.uk/Keith/Preface.html)
2. W.R. Hersh, "Information Retrieval: A Health and Biomedical Perspective", Springer, 2002.
3. G. Kowalski, M.T. Maybury, "Information storage and Retrieval Systems", Springer, 2003.
4. W.B. Croft, J. Lafferty, "Language Modelling for Information Retrieval", Springer, 2003.

e-Books :

1. Information Retrieval- www.informationretrieval.org

MOOC Courses Links

- https://ojtel.ac.in/courses/117302068

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	2	1	-	-	-	-	-	-	-	-
CO2	1	1	2	1	-	-	-	-	-	-	-	-
CO3	1	1	2	1	-	-	-	-	-	-	-	-
CO4	1	1	2	1	-	-	-	-	-	-	-	-
CO5	1	1	2	1	2	-	-	-	-	-	-	-
CO6	1	2	2	2	1	-	-	-	-	-	-	-



Savitribai Phule Pune University

Fourth Year of Computer Engineering (2019 Course) (Sem-)

Elective V

410245(B): GPU Programming and Architecture

Teaching Scheme:	Credit	Examination Scheme:
TH: 03	03	Mid-Semester (TH) : 30 Marks
Hours/Week:		End-Sem (TH): 70 Marks

Prerequisite Courses: Computer Graphics(210244)

Companion Course: Laboratory Practice IV(410247)

Course Objectives:

- To Understand Graphics Processing Unit (GPU) Concepts
- To understand the basics of GPU architectures
- To write programs for massively parallel processors
- To understand the issues in mapping algorithms for GPUs
- To introduce different GPU programming models
- To examine the architectures and capabilities of modern GPUs

Course Outcomes:

After completion of the course, students should be able to-

CO1: Describe GPU architecture

CO2: Write programs using CUDA, identify issues and debug them

CO3: Implement efficient algorithms in GPUs for common application kernels, such as matrix multiplication

CO4: Write simple programs using OpenCL

CO5: Identify efficient parallel programming patterns to solve problems

CO6: Explore the modern GPUs architecture and it's Applications.

Course Contents

Unit I	Introduction to Graphics Processing Unit (GPU)	07 Hours

Evolution of GPU architectures – Understanding Parallelism with GPU – Typical GPU Architecture – CUDA Hardware Overview – Threads, Blocks, Grids, Warps, Scheduling – Memory Handling with CUDA: Shared Memory, Global Memory, Constant Memory and Texture Memory

Examples/Case Studies	Review of traditional Computer Architecture
Mapping of Course Outcomes for Unit I	CO1

Unit II	Cuda Programming	07 Hours

Using CUDA – Multi GPU – Multi GPU Solutions – Optimizing CUDA Applications: Problem Decomposition, Memory Considerations, Transfers, Thread Usage, Resource Contentions

Examples/Case Studies	Write basic CUDA programs.
Mapping of Course Outcomes for Unit II	CO2

Unit III	Programming Issues	07 Hours

Common Problems: CUDA Error Handling, Parallel Programming Issues, Synchronization, Algorithmic Issues, Finding and Avoiding Errors.

Exemplar/Case Studies	Study of various CUDA errors
Mapping of Course Outcomes for Unit III	CO 3

Unit IV	**OpenCL Basics**	**8 Hours**

OpenCL Standard, Kernels, Host Device Interaction, Execution Environment, Memory Model, Basic OpenCL Examples.

Exemplar/Case Studies	Write OpenCL basic programs
Mapping of Course Outcomes for Unit IV	CO 4

Unit V	**Algorithms on GPU**	**8 Hours**

Parallel Patterns: Convolution, Prefix Sum, Sparse Matrix – Matrix Multiplication – Programming Heterogeneous Cluster

Exemplar/Case Studies	Describe multi-dimensional mapping of datapace
Mapping of Course Outcomes for Unit V	CO 5

Unit VI	**OpenCL and Application Design**	**8 Hours**

OpenCL for Heterogeneous Computing, Application Design : Efficient Neural Network Training/Inferencing

Exemplar/Case Studies	Describe OpenCL for Heterogeneous computing
Mapping of Course Outcomes for Unit VI	CO6

Learning Resources

Text Books:

1. Shane Cook, "CUDA Programming: A Developer's Guide to Parallel Computing with GPUs (Applications of GPU Computing)", First Edition, Morgan Kaufmann, 2012.
2. David B. Kaeli, Perhaad Mistry, Dana Schaa, Dong Ping Zhang, "Heterogeneous computing with OpenCL", 3rd Edition, Morgan Kaufmann, 2015.
3. Benedict Gaster,Lee Howes, David B. Kaeli, "Heterogeneous Computing with OpenCL"

Reference Books :

1. Nicholas Wilt, "CUDA Handbook: A Comprehensive Guide to GPU Programming", Addison – Wesley, 2013.
2. Jason Sanders, Edward Kandrot, "CUDA by Example: An Introduction to General Purpose GPU Programming", Addison – Wesley, 2010.
3. David B. Kirk, Wen-mei W. Hwu, "Programming Massively Parallel Processors ", A Hands-on Approach, Third Edition, Morgan Kaufmann, 2016.
4. http://www.nvidia.com/object/cuda_home_new.html
5. http://www.openCL.org

e-Books :

1. https://www.perlego.com/book/1418742/cuda-handbook-a-comprehensive-guide-to-gpu-programming-the-pdf

NPTEL/YouTube video lecture link

- https://nodimenurses.nptel.ac.in/noc20_cs41/preview

@The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	1	2	-	1	-	-	-	-	-
CO2	1	2	2	2	2	-	-	-	-	-	-	-
CO3	1	2	2	2	2	-	-	-	-	-	-	-
CO4	1	2	2	2	2	-	-	-	-	-	-	-
CO5	1	2	2	2	2	-	-	-	-	-	-	-
CO6	1	2	2	1	2	-	-	-	-	-	-	-

Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
Elective V
410245(C): Mobile Computing

Teaching Scheme:	Credit	Examination Scheme: 100
TH: 3 Hours/Week	3	Mid-Semester (TH) : 30 End- Sem (TH): 70

Prerequisite Courses: Computer Networks and Security(310244)

Companion Course: Laboratory Practice IV(410247)

Course Objectives:

- To introduce the basic concepts and principles in mobile computing. This includes major techniques involved, and networks & systems issues for the design and implementation of mobile computing systems and applications.
- To demonstrate the protocols of mobile communication.
- To know GSM architecture and support services
- To Study on location, handoff management and wireless fundamentals.
- To summarize VLR and HLR identification algorithms
- To learn current technologies being used on field and design and development of various network protocol using simulation tools.

Course Outcomes:

CO1: Develop a strong grounding in the fundamentals of mobile Networks

CO2: Apply knowledge in MAC, Network, and Transport Layer protocols of Wireless Network

CO3: Illustrate Global System for Mobile Communications

CO4: Use the 3G/4G technology based network with bandwidth capacity planning,VLR and HLR identification algorithms

CO5: Classify network and transport layer of mobile communication

CO6: Design & development of various wireless network protocols using simulation tools

Course Contents

Unit I	Introduction to Mobile Computing	07 Hours

Introduction to Mobile computing, Constraints in mobile computing, Application of mobile computing, Generations of mobile wireless 1G to 3G, Future of mobile computing, Radio frequency Technology, Public Switched Telephone network, (PSTN), Public Communication service (PCS), PCS Architecture, , Bluetooth, Ad-hoc Networks.

*Exemplar/Case Studies	3G Network , Spectrum sharing for D2D communication in 3G cellular networks
*Mapping of Course Outcomes for Unit I	CO1

Unit II	Mobile/Wireless protocols	07 Hours

Introduction of WAP, WAP applications, WAP Architecture, WAP Protocol Stack, Challenges in WAP , Introduction, Benefits, Difference, Routing protocols for ad hoc wireless networks, DSDV and AODV.

Wireless Application protocols: MAC,TDMA,FDMA,TDMA,CDMA, Cellular Wireless Networks, Wireless Communication, Cellular systems, Frequency Management and Channel Assignment, Types of handoff

and their characteristics.

***Exemplar/Case Studies**	IPoC: A New Core Networking Protocol for 5G Networks
***Mapping of Course Outcomes for Unit II**	CO2

Unit III	**Global System for Mobile Communication**	**07 Hours**

Global System for Mobile Communications (GSM) architecture , Mobile Station, Base Station System, Switching subsystem, Security, Data Services, HSCSD, GPRS - GPRS system and protocol architecture 2.5 UTRAN, UMTS core network, Improvements on Core Network, 802.11 Architecture 802.11a, 802.11b standard.

***Exemplar/Case Studies**	5G mobile communications
***Mapping of Course Outcomes for Unit III**	CO3

Unit IV	**GSM Networking Signaling and Mobile Management**	**07 Hours**

GSM MAP Service framework, MAP protocol machine, GSM location management, Transaction management, Mobile database, Introduction to location management HLR andLR
VLR and HLR Failure restoration, VLR identification algorithm, O-I, O-II algorithm etc. Overview of handoff process, Factors affecting handoffs and performance evaluation metrics, Handoff strategies, Different types of handoffs (soft, hard, horizontal, vertical).

***Exemplar/Case Studies**	5G Mobility Management , Micro Mobility: CellularIP, HAWAII, HMIPv6
***Mapping of Course Outcomes for Unit IV**	CO4

Unit V	**Mobile Network and Transport Layers**	**07 Hours**

Mobile IP , IP packet delivery, Tunnelling and encapsulation, IPv6, DHCP, Vehicular Ad Hoc networks (VANET), MANET , Traditional TCP, Snooping TCP, Mobile TCP, 3G wireless network, Wireless Application Protocol, WDP WTP, WML, WTA architecture, Cellular IP

***Exemplar/Case Studies**	5G Network and Transport Layers
***Mapping of Course Outcomes for Unit V**	CO5

Unit VI	**Wireless Application Protocol (WAP) and current trends**	**07 Hours**

WAP model, WAP Gateway, WAP protocol, WAP UAProf and Caching, Wireless Bearer for WAP, WAP Developer Toolkits, Introduction to D2D communications, High level requirements for 5G architecture, Introduction to the radio resource management, power control and mode selection problems, Millimeter wave communication in 5G,
Introduction to mobile cloud computing and its Applications

#Exemplar/Case Studies	Long-Term Evolution (LTE) of 3GPP
***Mapping of Course Outcomes for Unit VI**	CO6

Learning Resources

Text Books:

1. Jochen Schiller, "Mobile **Communications**", Pearson Education, 2009.
2. Martin Sauter, "**3G**, 4G and Beyond: Bringing Networks, Devices and the Web Together", 2012, ISBN-13: 978-1118341483
3. Raj Kamal, "Mobile Computing", 2/e, Oxford University Press

Reference Books :

1. William Stallings, "Wireless Communications & Networks", Second Edition, Pearson Education
2. Christopher Cox, "**An** Introduction to LTE: LTE, LTE-Advanced, SAE and 4G Mobile **Communications**", Wiley publications
3. Andrea Goldsmith, "Wireless **Communications**", Cambridge University Press, 2012

e-Books :

1. http://www.dauniv.ac.in/download/Mobilecomputing/Mcomp%20%20MobileComp%20Ch01%20MobileComputeMobileOSes.pdf

MOOC Courses Links :

- https://nptel.ac.in/courses/106106147

@The CO-PO Mapping Matrix

CO PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	-	-	-	-	-	-	-	-	-	-
CO2	2	1	-	-	-	-	-	-	-	-	-	
CO3	2	1	-	-	-	-	-	-	-	-	-	-
CO4	1	2	-	2	-	-	-	-	-	-	-	-
CO5	1	2	-	2	-	-	-	-	-	-	-	1
CO6	2	2	-	2	-	-	-	-	-	-	-	1

Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
Elective V
410245 (D): Software Testing and Quality Assurance

Teaching Scheme:	Credit	Examination Scheme:
TH: 03 Hours/Week	03	In-Sem (Paper): 30 Marks
		End-Sem (Paper): 70 Marks

Prerequisite Courses: Software Engineering (210251), Software Project Management(310254)(D)
Companion Course: Lab Practice IV

Course Objectives:

- Introduce basic concepts of software testing.
- Understand the best way to increase the effectiveness, test coverage, and execution speed in software testing.
- Understand white box, black box, object oriented, web based and cloud testing.
- Understand the importance of software quality and assurance software systems development.
- Know in details automation testing and tools used for automation testing.
- To learn and understand the combination of practices and tools that are designed to help QA professionals test more efficiently.

Course Outcomes:

On completion of the course, student will be able to–

- **CO1: Describe** fundamental concepts in software testing such as manual testing, automation testing and software quality assurance.
- **CO2: Design and Develop** project test plan, design test cases, test data, and conduct test operations.
- **CO3: Apply** recent automation tool for various software testing for testing software.
- **CO4: Apply** different approaches of quality management, assurance and quality standard to software system.
- **CO5: Apply** and analyze efficient open Software Quality Tools.
- **CO6: Apply** tools necessary for efficient testing framework.

Course Content

Unit I Introduction to Software Testing 07 Hours

Introduction: Historical perspective, Definition, Cost Components, Customers suppliers and process, Objectives of Testing, Testing and Debugging, Need of Testing, Quality Assurance and Testing, Why Software has Errors, IMGarts and Failures and its Causes and Effects, Total Quality Management(TQM), Quality practices of TQM, Quality Management through- Statistical process Control, Cultural Changes, Continual Improvement cycle Benchmarking and metrics, Problem Solving Techniques and Software Tools. Software Quality: Constructs of Software product Quality assessment, Quality and Productivity Relationship, Requirements of Product, Software Development Process, Types of Products, Software Development Lifecycle Models, Software Quality Management, Processes related to Software Quality, Quality Management System's Structure, Pillars of Quality Management System, Important aspects of quality management.

Complex Case Studies

1. Offshore delivery model for an Airline Company.
2. SAP test automation CoE for Financial Service Provider.

*Mapping of Course Outcomes for Unit I	CO1

Unit II	Test Planning and Quality Management	07 Hours

Test Planning –Artifacts & Strategy, Test Organization –Test Manager & Tester Role, Test plan purpose & contents, Test Strategy and Approach, Test cases & Test Data, Test Entry-Exit criteria, Test Execution Schedule, Use case Testing, Scenario Testing, Test Monitoring & Control, Test Metrics –Test Case Productivity, Test case Coverage, Defect Acceptance & Rejection, Test Efficiency, Efforts and Schedule Variance, Test Efforts, Hiring Factors, Test Report & configuration Management, Quality Assurance Process, Documentation Risk & Issues, Software Quality, Quality Management Importance, Quality Best practices.

*Exemplar/CaseStudies	1. Online Recommendation System 2. Quality Engineering services for Medical Devices company (CaseStudy (cigniti.com)
*Mapping of Course Outcomes for Unit II	CO2

Unit III	Test Case Design Techniques	07 Hours

Software Testing Methodologies: White Box Testing, Black Box Testing, Grey Box Testing, Test Case Design Techniques: Static Techniques: Informal Reviews, Walkthroughs, Technical Reviews, Inspection, Dynamic Techniques: Structural Techniques: Statement Coverage Testing, Branch Coverage Testing, Path Coverage Testing, Conditional Coverage Testing, Loop Coverage Testing Black Box Techniques: Boundary Value Analysis, Equivalence Class Partition, State Transition Technique, Cause Effective Graph, Decision Table, Use Case Testing, Experienced Based Techniques: Error guessing, Exploratory testing.

Levels of Testing: Functional Testing: Unit Testing, Integration Testing, System Testing, User Acceptance Testing, Sanity/Smoke Testing, Regression Test, Retest, Non-Functional Testing: Performance Testing, Memory Test, Scalability Testing, Compatibility Testing, Security Testing, Cookies Testing, Session Testing, Recovery Testing, Installation Testing, Adhoc Testing, Risk Based Testing, I18N Testing, L10N Testing, Compliance Testing.

Link: https://www.bosantechnologies.com/training-courses/software-testing-training-manual-testing-training-institute-in-chennai

*Exemplar/Case Studies	1. Case Study: Manual Testing (Online Marketing SoftwarePlatforms) Link: https://www.3rillogica.com/blog/case-study-manual-testing-online-marketing-software-platform/ 2. Case Study: Decision Table Testing (transferring money online to an account which is already added and approved.)
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	Software Quality Assurance and Quality Control	07 Hours

Software Quality Assurance: Introduction, Constraints of Software Product Quality Assessment, Quality and Productivity Relationship, Requirements of a Product, Characteristics of Software,

Software Development Process, Types of Products, Schemes of Criticality Definitions, Software Quality Management, Why Software Has Defects? Processes Related to Software Quality, Quality Management System Structure, Pillars of Quality Management System, Important Aspects of Quality Management.

Software Quality Control: Software quality models, Quality measurement and metrics, Quality plan, implementation and documentation, Quality tools including CASE tools, Quality control and reliability of quality process, Quality management system models, Complexity metrics and Customer Satisfaction, International quality standards – ISO, CMM

Exemplar/Case Studies	1. Case Study #1 – Android Application Acceptance Test Suite 2. Case Study #2 – API Acceptance Test Suite Link for above case studies – Software Quality Assurance Case Studies – Beta Breakers
***Mapping of Course Outcome for Unit IV**	: CO4

Unit V — Automation Testing Tools – Performance Testing Tools — 07 Hours

Automation Testing: What is automation testing, Automated Testing Process, Automation Frameworks, Benefits of automation testing, how to choose automation testing tools Selenium Automation Tools: Selenium's Tool Suite- Selenium IDE, Selenium RC, Selenium Web driver, Selenium Grid, Automation Tools, SoapUI, Robotic Process Automation (RPA), Tosca, Appium

Performance Testing – What is Performance Testing, what is use of it? Tools used for performance testing – Apache Jmeter

Exemplar/Case Studies	1. Case Study: Cucumber open-source automation testing framework. 2. Case Study: (PDF) Automated Software Testing—A Case Study (researchgate.net)
***Mapping of Course Outcome for Unit V**	: CO5

Unit VI — Testing Framework — 07 Hours

Testing Framework: Software Quality, Software Quality Dilemma, Achieving Software Quality, Software Quality Assurance Elements of SQA, SQA Tasks, Goals and Metrics, Formal Approaches to SQA, Statistical Software Quality Assurance, Six Sigma for Software Engineering, ISO 9000 Quality Standards, SQA Plan, Total Quality Management, Product Quality Metrics, In process Quality Metrics, Software maintenance, Ishikawa's 7 basic tools, Flow Chart, Checklists, Pareto diagrams, Histograms, Run Charts, Scatter diagrams, Control chart, Cause-Effect diagram, Defect Removal Effectiveness and Process

Exemplar/Case Studies	1. Case study: Software Quality in Academia (researchgate.net) 2. Case study: Evaluation of an Automated Testing Framework: A Case Study (scirp.org)
***Mapping of Course Outcome for Unit VI**	CO6

Learning Resources

Text Books:

1. M G Limaye, "Software Testing: Principles, Techniques and Tools", Tata McGraw Hill, ISBN 9780070139909/0070139903
2. Srinivasan Desikan, Gopal Swamy Ramesh, "Software Testing Principles and Practices", Pearson, ISBN-10: 8177582213

Reference Books:

1. Naresh Chauhan, "Software Testing Principles and Practices", OXFORD, ISBN-10: 0198061846, ISBN-13: 9780198061847
2. Stephen Kan, "Metrics and Models in Software Quality Engineering", Pearson, ISBN-10: 0321398882, ISBN-13: 978-0321398888

e-Books :

1. M G Limaye, "Software Testing: Principles, Techniques and Tools"
https://books.google.co.in/books?id=sRmtDwAAQBAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false
2. Srinivasan Desikan, Gopalswamy Ramesh, "Software Testing: Principles and Practices"
https://topsfloor.com/software-testing-principles-and-practices-by-srinivasan-desikan-gopalswamy-ramesh/?gclid=Cj0KCQiA1ZWABhCoARIsAIqJ1Ln8Ow4qNDhNwAaAgEEALw_wcB
3. Naresh Chauhan, "Software Testing Principles and Practices"
https://pdfstuffs.com/download/software-testing-principles-and-practices-by-naresh-chauhan-pdf-free.html

MOOC Course Links:

- https://nptel.ac.in/courses/106105150
- NPTEL - NOC - Software Testing (IIIT C) (Computer Science and Engineering) (iiitkottayam.ac.in)

CO-PO Mapping Matrix

CO1	1	1	1	2	2	-	-	1	2	1	2	1
CO2	1	1	1	2	1	-	-	1	2	1	2	-
CO3	1	-	1	2	3	-	-	-	2	1	1	-
CO4	1	1	2	3	1	1	1	2	2	2	2	-
CO5	1	2	1	2	3	1	-	-	1	1	2	-
CO6	1	2	3	2	3	1	-	-	2	1	1	-



Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
Elective V
410251(E): Compilers

Teaching Scheme:	Credit	Examination Scheme:
TH: 03 Hours/Week	03	In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Prerequisite Courses: Theory of Computation(310241), Systems Programming and Operating System(310251)

Companion Course : Laboratory Practice IV (410247)

Course Objectives:

- To aware about language translation theories and compiler design stages
- To illustrate the various parser configurations
- To exemplify the use of syntax directed translation to intermediate code
- To Understand Storage Management and Control Structure Environment
- Learn to develop a Code generator
- To demonstrate the numerous optimization methods used in the creation of efficient optimizing compilers

Course Outcomes:

On completion of the course, student will be able to–

CO1 : **Design** and **implement** a lexical analyzer using LEX tools

CO2: **Design** and **implement** a syntax analyzer using YACC tools

CO3 **Understand** syntax-directed translation and run-time environment

CO4 : **Generate** intermediate codes for high-level statements

CO5 : **Construct** algorithms to produce computer code

CO6 : **Analyze and transform** programs to improve their time and memory efficiency

Course Content:

Unit I — Notion and Concepts — 08 Hours

Introduction to compilers Design issues, passes, phases, symbol table Preliminaries Memory management, Operating system support for compiler, Lexical Analysis Tokens, Regular Expressions, Process of Lexical analysis, Block Schematic, Automatic construction of lexical analyzer using LEX, LEX features and specifications

Exemplar/Case Studies — Study of LEX Compiler

Mapping of Course Outcomes for Unit — CO1

Unit II — Parsing — 08 Hours

Syntax Analysis CFG, top-down and bottom-up parsers, RDP, Predictive parser, SLR, LR(1), LALR parsers, using ambiguous grammar, Error detection and recovery, automatic construction of parsers using YACC, Introduction to Semantic analysis, Need of semantic analysis, type checking and type conversion.

*Exemplar/Case Studies	Study of YACC
*Mapping of Course Outcomes for Unit II	CO2

Unit III — Syntax Translation Schemes — 08 Hours

Syntax Directed Translation :- Attribute grammar, S and L attributed grammar, bottom up and top down evaluation of S and L attributed grammar, Syntax directed translation scheme, Intermediate code - need, types: Syntax Trees, DAG, Three Address codes, Quadruples, Triples and Indirect Triples, Intermediate code generation of declaration statement and assignment statement.

*Exemplar/Case Studies	Application of Syntax Directed Translation
*Mapping of Course Outcomes for Unit III	CO3

Unit IV — Run-time Storage Management — 08 Hours

Storage Management – Static, Stack and Heap, Activation Record, static and control links, parameter passing, return value, passing array and variable number of arguments, Static and Dynamic scope, Dangling Pointers, translation of control structures – if-else statement, switch-case, while, do -while statements, for, nested blocks, display mechanism, array assignment, pointers, function call and return. Translation of OO constructs: Class, members and Methods.

*Exemplar/Case Studies	CARAT :-Compiler and runtime based address translation model
*Mapping of Course Outcomes for Unit IV	CO4

Unit V — Code Generation — 07 Hours

Code Generation :- Issues in code generation, basic blocks, flow graphs, DAG representation of basic blocks, Target machine description, peephole optimization, Register allocation and Assignment, Simple code generation, Code generation from labeled tree, Concept of code generation.

*Exemplar/Case Studies	Code Generator for a Virtual Machine Code based JavaScript Compiler (http://article.sciencepub.org/IJNET/vol1[1]/22.pdf)
*Mapping of Course Outcomes for Unit V	CO5

Unit VI — Code Optimization — 07 Hours

Need for Optimization, local, global and loop optimization, Optimizing transformations, compile time evaluation, common sub-expression elimination, variable propagation, code movement, strength reduction, dead code elimination, DAG based local optimization, Introduction to global data flow analysis, Data flow equations and iterative data flow analysis.

#Examples/Case Studies	Execution of super-scalar processors
***Mapping of Course Outcomes for Unit VI**	CO6

Learning Resources

Text Books:

1. V. Aho, R. Sethi, J. D. Ullman, "**Compilers**: Principles, Techniques, and Tools", Pearson Edition, ISBN 81-7758-590-8
2. Dick Grune, Bal, Jacobs, Langendoen, " Modern Compiler **Design**", Wiley, ISBN 81-265-0418-8

Reference Books:

1. Anthony J. Dos Reis, "**Compiler** Construction Using **Java**", Jacob C and Vace Wiley, ISBN 978-0-470-94959-7
2. K Muneeswaran, "**Compiler** Design", Oxford University press, ISBN 0-19-806664-3
3. J R Levin, T Mason, D Brown, "**Lex and Vace**", O'Reilly, 2000 ISBN 81-7366-061-X

eBooks:

1. **Basics of Compiler Design**
   http://bjcommcsidcc.dikw.dk/~torbrom/Basics/basics_lulu2.pdf
2. **Modern Compiler Design**
   http://160592857366.free.fr/joe/ebooks/ShareData/Modern%20Compiler%20Design%202c.pdf

MOOC Courses Links:

- https://nptel.ac.in/courses/106105190

#The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	–	–	–	–	–	–	–
CO2	3	3	3	3	3	–	–	–	–	–	3	–
CO3	3	3	3	3	3	–	–	–	–	–	–	–
CO4	3	3	3	3	3	–	–	–	–	–	–	–
CO5	3	3	3	3	–	–	–	–	–	–	–	–
CO6	3	3	3	3	–	–	–	–	–	–	–	–

Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
410246: Laboratory Practice III

Teaching Scheme:	Credit	Examination Scheme:
Practical: 04 Hours/Week	02	Term work: 50 Marks Practical: 50 Marks

Companion Course: Design and Analysis of Algorithms (410241), Machine Learning(410242), Blockchain Technology(410243)

Course Objectives:

- Learn effect of data preprocessing on the performance of machine learning algorithms
- Develop in depth understanding for implementation of the regression models
- Implement and evaluate supervised and unsupervised machine learning algorithms
- Analyze performance of an algorithm.
- Learn how to implement algorithms that follow algorithm design strategies namely divide and conquer, greedy, dynamic programming, backtracking, branch and bound.
- Understand and explore the working of Blockchain technology and its applications

Course Outcomes:

After completion of the course, students will be able to

CO1: Apply preprocessing techniques on datasets

CO2: Implement and evaluate linear regression and random forest regression models

CO3: Apply and evaluate classification and clustering techniques

CO4: Analyze performance of an algorithm

CO5: Implement an algorithm that follows one of the following algorithm design strategies: divide and conquer, greedy, dynamic programming, backtracking, branch and bound.

CO6: Interpret the basic concepts in Blockchain technology and its applications

Guidelines for Instructor's Manual

The instructor's manual is to be developed as a reference and hands-on resource. It should include: prologue (about University/program/ institute/ department/foreword/ preface), curriculum of the course, conduction and assessment guidelines, topics under consideration, concept, objectives, outcomes, set of typical applications/assignments/ guidelines, and references.

Guidelines for Student's Laboratory Journal

The laboratory assignments are to be submitted by students in the form of a journal. Journal consists of Certificate, table of contents, and handwritten write-up of each assignment (Title, Date of Completion, Objectives, Problem Statement, Software and Hardware requirements, Assignment grade/marks and instructor's sign, Theory- Concept in brief, algorithm, flowchart, test cases, Test Data Set(if applicable), mathematical model (if applicable), conclusion/analysis, Program codes with sample output of all performed assignments are to be submitted as a softcopy. As a conscious effort and little contribution towards Green IT and environment awareness, attaching printed papers as part of write-ups and program listing to a journal must be avoided. Use of DVD containing student programs maintained by Laboratory In-charge is highly encouraged. For reference one or two journals may be maintained with program prints in the Laboratory.

Guidelines for Laboratory Term Work Assessment

Continuous assessment of laboratory work should be based on overall performance of Laboratory assignments by a student. Assessment of each Laboratory assignment will assign grade/marks based on parameters, such as timely completion, performance, innovation, efficient codes, punctuality, documentation and neatness.

Guidelines for Practical Examination

Problem statements must be decided jointly by the internal examiner and external examiner. During practical assessment, maximum weightage should be given to satisfactory implementation of the problem statement. Relevant questions may be asked at the time of evaluation to test the student's understanding of the fundamentals, effective and efficient implementation. This will encourage transparent evaluation and fair approach, and hence will not create any uncertainty or doubt in the minds of the students. So, adhering to these principles will consummate our team efforts to the promising start of student's academics.

Guidelines for Laboratory Conduction

The instructor is expected to frame the assignments by understanding the prerequisites, technological aspects, utility and recent trends related to the topic. The assignment framing policy needs to address the average students and inclusive of an element to attract and promote the intelligent students. Use of open source software is encouraged. Based on the concepts learned, Instructor may also set one assignment or mini-project that is suitable to each branch beyond the scope of the syllabus.

Operating System recommended :- 64-bit Open source Linux or its derivative

Programming tools recommended:- C++, Java, Python, Scilab, etc.

Virtual Laboratory:

- http://cse01-iiith.vlabs.ac.in/
- http://vlabs.iitb.ac.in/vlabs-dev/labs/blockchain/labs/index.php
- http://vlabs.iitb.ac.in/vlabs-dev/labs/machine_learning/labs/index.php

Suggested List of Laboratory Experiments/Assignments
Assignments from all the Groups (A, B, C) are compulsory.

Course Content

Group A: Design and Analysis of Algorithms

Any 8 assignments and 1 mini project are mandatory.

1.	Write a program to calculate Fibonacci numbers and find its step count.
2.	Implement job sequencing with deadlines using a greedy method.
3.	Write a program to solve a fractional Knapsack problem using a greedy method.
4.	Write a program to solve a 0-1 Knapsack problem using dynamic programming or branch and bound strategy.
5.	Write a program to generate binomial coefficients using dynamic programming.
6.	Design 8-Queens matrix having first Queen placed. Use backtracking to place remaining Queens to generate the final 8-queen's matrix.

7.	**Mini Project** Write a program to implement matrix multiplication. Also implement multithreaded matrix multiplication with either one thread per row or one thread per cell. Analyze and compare their performance. OR Implement merge sort and multithreaded merge sort. Compare time required by both the algorithms. Also analyze the performance of each algorithm for the best case and the worst case. OR Implement the Naive string matching algorithm and Rabin-Karp algorithm for string matching. Observe difference in working of both the algorithms for the same input.

Group B: Machine Learning

Any 4 assignments and 1 Mini project are mandatory.

1.	Predict the price of the Uber ride from a given pickup point to the agreed drop-off location. Perform following tasks: 1. Pre-process the dataset. 2. Identify outliers. 3. Check the correlation. 4. Implement linear regression and random forest regression models. 5. Evaluate the models and compare their respective scores like R2, RMSE, etc. Dataset link: https://www.kaggle.com/datasets/yasserh/uber-fares-dataset
2.	Classify the email using the binary classification method. Email Spam detection has two states: a) Normal State – Not Spam, b) Abnormal State – Spam. Use K-Nearest Neighbors and Support Vector Machine for classification. Analyze their performance. Dataset link: The emails.csv dataset on the Kaggle https://www.kaggle.com/datasets/balaka18/email-spam-classification-dataset-csv
3.	Given a bank customer, build a neural network-based classifier that can determine whether they will leave or not in the next 6 months. Dataset Description: The case study is from an open-source dataset from Kaggle. The dataset contains 10,000 sample points with 14 distinct features such as CustomerId, CreditScore, Geography, Gender, Age, Tenure, Balance, etc. Link to the Kaggle project: https://www.kaggle.com/shrutimechlearn/churn-modelling Perform following steps: 1. Read the dataset. 2. Distinguish the feature and target set and divide the data set into training and test sets. 3. Normalize the train and test data. 4. Initialize and build the model. Identify the points of improvement and implement the same. 5. Print the accuracy score and confusion matrix (5 points).
4.	Implement Gradient Descent Algorithm to find the local minima of a function. For example, find the local minima of the function $y=(x+3)^2$ starting from the point $x=2$.
5.	Implement K-Nearest Neighbours algorithm on diabetes.csv dataset. Compute confusion matrix, accuracy, error rate, precision and recall on the given dataset. Dataset link: https://www.kaggle.com/datasets/akshaydattatraykhare/diabetes-dataset

6.	Implement K-Means clustering/ hierarchical clustering on sales_data_sample.csv dataset. Determine the number of clusters using the elbow method. Dataset link : https://www.kaggle.com/datasets/kyanyoga/sample-sales-data
7.	**Mini Project** Use the following dataset to analyze ups and downs in the market and predict future stock price returns based on Indian Market data from 2000 to 2020. Dataset Link: https://www.kaggle.com/datasets/sagara9515/stock-data OR Build a machine learning model that predicts the type of people who survived the Titanic shipwreck using passenger data (i.e. name, age, gender, socio-economic class, etc.). Dataset Link: https://www.kaggle.com/competitions/titanic/data

Group C: Blockchain Technology

Any 4 assignments and a Mini project are mandatory.

1.	Installation of Metamask and study spending Ether per transaction.
2.	Create your own wallet using Metamask for crypto transactions.
3.	Write a smart contract on a test network, for Bank account of a customer for following operations: • Deposit money • Withdraw Money • Show balance
4.	Write a program in solidity to create Student data. Use the following constructs: • Structures • Arrays • Fallback Deploy this as smart contract on Ethereum and Observe the transaction fee and Gas values.
5.	Write a survey report on types of Blockchains and its real time use cases.
6.	**Mini Project:** Create a dApp (de-centralized app) for e-voting system.

Q.The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1	2	1	-	1	2	-	2	3
CO2	3	3	3	2	2	1	-	1	2	-	2	3
CO3	3	3	3	2	2	2	-	1	2	-	2	3
CO4	3	2	2	-	1	-	-	1	2	-	2	2
CO5	3	2	2	-	1	-	-	1	2	-	-	2
CO6	3	3	2	2	2	-	-	1	2	-	-	2



Savitribai Phule Pune University
Fourth Year of Computer Engineering(2019Course)
410247:Laboratory Practice IV

Teaching Scheme:	Credit:	Examination Scheme and Marks
Practical:04 Hours/Week	02	Term Work: 50 Marks

Companion Course: Elective III(410244) & Elective IV(410245)

Course Objectives:

- Learn android application development related to pervasive computing
- Understand various multimedia file formats
- Understand various vulnerabilities and use of various tools for assessment of vulnerabilities
- Understand information retrieval process using standard tools available
- Learn GPU programming and implementation of same using open source libraries
- Learn installation and use of open source software testing tools

Course Outcomes:

After completion of the course, student will be able to

CO1: Apply android application development for solving real life problems
CO2: Design and develop system using various multimedia components.
CO3: Identify various vulnerabilities and demonstrate using various tools.
CO4: Apply information retrieval tools for natural language processing
CO5: Develop an application using open source GPU programming languages
CO6: Apply software testing tools to perform automated testing

Guidelines for Instructor's Manual

The instructor's manual is to be developed as a reference and hands-on resource. It should include: prologue (about University/program/ institute/ department/foreword/ preface), curriculum of the course, conduction and Assessment guidelines, topics under consideration: concept, objectives, outcomes, set of typical applications/assignments/ guidelines, and references.

Guidelines for Student's Laboratory Journal

The laboratory assignments are to be submitted by student in the form of journal. Journal consists of Certificate, table of contents, and handwritten write-up of each assignment (Title, Date of Completion, Objectives, Problem Statement, Software and Hardware requirements, Assessment grade/marks and assessor's sign, Theory- Concept in brief, algorithm, flowchart, test cases, Test Data Set(if applicable), mathematical model (if applicable), conclusion/analysis. Program codes with sample output of all performed assignments are to be submitted as softcopy. As a conscious effort and little contribution towards Green IT and environment awareness, attaching printed papers as part of write-ups and program listing to journal must be avoided. Use of DVD containing students programs maintained by Laboratory In-charge is highly encouraged. For reference one or two journals may be maintained with program prints in the Laboratory.

Guidelines for Laboratory/Term Work Assessment

Continuous assessment of laboratory work should be based on overall performance of Laboratory assignments by a student. Each Laboratory assignment assessment will assign grade/marks based on parameters, such as timely completion, performance, innovation, efficient codes and punctuality.

Guidelines for Practical Examination

Problem statements must be decided jointly by the internal examiner and external examiner. During practical assessment, maximum weightage should be given to satisfactory implementation of the

problem statement. Relevant questions may be asked at the time of evaluation to test the student's understanding of the fundamentals, effective and efficient implementation. This will encourage transparent evaluation and fair approach, and hence will not create any uncertainty or doubt in the minds of the students. So, adhering to these principles will consummate our team efforts in the promising start of student's academics.

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The instructor is expected to frame the assignments by understanding the prerequisites, technological aspects, utility and recent trends related to the topic. The assignment framing policy need to address the average students and inclusive of an element to attract and promote the intelligent students. Use of open source software is encouraged. Based on the concepts learned, Instructor may also set one assignment on mini-project that is suitable to respective branch beyond the scope of syllabus.

Virtual Laboratory:
1. http://hci-iitg.vlabs.ac.in/
2. http://vlab.amrita.edu/?sub=3&brch=179&sim=1293&cnt=3

410244(A) Pervasive Computing

Any 5 assignments from group 1 and 2 Mini project from group 3 is mandatory

Group 1

1. Develop an indoor location system to Library public system where it can direct a user to the bookshelf from a mobile device.
2. Design a pervasive application in which remote computer monitors our health statistics & will determine when one is in trouble & will take appropriate action for rescue.
3. Develop an Android application in which one will use the Internet to find nearby open parking space.
4. Android User Activity Recognition - Still, Walking, Running, Driving etc.
5. Design and build a sensing system using micro-controllers like - Arduino / Raspberry Pi / Intel Galileo to sense the environment around them and act accordingly.
6. Smart Mobile Application with orientation sensing for users to put the phone in meeting / silent mode, OR, outdoor/ loud mode based on the orientation of the device.

Group 2:

7. **Mini project:** Develop Food Ordering System which uses the GPS of an Android-based Smartphone to record and analyze various locations that could give alert to the user, thus asking the user to select particular food from given hotel list and place an order.

8. **Mini Project:** Design a mobile sensing platform mounted on a phone that integrates several sensors, such as touch pressure, imaging, inertial measurements, localization and a Radio Frequency Identification (RFID) reader for fast classification and grading system.

9. **Mini Project :** Sensor-Based Assistive Devices for Visually Impaired People. It should cover following points:
   - Determining obstacles around the user body from the ground to the head.
   - Affording some instructions to the user about the movement surface consists of gaps or features.
   - Finding items surrounding the obstacles.
   - Providing information about the distance between the user and the obstacle with essential direction instructions.
10. **Mini Project:** Develop a Real time application like a smart home with following requirements. If anyone comes at door the camera module automatically captures his image send it to the email account of user or send notification to the user. Door will open only after user's approval.

410244(B) Multimedia Techniques

Group 1

Any 3 assignments from group 1 and 1 Mini project from group 2 is mandatory.

1. To study and install open-source multimedia tools and create an application using appropriate tool to design the college webpage.
2. To create JPEG Image that demonstrate various features of an Image editing tool.
3. Create or play a sample MIDI format sound file using LMMS / MuseScore / Tiregular software tool. Edit the sample file by applying effects like bend, slide, vibrato, and hammer-on/pull-off. Export / Convert final MIDI to WAV file format.
4. Implement transform coding, quantization, and hierarchical coding for the encoder and decoder of three-level Hierarchical JPEG.
5. Create an immersive environment (living room/ battlefield/ tennis court) with only static game objects. 3D game objects can be created using Blender or use available 3D models.
6. Create a web page for a clothing company which contains all the details of that company and atleast five links to other web pages.

Group2

7. Mini Project: Design and develop a Navigation Assistance System.
8. Mini Project: Design and Develop a Traffic Monitoring System.

410244(C) Cyber Security and Digital Forensics

Any 3 assignments from group 1 and 1 Mini project from group 2 is mandatory.

Group 1

1. Write a program for Tracking Emails & Investigating Email Crimes. i.e. Write a program to analyze e-mail header
2. Implement a program to generate & verify CAPTCHA image
3. A person on a nearby road is trying to enter into a WiFi network by trying to crack the Password to use the IP Printer resource, write a program detect such attempt and prohibit the

access. Develop the necessary scenario by Using an IEEE 802.11, configure a Wi-Fi adaptor and Access Point

4. Write a computer forensic application program for Recovering permanent Deleted Files and Deleted Partitions
5. Write a program for Log Capturing and Event Correlation
6. Configure and demonstrate use of vulnerability assessment tool like Wireshark or SNORT
7. Study of Honeypot

Group 2

1. Mini-project: Perform the following steps:
   - Go to the National Child Exploitation Coordination Center (NCECC) Web site at http://www.nccec.ca
   - Click on the Reporting child exploitation link.
   - **c. Read "How to Report Internet Pornography or Internet Luring Related to Children."**
2. Mini- Project: Perform the following steps:
   - Go to http://www.usdoj.gov/criminal/cybercrime/cyberstalking.htm
   - b. Read the 1999 report on cyber stalking.

410244(D) Object Oriented Modeling and Design

Any 5 assignments from group 1 and 1 Mini project from group 2 is mandatory.

Group 1

1. Draw state model for telephone line, with various activities.
2. Draw basic class diagrams to identify and describe key concepts like classes, types in your system and their relationships.
3. Draw one or more Use Case diagrams for capturing and representing requirements of the system. Use case diagrams must include template showing description and steps of the Use Case for various scenarios.
4. Draw one or more Use Case diagrams for capturing and representing requirements of the system. Use case diagrams must include template showing description and steps of the Use Case for various scenarios.
5. Draw activity diagrams to display either business flows or like flow charts
6. Draw component diagrams assuming that you will build your system reusing existing components along with a few new ones
7. Draw deployment diagrams to model the runtime architecture of your system.

Group 1

8. Mini Project: Draw all UML diagrams for your project work.
9. Mini Project: Draw following UML Diagrams for Bank Management application
   a. Class Diagram
   b. Object Diagram
   c. ER Diagram
   d. Component Diagram

410244(E) Digital Signal Processing

Any 5 assignments from group 1 and 1 Mini project from group 2 is mandatory.

Group 1:

1. Develop a program to generate samples of sine, Cosine and exponential signals at specified sampling frequency and signal parameters. (Test the results for different analog frequency (F) and sampling frequency (Fs) i.e. 25, 4, 5, 6, 7.
2. Find the output of a system described by given difference equation and initial conditions for given input sequence. (Solution of difference equation) (Obtain the response for different systems by changing Degree of difference equation (N) and coefficients and also for different input sequence x(n). Observe the response by considering system as FIR and IIR system).
3. Write a program to plot the magnitude and phase response of a Fourier Transform (FT). (Observe the spectrum for different inputs. Observe the Periodicity).
4. Find the N point DFT / IDFT of the given sequence x (n). Plot the magnitude spectrum (M(K)) Vs K. (Analyze the output for different N and the same input sequence x(n). Also observe the periodicity and symmetry property).
5. Find the N point circular convolution of given two sequences. Test it for Linear convolution. Compute the circular convolution of given two sequences using DFT and IDFT.
6. Develop a program to plot the magnitude and phase response of a given system/ given h(n) impulse response of system h) (Observe the frequency response for different systems. Compare the frequency response of a system (filter) for different length h(n) i.e filter coefficients).

Group 2:

7. **Mini-Project:** Design and Develop the N-point radix-2 DIT or DIF FFT algorithm to find DFT or IDFT of given sequence x (n). (Analyze the output for different N. Program should work for any value of N and output should be generated for all intermediate stages.) 8 9
8. **Mini-Project:** Obtain the Fourier transform of different window functions to plot the magnitude and phase spectrums. (Window functions: Rectangular, Triangular, Bartlett, Hamming, Henning, Kaiser. Observe and compare the desirable features of window sequences for different length. Observe the main and side lobes).
9. **Mini-Project:** Design an FIR filter from given specifications using windowing method. (Application should work for different types of filter specifications i.e. LPF, HPF, BPF etc and all window sequences. Plot the frequency response for different frequency terms i.e. analog and DT frequency). 10
10. **Mini-Project:** Design of IIR filter for given specifications using Bilinear Transformation. (Generalised code to accept any filter length for a transfer function H(Z). Application should work for different types of filter specifications that is LPF, HPF, BPF etc. and for different transfer functions of an analog filter).

410245(A) Information Retrieval

Any 3 assignments from group 1 and 1 Mini project from group 2 is mandatory.

Group 1:

1. Write a program to Compute Similarity between two text documents.
2. Implement Page Rank Algorithm.
3. Write a program for Pre-processing of a Text Document: stop word removal.
4. Write a map-reduce program to count the number of occurrences of each alphabetic character in the given dataset. The count for each letter should be case-insensitive (i.e., include both upper-case and lower-case versions of the letter; ignore non-alphabetic characters).
5. Write a program to implement simple web crawler.
6. Write a program to parse XML text, generate Web graph and compute topic specific page

Group 2:

7. Mini project: Develop Document summarization system

8. Mini Project: Develop Tweet sentiment analysis system.

9. Mini Project:Develop Fake news detection system.

410245(B) GPU Programming and Architecture

Any 3 assignments from group 1 and 1 Mini project from group 2 is mandatory.

Group 1:

1. Write program using OpenCL for Heterogeneous computing
2. Write CUDA programming with some simple things such as dot product, calculation of pi using integration method etc.
3. Write CUDA programming for matrix transpose and matrix multiplication.
4. **Write OpenCL "Hello World" basic program**
5. Develop program using combining abilities of OpenGL and CUDA to accelerate the performance of simple graphics.
6. Case study on "Review of traditional Computer Architecture"

Group 2:

Mini Project : huge data computation

Mini Project : Visualization to develop project for image processing and then video processing

Mini Project : Parallel programming

410245(C) Mobile Computing

Any 3 assignments from group 1 and 1 Mini project from group 2 is mandatory.

Group 1:

1. To implement a basic function of Code Division Multiple Access (CDMA) to test the orthogonality and autocorrelation of a code to be used for CDMA operation. Write an application based on the above concept.
2. Implementation of GSM security algorithms (A3/A3/A8)
3. Write an application that draws basic graphical primitives on the screen
4. Develop a native application that uses GPS location information.
5. Design an android Application for Frame Animation

Group 2:

6. **Mini Project:** Create an application for Bank using spinner, intent
   a) Form 1: Create a new account for customer.
   b) Form 2: Deposit money in customer account.
   c) Link both forms, after completing of first form the user should be directed to the second form.

(d) Provide different menu options

7. **Mini Project:** Create the module for collecting cellular mobile network performance parameters using telephony API Manager
   (i) Nearest Base Station
   (ii) Signal Strengths
   (iii) SIM Module Details
   (iv) Mobility Management Information
8. **Mini Project:** Create the module for payment of fees for College by demonstrating the following methods.
   i) FeesMethod()- for calculation of fees
   ii) Use customized Toast for successful payment of fees
   iii) Implement an alarm in case someone misses out on the fee submission deadline
   iv) Demonstrate the online payment gateway
9. **Mini Project:** Create an app to add of a product to SQLite database and make sure to add following features
   i) SMS messaging and email provision
   ii) Bluetooth options
   iii) Accessing Web services
   iv) Asynchronous remote method call
      v) Use Alert box for user notification

418245(D)Software Testing and Quality Assurance

Any 3 assignments from group 1 and 3 Mini project from group 2 is mandatory

Group 1:

1. Write TEST Scenario for Gmail Login Page
2. TEST Scenario for Gmail Login Page
3. Write Test cases in excel sheet for Social Media application or website
4. Create Defect Report for Any application or web application
5. Installation of Selenium grid and selenium Webdriver ikamp; java eclipse (automation tools)
6. Prepare Software requirement specification for any project or problem statement

Group 2:

7. **Mini Project :** Software Testing and Quality Assurance Mini Project Dynamic website of Covid-19 information using HTML, CSS, JAVASCRIPT And PHP, MySQL database used to store user account, comment, and registration form details. Regular Expression features for testing purpose.
8. **Mini Project** :Create a small application by selecting relevant system environment / platform and programming languages. Narrate concise Test Plan consisting features to be tested and bug taxonomy. Prepare Test Cases inclusive of Test Procedures for identified Test Scenarios. Perform selective Black-box and White-box testing covering Unit and Integration test by using

	suitable Testing tools. Prepare Test Reports based on Test Pass/Fail Criteria and judge the acceptance of application developed
8.	**Mini Project :** Create a small web-based application by selecting relevant system environment / platform and programming languages. Narrate concise Test Plan consisting features to be tested and bug taxonomy. Narrate scripts in order to perform regression tests. Identify the bugs using Selenium WebDriver and IDE and generate test reports encompassing exploratory testing

410545(E) Quantum Computing

1.	Analyze simple states of superposition and the effect of doing the measurement in different basis states
2.	Build simple quantum circuits with single and two-qubit gates
3.	Install Setup for running quantum programs on IBM machines
4.	Analyze the efficiencies of simple error correction schemes
5.	Implement quantum programs in NISQ model of computing

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	–	3	–	3	-	–	3	3	3	3	3
CO2	3	–	3	3	3	2	-	3	3	3	3	3
CO3	3	–	3	3	3	2	-	3	3	3	3	3
CO4	3	–	3	–	3	-	–	3	3	3	3	3
CO5	3	–	3	–	3	-	–	3	3	3	3	3
CO6	3	–	3	–	3	-	-	3	3	3	3	3



Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
410245: Project Work Stage I

Teaching Scheme:	Credit	Examination Scheme:
Practical: 8 Hours/Week	08	Presentation: 50 Marks

Course Objectives:

- To Apply the knowledge for solving realistic problem
- To develop problem solving ability
- To Organize, sustain and report on a substantial piece of team work over a period of several months
- To Evaluate alternative approaches, and justify the use of selected tools and methods
- To Reflect upon the experience gained and lessons learned
- To Consider relevant social, ethical and legal issues
- To find information for yourself from appropriate sources such as manuals, books, research journals and from other sources, and to have exercise analytical skills
- To Work in Team and learn professionalism

Course Outcomes:

On completion of the course, student will be able to–

- Solve real life problems by applying knowledge.
- Analyze alternative approaches, apply and use most appropriate one for feasible solution.
- Write precise reports and technical documents in a standard.
- Participate effectively in multi-disciplinary and heterogeneous teams exhibiting team work.
- Inter-personal relationships, conflict management and leadership quality.

Guidelines

Project work Stage – I is an integral part of the Project work. In this, the student shall complete the partial work of the Project which will consist of problem statement, literature survey, SRS, Model and Design. The student is expected to complete the project at least up to the design phase. As a part of the progress report of project work Stage-I, the candidate shall deliver a presentation on the advancement in Technology pertaining to the selected project topic. The student shall submit the duly certified progress report of Project work Stage-I in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute. The assessment will be assessed by a panel of examiners of which one is necessarily an external examiner. The assessment will be broadly based on work undergone, seminar delivery, presentation skills, documentation, question-answers and report.

Follow guidelines and formats as mentioned in Project Workbook recommended by Board of Studies

Savitribai Phule Pune University
Fourth Year of Engineering (2019 Course)
410249: Audit Course 7

In addition to credits, it is recommended that there should be audit course, in preferably in each semester starting from second year in order to supplement students' knowledge and skills. Student will be awarded the bachelor's degree if he/she earns specified total credit [1] and clears all the audit courses specified in the curriculum. The student will be awarded grade as AP on successful completion of audit course. The student may opt for one of the audit courses per semester, starting in second year first semester. Though not mandatory, such a selection of the audit courses helps the learner to explore the subject of interest in greater detail resulting in achieving the very objective of audit course's inclusion. List of options offered is provided. Each student has to choose one audit course from the list per semester. Evaluation of audit course will be done at Institute level itself. Method of conduction and method of assessment for audit courses are suggested.

Criteria

The student registered for audit course shall be awarded the grade AP (Audit Course Pass) and shall be included such AP grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory performance and secured a passing grade in that audit course. No grade points are associated with this **'AP' grade** and performance in these courses is not accounted in the calculation of the performance indices SGPA and CGPA. Evaluation of audit course will be done at Institute level itself [1].

Guidelines for Conduction and Assessment (Any one or more of following but not limited to)

- Lectures/ Guest Lectures
- Visits (Social/Field) and reports
- Demonstrations or presentations
- Surveys
- Mini-Project
- Hands on experience on focused topic

Course Guidelines for Assessment (Any one or more of following but not limited to)

- Written Test
- Demonstrations/ Practical Test
- Presentation or Report

Audit Course 5 Options

Audit Course Code	Audit Course Title
AC7-I	MOOC- Learn New Skills
AC7-II	Entrepreneurship Development
AC7-III	Robot of Things
AC7-IV	3D Printing
AC7-V	Industrial Safety and Environment Consciousness

Savitribai Phule Pune University
Fourth Year of Engineering (2019 Course)
410249: Audit Course 7
AC7 – I: MOOC-Learn New Skill

This course aims to create awareness among the students regarding various courses available on the MOOC and learn new skills through these courses.

Course Objectives:

- To promote interaction user forums to support community interactions among students, professors, and experts
- To promote learn additional skills anytime and anywhere
- To enhance teaching and learning on campus and online

Course Outcomes:

On completion of the course, , students will be able to

CO1- To acquire additional knowledge and skill.

About Course

MOOC's (Massive Open Online Courses) provide affordable and flexible way to learn new skills, pursue lifelong interests and deliver quality educational experiences at scale. Whether you're interested in learning for yourself, advancing your career or leveraging online courses to educate your workforce, SWAYAM, NPTEL, edx or similar ones can help. World's largest SWAYAM MOOCs, a new paradigm of education for anyone, anywhere, anytime, as per your convenience, aimed to provide digital classroom free of cost and to facilitate hosting of all the interactive courses prepared by the best more than 1000 specially chosen faculty and teachers in the country. SWAYAM MOOCs enhances active learning for improving lifelong learning skills by providing easy access to global resources.

SWAYAM is a programme initiated by Government of India and designed to achieve the three cardinal principles of Education Policy viz., access, equity and quality. The objective of this efforts is to take the best teaching learning resources to all, including the most disadvantaged. SWAYAM seeks to bridge the digital divide for students who have hitherto remained untouched by the digital revolution and have not been able to join the mainstream of the knowledge economy. This is done through an indigenous developed IT platform that facilitates hosting of all the courses, taught in classrooms from 9th class till post-graduation to be accessed by anyone, anywhere at any time. All the courses are interactive, prepared by the best teachers in the country and are available, free of cost to the residents in India. More than 1,000 specially chosen faculty and teachers from across the Country have participated in preparing these courses.

The courses hosted on SWAYAM is generally in 4 quadrants – (1) video lectures, (2) specially prepared reading material that can be downloaded/printed, (3) self-assessment tests through tests and quizzes, and (4) an online discussion forum for clearing the doubts. Steps have been taken to enrich the learning experience by using audio-video and multi-media and state of the art pedagogy / technology. In order to ensure best quality content are produced and delivered, seven National Coordinators have been appointed. They are NPTEL for engineering and UGC for post-graduation education.

Guidelines:

Institutes are requested to promote students to opt for courses (not opted earlier) with proper monitoring. The departments will take care of providing necessary infrastructural and facilities for the learners.

References:

1. https://swayam.gov.in/
2. https://onlinecourses.nptel.ac.in/
3. https://www.edx.org

Savitribai Phule Pune University, Pune
Fourth Year of Computer Engineering (2019 Course)
410249: Audit Course 7
AC7 – II: Entrepreneurship Development

This Course aims at instituting Entrepreneurial skills in the students by giving an overview of, who the entrepreneurs are and what competences are needed to become an entrepreneur

Course Objectives:

- To introduce the aspects of Entrepreneurship
- To acquaint with legalities in product development
- To understand IPR, Trademarks, Copyright and patenting
- To know the facets of functional plans, Entrepreneurial Finance and Enterprise Management

Course Outcomes:

On completion of the course, learner will be able to–

CO1: Understand the legalities in product development
CO2: Undertake the process of IPR, Trademarks, Copyright and patenting
CO3: Understand and apply functional plans
CO4: Manage Entrepreneurial Finance
CO5: Inculcate managerial skill as an entrepreneur

Course Content:

1. Introduction: Concept and Definitions, Entrepreneur v/s Intrapreneur, Role of entrepreneurship in economic development, Entrepreneurship process, Factors impacting emergence of entrepreneurship, Managerial versus entrepreneurial Decision Making, Entrepreneur v/s Inventors, Entrepreneurial attributes and characteristics, Entrepreneurs versus inventors, Entrepreneurial Culture, Women Entrepreneurs, Social Entrepreneurship, Classification and Types of Entrepreneurs, EDP Programmes, Entrepreneurial Training, Traits Qualities of an Entrepreneurs.

2. Creating Entrepreneurial Venture : Generating Business idea- Sources of Innovation, methods of generating ideas, Creativity and Entrepreneurship, Business planning process, Drawing business plan, Business plan failures, Entrepreneurial leadership – components of entrepreneurial leadership, Entrepreneurial Challenges, Legal issues – forming business entity, considerations and Criteria, requirements for formation of a Private/Public Limited Company, Intellectual Property Protection - Patents Trademarks and Copyrights.

3. Functional plans: Marketing plan–for the new venture, environmental analysis, steps in preparing marketing plan, marketing mix, contingency planning, Organizational plan – designing organization structure and Systems, Financial plan – pro forma income statements, Ratio Analysis.

4. Entrepreneurial Finance: Debt or equity financing, Sources of Finance - Commercial banks, private placements, venture capital, financial institutions supporting entrepreneurs, Lease Financing, Funding opportunities for Startups in India. 5. Enterprise Management: Managing growth and sustenance- growth norms, Factors for growth, Time management, Negotiations, Joint ventures, Mergers and acquisitions

Books

1. Kumar, Arya, "Entrepreneurship: Creating and Leading an Entrepreneurial Organization"", Pearson ISBN-10: 8131765784, ISBN-13: 978-8131765784

2. Hodrich, Peters, "Entrepreneurship: Starting, Developing and Managing a New Enterprise"", ISBN 0-256-14147-9

3. Irwin Taneja, "Entrepreneurship,"" Galgotia Publishers, ISBN: 978-93-84044-82-4

4. Charantimath, Poornima, "Entrepreneurship Development and Small Business Enterprises,"" Pearson Education, ISBN, 8177582007, 9788177582604

Savitribai Phule Pune University, Pune
Fourth Year of Computer Engineering (2019 Course)
410249: Audit Course 7
AC7 – III: Botnet of Things

This course aims to provide an understanding of the various security attacks and knowledge to recognize and remove common coding errors that lead to vulnerabilities. It gives an outline of the techniques for developing a secure application.

Course Objectives:

- To Understand the various IoT Protocols
- To Understand the IoT Reference Architecture and Real World Design Constraints
- To learn the concept of Botnet

Course Outcomes:

On completion of the course, learner will be able to–

CO1: Implement security as a culture and show mistakes that make applications vulnerable to attacks.
CO2: Understand various attacks like DoS, buffer overflow, web specific, database specific, web -spoofing attacks.
CO3: Demonstrate skills needed to deal with common programming errors that lead to most security problems and to learn how to develop secure applications.

Course Contents

1. Introduction

2. IRC-Based Bot Networks

3. Anatomy of a Botnet: The Gaobot Worm

4. IoT Sensors and Security : Sensors and actuators in IoT, Communication and networking in IoT, Real-time data collection in IoT, Data analytics in IoT , IoT applications and requirements, Security threats and techniques in IoT, Data trustworthiness and privacy in IoT, Balancing utility and other design goals in IoT , Future of Botnets in the Internet of Things, Thingbots, Elements of Typical IRC Bot Attack , Malicious use of Bots and Botnet

5. Service Layer Protocols and Security : Security, PHP Exploits, Cross-Site Scripting and Other Browser-Side Exploits, Bots and Botnets, Service Layer -oneM2M, ETSI M2M, OMA, BBF – Security in IoT Protocols –MAC 802.15.4 , 6LoWPAN, RPL, Application Layer Transport and Session layer protocols-transport Layer (TCP, MPTCP, UDP, DCCP, SCTP) - (TLS, DTLS)–

Session Layer – HTTP, CoAP, XMPP, AMQP, MQTT

Books:

1. Bernd Scholz - **Reiter, Florian Michahelles, "Architecting the Internet of Things", Springer ISBN 978 – 3 – 642 – 19156 - 5 e ; ISBN 978 – 3 -642 - 19157 - 2.**
2. Threat Modeling, Frank Swiderski and Window Snyder Microsoft Professional, 1 st Edition 2004
3. Gunter Ollmann 2007. The Phishing Guide Understanding and Preventing Phishing Attacks. IBM Internet Security Systems.
4. **Daniel Minoli, "Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications"**, ISBN: 978 – 1 – 118 – 47347 - 4, Willy Publications
5. White Papers – https://www.sans.org/reading-room/whitepapers/malicious/bots-botnet-overview-1299
6. https://www.ifi.ibm.com/marketing/bots/dx

Mike Kuniavsky, **"Smart Things: Ubiquitous Computing User Experience Design,"** Morgan Kaufmann Publishers.

Savitribai Phule Pune University
Fourth Year of Engineering (2019 Course)
410249: Audit Course I
AC1 – IV: 3D Printing

This course aims to provide knowledge of 3D printing devices and explore the business side of 3D printing.

Course Objectives:

- To **acquire** basic knowledge of drafting terminology and construction of geometrical figures using drawing instruments, procedure to prepare a drawing sheet as per SP-46:2003
- To **inculcate** skill of technical sketching, multi-view drawings, Lettering, tolerance, and metric construction
- To **impart** practical aspects to generate detailed and assembly views with dimensions, annotations in 3D Modeling software.
- To **develop** prototype and use product for 3D Printing

Course Outcomes:

On completion of the course, learner will be able to–

CO1: Understand the basic knowledge of Shop Floor Safety rules and regulations basics of Machine tools and 3D printing machines

CO2: Understand the concept of concept of technical sketching, multi-view drawings, Lettering, tolerance, and metric construction

CO3:Identify and Distinguish drafting terminologies and construction of geometrical figures using drawing instruments, procedure to prepare a drawing sheet as per SP-46:2003

CO4:Describe and Explain practical aspects to generate detailed and assembly views with dimensions, annotations, in 3D Modeling software.

CO5: Apply concepts and **Fabricate** the simple mechanical parts, prototype and use product for 3D Printing

Course Contents

1. Getting Started with 3D Printing: How 3D Printers Fit into Modern Manufacturing, Exploring the Types of 3D Printing, Exploring Applications of 3D Printing.

2. Outlining 3D Printing Resources: Identifying Available Materials for 3D Printing, Identifying Available Sources for 3D Printable Objects.

3. Exploring the Business Side of 3D Printing: Commercializing 3D Printing, Understanding 3D Printing's Effect on Traditional lines of Business, Reviewing 3D Printing Research.

4. Employing Personal 3D printing Devices: Exploring 3D printed Artwork, Considering Consumer level 3D Printers, Deciding on Rapid of Your Own

Books:

1. Richard Horne, Kaleel Kirk Shannon, "3D Printing for **Dummies**", Touchstone, ISBN: 9781119386315

2. Cory Norton, "3D Printing Business - 3D Printing for Beginners – How to 3D Print",ISBN:9781514785669

2. Lisa Wallach Kholkl and Nick Kholkl, " Getting Started with 3D Printing: A Hands-on Guide to the **Hardware, Software, and Services Behind the New Manufacturing Revolution**", Maker Media, ISBN: 1680450204

4.Jeff Heldrich , "3D Printing: Tips on Getting Started with 3D Printing to Help you make Passive income for your Business"

Savitribai Phule Pune University, Pune
Fourth Year of Computer Engineering (2019 Course)
410249: Audit Course 7
AC7 – V: Industrial Safety and Environment Consciousness

This course aims to provide knowledge of industrial safety performance planning and accident prevention.

Course Objectives:

- To understand Industrial hazards and Safety requirements with norms
- To learn the basics of Safety performance planning
- To know the means of accident prevention
- To understand the impact of industrialization on environment
- To know the diversified industrial requirements of safety and security

Course Outcomes:

On completion of the course, learner will be able to—

CO1: Develop the plan for Safety performance

CO2: Demonstrate the action plan for accidents and hazards

CO3: Apply the safety and security norms in the industry

CO4: Evaluate the environmental issues of Industrialization

Course Contents

1. Introduction: Elements of safety programming, safety management, Upgrading developmental programmes, safety procedures and performance measures, education, training and development in safety.

2. Safety Performance Planning

Safety Performance: An overview of an accident, It is an accident, injury or incident, The safety professional, Occupational health and industrial hygiene, Understanding the risk, Emergency preparedness and response, prevention of accidents involving hazardous substances.

3. Accident Prevention

What is accident prevention?, Maintenance and Inspection, Monitoring Techniques, General Accident Prevention, Safety Education and Training.

4. Organization Safety

Basic Elements of Organized Safety, Duties of Safety Officer, Safe work Practices, Safety Sampling and Inspection, Job Safety Analysis(JSA), Safety Survey, On- site and Off-site Emergency Plan, Reporting of Accidents and Dangerous Occurrences.

5. Industrial Pollution

Introduction, Work Environment, Remedy, pollution of Marine Environment and Prevention, Basic Environmental Protection Procedures, Protection of Environment in Global Scenario, Greenhouse Gases, Climate Change Impacts, GHG Mitigation Options, Sinks and Barriers.

6. Industrial Security(Industry wise)

General security Systems in Factories, Activation Security, Computer Security, Banking Security, V.I.P. Security, Women Security, Event Security, Security in Open Environments.

Books :

1. Bhandev Panda, "Industrial Safety, Health Environment and Security", Laxmi Publications, ISBN-10: 9381159432, 13: 978-9381159439

2. L.M. Deshmukh, "Industrial Safety Management", TMH, ISBN: 9780070617681

SEMESTER VIII



Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
410250: High Performance Computing

Teaching Scheme:	Credit	Examination Scheme: 100
TH: 4 Hours/Week	3	Mid-Semester (TH) : 30
		End-Sem (TH): 70

Prerequisites Courses: Microprocessor (210254), Principles of Programming languages(210255), Computer Networks and Security(410244)

Companion Course: Laboratory Practice V(410254)

Course Objectives:

- To understand different parallel programming models
- To analyze the performance and modeling of parallel programs
- To illustrate the various techniques to parallelize the algorithm
- To implement parallel communication operations
- To demonstrate CUDA Architecture and its components
- To Understand Scope of Parallel Computing and its search algorithm

Course Outcomes:

CO1: **Understand** various Parallel Paradigm

CO2: **Design and Develop** an efficient parallel algorithm to solve given problem

CO3: **Illustrate** data communication operations on various parallel architecture

CO4: **Analyze** and measure performance of various parallel computing systems

CO5: **Apply** CUDA architecture for parallel programming

CO6: **Analyze** the performance of HPC applications

Course Contents

Unit I **Introduction to Parallel Computing** **09 Hours**

Introduction to Parallel Computing: Motivating Parallelism, **Modern Processor:** Stored-program computer architecture, General-purpose Cache-based Microprocessor architecture. **Parallel Programming Platforms:** Implicit Parallelism, Dichotomy of Parallel Computing Platforms, Physical Organization of Parallel Platforms, Communication Costs in Parallel Machines, Levels of parallelism, **Models:** SIMD, MIMD, SIMT, SPMD, Data Flow Models, Demand-driven Computation. **Architectures:** N-wide superscalar architectures, multi-core, multi-threaded.

Exemplar/Case Studies	Case study: Multicore System
Mapping of Course Outcomes for Unit I	CO1

Unit II **Parallel Algorithm Design** **08 Hours**

Global System for Mobile Communications (GSM) architecture , Mobile Station, Base Station System, Switching subsystem, Security, Data Services, HSCSD, GPRS – GPRS system and protocol architecture 2.5 UTRAN, UMTS core network, Improvements on Core Network, 802.11 Architecture 802.11a, 802.11b standard.

Exemplar/Case Studies	**IPoC**: A New Core Networking Protocol for 5G Networks

***Mapping of Course Outcomes for Unit II**	CO2

Unit III	**Parallel Communication**	**09 Hours**

Basic Communication: One-to-All Broadcast, All-to-One Reduction, All-to-All Broadcast and Reduction, All-Reduce and Prefix-Sum Operations, Collective **Communication using MPI:** Scatter, Gather, Broadcast, Blocking and non blocking MPI, All-to-All Personalized Communication, Circular Shift, Improving the speed of some communication operations

***Exemplar/Case Studies:**	Case study: Monte-Carlo Pi computing using MPI
***Mapping of Course Outcomes for UnitIII**	CO3

Unit IV	**Analytical Modeling of Parallel Programs**	**08 Hours**

Sources of Overhead in Parallel Programs, **Performance Measures and Analysis:** Amdahl's and Gustafson's Laws, Speedup Factor and Efficiency, Cost and Utilization, Execution Rate and Redundancy, The Effect of Granularity on Performance, Scalability of Parallel Systems, Minimum Execution Time and Minimum Cost, Optimal Execution Time, Asymptotic Analysis of Parallel Programs. **Matrix Computation:** Matrix-Vector Multiplication, Matrix-Matrix Multiplication

***Exemplar/Case Studies:**	Case study: The DAG Model of parallel computation
***Mapping of Course Outcomes for UnitIV**	CO4

Unit V	**CUDA Architecture**	**09 Hours**

Introduction to GPU: Introduction to GPU Architecture overview, Introduction to CUDA C-CUDA programming model, write and launch a CUDA kernel, Handling Errors, CUDA memory model, Manage communication and synchronization, Parallel programming in CUDA-C

***Exemplar/Case Studies:**	Case study: GPU applications using SYCL and CUDA on NVIDIA
***Mapping of Course Outcomes for Unit V**	CO5

Unit VI	**High Performance Computing Applications**	**09 Hours**

Scope of Parallel Computing, **Parallel Search Algorithms:** Depth First Search(DFS), Breadth First Search(BFS), **Parallel Sorting:** Bubble and Merge, **Distributed Computing:** Document classification, Frameworks – Kubeflow, GPU Applications, Parallel Computing for AI/ML

***Exemplar/Case Studies:**	Case study: Disaster detection and management: Smart Mobility Urban planning
***Mapping of Course Outcomes for Unit VI**	CO6

Learning Resources

Text Books:

1. Ananth Grama, Anshul Gupta, George Karypis, and Vipin Kumar, "Introduction to Parallel Computing", 2nd edition, Addison Wesley, 2003, ISBN: 0-201-64865-2
2. Sayed H. **Roosta**, "**Parallel** Processing and Parallel Algorithms: Theory and **Computation**", Springer-Verlag 2000 ,ISBN 978-1-4612-7048-5 ISBN 978-1-4612-1220-1
3. John Cheng, Max Grossman, and Ty McKercher, "Professional CUDA C **Programming**", John Wiley & Sons, Inc., ISBN: 978-1-118-73932-7

Reference Books :

1. Kai Hwang, "Scalable Parallel Computing", McGraw Hill 1998.
2. George S. Almasi and Allan Gottlieb, "Highly Parallel Computing", The Benjamin and Cummings Pub. Co., Inc.
3. Jason sanders, Edward Kandrot, "CUDA by Example!", Addison-Wesley, ISBN-13: 978-0-13-138768-3
4. Pacheco, Peter S.,"An Introduction to Parallel **Programming**", Morgan Kaufmann Publishers ISBN 978-0-12-374260-5
5. Rieffel Wolfgang Polak, "Quantum Computing: A gentle **introduction**", MIT Press, 2011,ISBN 978-0-262-01506-6
6. Ajay D. Kshemkalyani , Mukesh Singhal, "Distributed Computing: Principles, Algorithms, and **Systems**", Cambridge March 2011, ISBN: 9780521189842

e-Books :

1. http://nptel.ac.in/courses/106102114/pdf/Lecture_Notes/Module_1_Lecture_1_Introduction_to_Parallel_Computing.pdf
2. https://www.cse.iitk.ac.in/users/mainak/lecture_notes/lecture1429843084.pdf

NPTEL/YouTube video lecture link:

- https://nptel.ac.in/courses/106106093/
- https://www.digimat.in/nptel/courses/video/106104203/L01.html

The CO-PO Mapping Matrix

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	-	-	-	-	-	-	-	-	-	-
CO2	2	1	-	-	-	-	-	-	-	-	-	-
CO3	2	1	-	-	-	-	-	-	-	-	-	-
CO4	1	2	-	2	-	-	-	-	-	-	-	-
CO5	1	2	-	2	-	-	-	-	-	-	-	1
CO6	2	2	-	2	-	-	-	-	-	-	-	1

Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
410251: Deep Learning

Teaching Scheme:	Credit	Examination Scheme:
TH: 03 Hours/Week	03	In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Prerequisite Courses: Machine Learning (410242)

Companion Course: Laboratory Practice V(410254)

Course Objectives:

- To understand the basics of neural networks.
- Comparing different deep learning models.
- To understand the Recurrent and Recursive nets in Deep Learning.
- To understand the basics of deep reinforcement Learning models.
- To analyze Types of Networks.
- To Describe Reinforcement Learning.

Course Outcomes:

On completion of the course, student will be able to–

CO1: Understand the basics of Deep Learning and apply the tools to implement deep learning applications

CO2: Evaluate the performance of deep learning models (e.g., with respect to the bias variance trade-off, overfitting and underfitting, estimation of test error).

CO3: To apply the technique of Convolution (CNN) and Recurrent Neural Network (RNN) for implementing Deep Learning models

CO4: To implement and apply deep generative models.

CO5: Construct and apply on-policy reinforcement learning algorithms

CO6 To Understand Reinforcement Learning Process

Course Contents

Unit I	Foundations of Deep learning	07 Hours

What is machine learning and deep learning?,Supervised and Unsupervised Learning, bias variance tradeoff,hyper parameters, under over fitting regularization, Limitations of machine learning, History of deep learning, Advantage and challenges of deep learning, Learning representations from data , Understanding how deep learning works in three figures, Common Architectural Principles of Deep Network, Architecture Design, Applications of Deep Learning, Introduction and use of popular industry tools such as TensorFlow,
Keras, PyTorch, Caffe, Shogun.

*Exemplar/Case Studies	Deep Mind, AlphaGo, Boston Dynamics
*Mapping of Course Outcomes for Unit I	CO1

Unit II	Deep Neural Networks(DNNs)	07 Hours

Introduction to Neural Networks: The Biological Neuron, The Perceptron, Multilayer Feed-Forward Networks. **Training Neural Networks**: Backpropagation and Forward propagation. **Activation Functions**: Linear Activation, Tanh, Hard Tanh, Softmax, Rectified Linear. **Loss Functions**: Loss Function Notation:, Loss Functions for Regression:, Loss Functions for Classification, Loss Functions for Reconstruction. **Hyperparameters**: Learning Rate, Regularization, Momentum, Sparsity. Deep Feedforward Networks – Example of Ex-OR, Hidden Units, cost functions, error backpropagation, Gradient-Based Learning, Implementing Gradient Descent, vanishing and Exploding gradient descent, Sentiment Analysis, Deep Learning with Pytorch, Jupyter, colab.

*Exemplar/Case Studies	A Case Study for Music Genre Classification
*Mapping of Course Outcomes for Unit II	CO2

Unit III	Convolution Neural Network(CNN)	07 Hours

Introduction, CNN architecture overview, The Basic Structure of a Convolutional Network, Padding, Stride, Typical Settings, the ReLU layer, Pooling, Fully Connected Layers, The Interleaving between Layers, Local Response Normalization, Training a Convolutional Network

*Exemplar/Case Studies	AlexNet, VGG
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	Convolution Neural Network(CNN)	07 Hours

Recurrent and Recursive Nets: Unfolding Computational Graphs, Recurrent Neural Networks, Bidirectional RNNs, Encoder-Decoder Sequence-to-Sequence Architectures, Deep Recurrent Networks, Recursive Neural Networks, The Challenge of Long-Term Dependencies, Echo State Networks, Leaky Units and Other Strategies for Multiple Time Scales, The Long Short-Term Memory and Other Gated RNNs, Optimization for Long-Term Dependencies, Explicit Memory. **Practical Methodology**: Performance Metrics, Default Baseline Models, Determining Whether to Gather More Data, Selecting Hyper parameters

*Exemplar/Case Studies	Multi-Digit Number Recognition
*Mapping of Course Outcomes for Unit IV	CO3

Unit V	Deep Generative Models	09 Hours

Introduction to deep generative model, Boltzmann Machine, Deep Belief Networks, Generative adversarial network (GAN), discriminator network, generator network, types of GAN, Applications of GAN networks

*Exemplar/Case Studies	GAN for detection of real or fake images
*Mapping of Course Outcomes for Unit V	CO4

Unit VI	Reinforcement Learning	07 Hours

Introduction of deep reinforcement learning, Markov Decision Process, basic framework of reinforcement learning, challenges of reinforcement learning, Dynamic programming algorithms for reinforcement learning:Q Learning and Deep Q-Networks, Deep Q recurrent networks, Simple reinforcement learning for Tic-Tac-Toe

#Examples/Case Studies	Self driving cars, Deep learning for chatbots
***Mapping of Course Outcomes for Unit VI**	CO5

Learning Resources

Text Books:

1. Goodfellow, I., Bengio, Y., Courville, A, "Deep Learning", MIT Press, 2016.
2. Josh Patterson & Adam Gibson, "Deep Learning"
3. Charu Agarwal, "Neural Networks and deep learning", A textbook
4. Nikhil Buduma, "Fundamentals of Deep Learning", SPD
5. Francois chollet, "Deep Learning with Python"

Reference Books:

1. Richard S. Sutton and Andrew G. Barto, "Reinforcement Learning: An Introduction"
2. by SethWeidman, "Deep Learning from Scratch: Building with Python from First Principles"O'Reily
3. Francois Duval, "Deep Learning for Beginners, Practical Guide with Python and Tensorflow"

e-Books :

1. http://cs.pnc.edu/support/cs855-18fall/DeepLearningPractitionersApproach.pdf
2. https://www.dlsteed.com/_media/science/neuronalnetze-en-ctu2-1-pl-dlsteed.com.pdf

MOOC Courses Links:

- https://www.my-mooc.com/en/categories/deep-learning

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	-	3	-	-	-	-	-	-	2
CO2	3	2	2	2	1	-	-	-	-	-	-	1
CO3	3	2	2	2	2	-	1	-	-	-	-	1
CO4	1	2	1	1	2	-	1	-	-	-	-	1
CO5	2	2	1	2	2	-	-	-	-	-	-	1
CO6	1	2	2	2	2	-	-	-	-	-	2	-

Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
Elective V
410252(A): Natural Language Processing

Teaching Scheme:	Credit	Examination Scheme:
		In-Sem (Paper): 30 Marks
TH: 03 Hours/Week	03	End-Sem (Paper): 70 Marks

Prerequisite Courses: Discrete Mathematics (210241), Theory of Computation (310242), Data Science and Big Data Analytics (310251)

Companion Course: Laboratory Practice VI(410253)

Course Objectives:

- To be familiar with fundamental concepts and techniques of natural language processing (NLP)
- To acquire the knowledge of various morphological, syntactic, and semantic NLP tasks
- To develop the various language modeling techniques for NLP
- To use appropriate tools and techniques for processing natural languages
- To comprehend the advance real world applications in NLP domain.
- To Describe Applications of NLP and Machine Translations.

Course Outcomes:

On completion of the course, student will be able to–

CO1: Describe the fundamental concepts of NLP, challenges and issues in NLP

CO2: Analyze Natural languages morphologically, syntactical and semantically OR Describe the concepts of morphology, syntax, semantics of natural language

CO3: Illustrate various language modelling techniques

CO4: Integrate the NLP techniques for the information retrieval task

CO5: Demonstrate the use of NLP tools and techniques for text-based processing of natural languages

CO6: Develop real world NLP applications

Course Contents

Unit I	Introduction to Natural Language Processing	07 Hours

Introduction: Natural Language Processing, Why NLP is hard? Programming languages Vs Natural Languages, Are natural languages regular? Finite automata for NLP, Stages of NLP, Challenges and Issues(Open Problems) in NLP

Basics of text processing: Tokenization, Stemming, Lemmatization, Part of Speech Tagging

*Exemplar/Case Studies	Why English is not a regular language: http://ca.haifa.ac.il/~ahaly/teaching/08/idp/complexity.pdf#page=20
*Mapping of Course Outcomes for Unit I	CO1

Unit II	Language Syntax and Semantics	07 Hours

Morphological Analysis: What is Morphology? Types of Morphemes, Inflectional morphology &Derivational morphology, Morphological parsing with Finite State Transducers (FST)

Syntactic Analysis: Syntactic Representations of Natural Language, Parsing Algorithms, Probabilistic context-free grammars, and Statistical parsing

Semantic Analysis: Lexical Semantic, Relations among lexemes & their senses – Homonymy,Polysemy, Synonymy, Hyponymy, WordNet, Word Sense Disambiguation (WSD), Dictionary

based approach, Latent Semantic Analysis

#Exemplar/CaseStudies	Study of Stanford Parser and POS Tagger https://nlp.stanford.edu/software/lex-parser.html https://nlp.stanford.edu/software/tagger.html
***Mapping of Course Outcomes for Unit II**	CO2

Unit III	**Language Modelling**	**07 Hours**

Probabilistic language modeling, Markov models, Generative models of language, Log-Linear Models, Graph-based Models

N-gram models: Simple n-gram models, Estimation parameters and smoothing, Evaluating language models, **Word Embeddings/ Vector Semantics:** Bag-of-words, TFIDF, word2vec, doc2vec, Contextualized representations (BERT)

Topic Modelling: Latent Dirichlet Allocation (LDA), Latent Semantic Analysis, Non Negative

Matrix Factorization

#Exemplar/Case Studies	Study of language modelling for Indian languages
***Mapping of Course Outcomes for Unit III**	CO3

Unit IV	**Information Retrieval using NLP**	**07 Hours**

Information Retrieval: Introduction, Vector Space Model

Named Entity Recognition: NER System Building Process, Evaluating NER System

Entity Extraction, Relation Extraction, Reference Resolution, Coreference resolution, Cross Lingual Information Retrieval

#Exemplar/Case Studies	Natural Language Processing based Information Extraction & Retrieval https://www.cdac.in/index.aspx?id=mc_cli_cross_lingual_info
***Mapping of Course Outcomes for Unit IV**	CO4

Unit V	**NLP Tools and Techniques**	**08 Hours**

Prominent NLP Libraries: Natural Language Tool Kit (NLTK), spaCy, TextBlob, Gensim etc.

Linguistic Resources: Lexical Knowledge Networks, WordNets, Indian Language WordNet (IndoWordnet), VerbNets, PropBank, Treebanks, Universal Dependency Treebanks

Word Sense Disambiguation: Leak Algorithm **Walker's algorithm**, WordNets for Word Sense Disambiguation

#Exemplar/Case Studies	Hindi Wordnet: https://www.cfilt.iitb.ac.in/wordnet/webhwn/ Sanskrit WordNet: https://www.cfilt.iitb.ac.in/wordnet/webhwn/ Indic Library: http://www.pkarchakuttan.sthuli.in/indic_rtlr_library/

*Mapping of Course Outcomes for Unit X	CO5

Unit XI	Applications of NLP	07 Hours

Machine Translation: Rule based techniques, Statistical Machine Translation (SMT), Cross Lingual Translation

Sentiment Analysis, Question Answering, Text Entailment, Discourse Processing, Dialog and Conversational Agents, Natural Language Generation.

*Examples/Case Studies	Study working of Google Translate Study working of IBM Watson Natural Language Processing
*Mapping of Course Outcomes for Unit XI	CO6

Learning Resources

Text Books:

1. Jurafsky, Daniel, and James H. Martin, "Speech and Language Processing: An Introduction to Natural Language Processing", Computational Linguistics and Speech Recognition, PEARSON Publication.
2. Manning, Christopher D., and mich Schütze, "Foundations of Statistical Natural Language Processing", Cambridge, MA: MIT Press

Reference Books:

1. Steven Bird, Ewan Klein, Edward Loper, "Natural Language Processing with Python – Analyzing Text with the Natural Language Toolkit", O'Reilly Publication
2. Dipanjan Sarkar, "Text Analytics with Python: A Practical Real-World Approach to Gaining Actionable Insights from your Data", Apress Publication ISBN: 9781484223871
3. Alexander Clark, Chris Fox, and Shalom Lappin, "The Handbook of Computational Linguistics and Natural Language Processing", Wiley Blackwell Publications
4. Jacob Eisenstein, "Natural Language Processing", MIT Press
5. Jacob Eisenstein, "An Introduction to Information Retrieval", Cambridge University Press

e-Books:

1. https://web.stanford.edu/~jurafsky/slp3/ed3book.pdf
2. https://www.cse.iitb.ac.in/~cs621-2010/lrec.ppt

NPTEL Course links:

- https://nptel.ac.in/courses/106101007
- https://nptel.ac.in/courses/106106211

The CO-PO Mapping Matrix

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	-	-	-	-	-	-	-	-	-
CO2	3	3	2	2	2	-	-	-	-	-	-	1
CO3	2	3	3	2	2	-	-	-	-	-	-	2
CO4	2	2	2	3	3	-	2	2	-	-	-	2
CO5	2	2	3	3	3	-	-	-	-	-	-	2
CO6	3	3	3	3	3	2	3	3	-	-	-	3

Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
Elective V
410252 (E) Image Processing

Teaching Scheme:	Credit	Examination Scheme:
TH: 03 Hours/Week	03	In-Sem (Paper): 30 Marks
		End-Sem (Paper): 70 Marks

Prerequisites Courses: Discrete Mathematics (210241)

Companion Course: Laboratory Practice VI (410253)

Course Objectives:

- To Understand Digital Image Processing Concepts
- To Study Various Methods for Image Enhancement using Spatial and Frequency Domain
- To Learn Classification Techniques for Image Segmentation
- To Understand Image Compression and Object Recognition
- To Study Various Image Restoration Techniques
- To Understand various Medical and Satellite Image Processing Applications

Course Outcomes:

On completion of the course, student will be able to–

CO1: Apply Relevant Mathematics Required for Digital Image Processing
CO2: Apply Special and Frequency Domain Method for Image Enhancement
CO3: Apply algorithmic approaches for Image segmentation
CO4: Summarize the Concept of Image Compression and Object Recognition
CO5: Explore the Image Restoration Techniques
CO6: Explore the Medical and Satellite Image Processing Applications

Course Contents

Unit I — Introduction to Digital Image Processing — 07 Hours

Introduction, Fundamental steps in Digital Image Processing, Components, Elements of visual perception, Image Sensing and Acquisition, Image Sampling and Quantization, Relationships between pixels, different Color Models, Image Types, Image File Formats, Connected Labeling algorithm

Introduction to OpenCV tool to Open and Display Images using Python or Eclipse C/C++.

#Exemplar/Case Studies: Write a program to create a simple image file, save the same in jpg, tiff, bmp format and display it.

***Mapping of Course Outcomes for Unit I:** CO1

Unit II — Image Enhancement — 08 Hours

Introduction to Image Enhancement and its Importance, Types of Image Enhancement: **Spatial Domain Image Enhancement:** Intensity Transformations, Contrast Stretching, Histogram Equalization, Correlation and Convolution, Smoothing Filters, Sharpening Filters, Gradient and Laplacian

Frequency Domain Image Enhancement: Low Pass Filtering in Frequency Domain (Ideal,

Butterworth, Gaussian), High Pass filter in Frequency Domain (Ideal, Butterworth, Gaussian).

***Exemplar/Case Studies**	Write a program for image enhancement using suitable algorithm for Histogram equalization. Local enhancement. Smoothing and Sharpening.
***Mapping of Course Outcomes for Unit II**	CO2

Unit III	**Image Segmentation and Analysis**	**08 Hours**

Introduction to Image Segmentation and its need. **Classification of Image Segmentation Techniques:** Threshold Based Image Segmentation, Edge Based Segmentation, Edge Detection, Edge Linking, Hough Transform, Watershed Transform, Clustering Techniques, region approach

***Exemplar/Case Studies**	Study the different image segmentation techniques for image segmentation
***Mapping of Course Outcomes for Unit III**	CO3

Unit IV	**Image Compression and Object Recognition**	**06 Hours**

Image Compression: Introduction to Image Compression and its need, Classification of Image Compression Techniques- run-length coding, Shannon Fano coding, Huffman coding, Scalar and vector quantization. Compression Standards-JPEG/MPEG, Video compression.

Object Recognition: Introduction, Computer Vision, Tensor Methods in Computer Vision, Classifications Methods and Algorithm. Object Detection and Tracking, Object Recognition.

***Exemplar/Case Studies**	Explain image compression and object recognition techniques
***Mapping of Course Outcomes for Unit IV**	CO4

Unit V	**Image Restoration and Reconstruction**	**07 Hours**

Introduction, Model of Image degradation, Noise Models, Classification of image restoration techniques, Blind deconvolution techniques, Lucy Richardson Filtering, Wiener Filtering

***Exemplar/Case Studies**	Explain classification of image restoration techniques
***Mapping of Course Outcomes for Unit V**	CO5

Unit VI	**Medical and Satellite Image Processing**	**07 Hours**

Medical Image Processing: Introduction, Medical Image Enhancement, Segmentation, Medical Image Analysis (Images of Brain MRI or Cardiac MRI or Breast Cancer).

Satellite Image Processing: Concepts and Foundations of Remote Sensing, GPS, GIS, Elements of Photographic Systems, Basic Principles of Photogrammetry, Multispectral, Thermal, and Hyper spectral Sensing, Earth Resource Satellites Operating in the Optical Spectrum

***Exemplar/Case Studies**	Implement application for medical image processing or satellite image processing using OpenCV or Python.

***Mapping of Course Outcomes for UnitVI** CO6

Learning Resources

Text Books:

1. Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image processing", Pearson Education, Fourth Impression, 2008, ISBN: 978-81-7758-898- 9.
2. A. K. Jain, "Fundamentals of Digital Image Processing", PHI, ISBN-978-81- 203- 0929- 6.
3. S. Annadurai, R. Shanmugalakshmi, "Fundamentals of Digital Image Processing", Pearson Education, First Edition, 2007, ISBN-8177584790.
4. Bogoslaw Cyganek, "Object Detection and Recognition in Digital Images: Theory and Practice", Wiley, First Edition, 2013, ISBN: 978-0-470-97637-1.
5. Ingemar Cox, Matthew Miller, Jeffrey Bloom, Jessica Fridrich, Ton Kalker, "Digital Watermarking and Steganography", Morgan Kaufmann (MK), ISBN: 978-0-12- 372585-1.
6. Thomas Lillesand, Ralph W. Kiefer, Jonathan Chipman, "Remote Sensing and Image Interpretation", Wiley, Seventh Edition, 2015, ISBN: 978-1-118-91947-7.

Reference Books :

1. Isaac Bankman, "Handbook of Medical Imaging", Academic Press, Second Edition, 2008, ISBN: 9780080139148.
2. Jayaraman, Esakkirajan,Veerakumar, "Digital image processing" , , Mc Graw Hill, Second reprint, 2010, ISBN(13): 978-0-07-01447-8, ISBN(10):0-07-014479-6.

e-Books :

- https://bookboon.com/en/3d-video-processing-and-transmission-fundamentals-ebook

MOOC Courses links :

- http://nptel.ac.in/courses/117105079

@The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	-	-	-	-	1	-	-	-
CO2	1	2	2	2	2	1	-	-	1	-	-	1
CO3	1	2	2	2	2	1	-	-	1	-	-	1
CO4	1	1	2	2	2	1	-	-	1	-	-	1
CO5	1	1	1	2	2	1	-	-	1	-	-	1
CO6	1	2	3	2	2	1	1	-	1	-	1	1



Savitribai Phule Pune University

Fourth Year of Computer Engineering (2019 Course)

Elective V

410253(C): Software Defined Networks

Teaching Scheme:	Credit:	Examination Scheme:
TH: 3 Hours/Week	3	Mid-Semester (TH) : 30 End-Sem (TH): 70

Prerequisite Courses: Computer Networks and Security(310244)

Companion Course: Laboratory Practice VI(410255)

Course Objectives:

- To learn the fundamentals of software defined networks and understand Differentiation between traditional networks and software defined networks
- To gain conceptual understanding of Software Defined Networking (SDN) and its role in Data Center.
- To study about the SDN Programming.
- To study industrial deployment use-cases of SDN.
- To study about the various applications of SDN
- To Describe SDN Framework.

Course Outcomes:

On completion of the course, student will be able to–

CO1: Interpret the need of Software Defined networking solutions.

CO2: Analyze different methodologies for sustainable Software Defined Networking solutions

CO3: Select best practices for design, deploy and troubleshoot of next generation networks

CO4: Develop programmability of network elements

CO5: Demonstrate virtualization and SDN Controllers using Open Flow protocol

CO6: Design and develop various applications of SDN.

Course Contents

Unit I **Introduction** **07 Hours**

Challenges of traditional networks, History of Software Defined Networking (SDN), Modern Data Center – Traditional Switch Architecture – Why SDN – Evolution of SDN – How SDN Works – Centralized and Distributed Control and Data Planes.

***Exemplar/Case Studies**	Video Streaming https://komprise.com/what-is-sdn-and-use-cases/video-streaming/
***Mapping of Course Outcomes for Unit I**	CO1,CO2

Unit II **OPEN FLOW & SDN CONTROLLERS** **07 Hours**

Open Flow Overview, The Open Flow Switch, The Open Flow Controller, Open Flow Ports, Message Types, Pipeline Processing, Flow Tables, Matching, Instructions, Action Set and List, Open Flow Protocol, Proactive and Reactive Flow, Timers, Open Flow Limitations, Open Flow Advantages and Disadvantages, Open v Switch Features, Drawbacks of Open SDN, Introduction to SDN controller.

•Exemplar/Case Studies	Behavior Anomaly Detection in SDN Control Plane: A Case Study of Topology Discovery Attacks https://www.hindawi.com/journals/wcmc/2020/8898049/
***Mapping of Course Outcomes for Unit II**	CO2,CO3

Unit III	**DATA CENTERS**	**07 Hours**

Data Center Definition, Data Center Demands (Adding, Moving, Deleting Resources, Failure Recovery, Multitenancy, Traffic Engineering and Path Efficiency), Tunneling Technologies for the Data Center, SDN Use Cases in the Data Center, SDN Solutions for the Data Center Network – VLANs – EVPN – VxLAN – NVGRE

•Exemplar/Case Studies	The World's Second Largest Tier IV Data Center A Yotta Infrastructure case study https://www.missioncriticalmagazine.com/articles/94105-the-worlds-second-largest-tier-iv-data-center
***Mapping of Course Outcomes for Unit III**	CO2

Unit IV	**SDN PROGRAMMING**	**07 Hours**

Programming SDNs, Northbound Application Programming Interface, Current Languages and Tools, Composition of SDNs – Introduction of Network Functions Virtualization (NFV) and Software Defined Networks: Concepts, Implementation and Applications

•Exemplar/Case Studies	Case study: Ballarat Grammar uses SDN to fight malware https://www.edrct.com/home-and-office/networking/case-study-ballarat-grammar-uses-sdn-to-fight-malware/
***Mapping of Course Outcomes for Unit IV**	CO4

Unit V	**Network Functions Virtualization (NFV)**	**07 Hours**

Definition of NFV, SDN Vs NFV, In-line network functions, Benefits of Network Functions Virtualization, Challenges for Network Functions Virtualization, Leading NFV Vendors, Comparison of NFV and NV

•Exemplar/Case Studies	NFV deployment case study failure migrate https://www.dell.com/en-us/blog/nfv-deployment-case-study-failure-migrate/
***Mapping of Course Outcomes for Unit V**	CO5

Unit VI	**SDN Use Cases**	**07 Hours**

Juniper SDN Framework – IETF SDN Framework – Open Daylight Controller – Floodlight Controller – Bandwidth Calendaring – Data Center Orchestration

•Exemplar/Case Studies	CloudSeeds automate IaaS using SDN and a high-performance network from Juniper.
***Mapping of Course Outcomes for Unit VI**	CO6

Learning Resources

Text Books:

1. Paul Goransson and Chuck Black, "Software Defined Networks: A Comprehensive Approach", Morgan Kaufmann, 2014. ISBN: 9780124166752, 9780124166844.
2. Siamak Azodolmolky, "Software Defined Networking with OpenFlow", Packt Publishing, 2013. ISBN: 9781849697728
3. Thomas D. Nadeau, Ken Gray, "SDN: Software Defined Networks", An Authoritative Review of Network Programmability Technologies", 2013. ISBN : 10:1-4493-4230-2, 978:1-4493-4230-2

Reference Books:

1. Vivek Tiwari, "SDN and Open Flow for Beginners", Amazon Digital Services, Inc., 2013.
2. Fei Hu, Editor, "Network Innovation through Open Flow and SDN: Principles and Design", CRC Press, 2014.

e-Books :

1. https://ridhanpara.staff.ramanuniversity.ac.in/files/2017/04/Paul-Goransson-and-Chuck-Black-Auth.-Software-Defined-Networks-A-Comprehensive-Approach.pdf
2. https://gesits.fti.itb.ac.id/KomunikasiTechnical/prodevsdn/7_11_2016/Smiha_pisteran.pdf
3. https://ridhanpara.staff.ramanuniversity.ac.in/files/2017/04/Thomas-D.-Nadeau-Ken-Gray-SDN-Software-Defined-Networks-O_635_Reilly-Media-2013.pdf

MOOC Courses Links:

- https://nptel.ac.in/courses/106105087

The CO-PO Mapping Matrix

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	1	2	-	1	-	-	-	-	-
CO2	1	2	1	1	2	-	-	-	-	-	1	-
CO3	1	1	1	1	2	-	-	-	-	-	2	-
CO4	1	2	2	1	2	-	-	-	-	-	2	-
CO5	3	2	2	3	3	-	-	-	-	-		-
CO6	3	2	2	1	3	-	-	-	-	-	1	-

Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)Elective VI
410252(D): Advanced Digital Signal Processing

Teaching Scheme: TH: 03 Hours/Week.	Credit 03	Examination Scheme:In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Prerequisite Courses: 410244(A)Digital Signal Processing

Companion Course: Laboratory Practice VI(410253)

Course Objectives:

- To study the parametric methods for power spectrum estimation.
- To study adaptive filtering techniques and applications of adaptive filtering.
- To learn and understand Multirate DSP and applications
- To explore appropriate transforms
- Understand basic concepts of speech production, speech analysis, speech coding andparametric representation of speech
- Acquire knowledge about different methods used for speech coding and understandvarious applications of speech processing
- Learn and understand basics of Image Processing and various image filters with its applications

Course Outcomes:

On completion of the course, student will be able to–

CO1: Understand and apply different transforms for the design of DT Digital systems

CO2: Explore the knowledge of adaptive filtering and Multi-rate DSP

CO3: Design DT systems in the fields/area of adaptive filtering, spectral estimation and multi-rateDSP

CO4: Explore use of DCT and WT in speech and image processing

CO5: Develop algorithms in the field of speech , image processing and other DSP applications

CO6:Identify Image Processing Techniques

Course Contents

Unit I	DFT and Applications	08 Hours

DFT and Applications – Linear filtering, spectral leakage, Spectral resolution and selection of Window Length, Frequency analysis, 2-D DFT, applications in Image and Speech Processing

*Exemplar Case Studies	Case Study of Image / Speech Processing Application
*Mapping of Course Outcomes for Unit I	CO1

Unit II	Adaptive FIR and IIR filter Design	08 Hours

Adaptive FIR and IIR filter Design – DT Filters, FIR and IIR filters, Adaptive FIR Filter design: Steepest descent and Newton method, LMS method, Applications. Adaptive IIR Filter design:Pade Approximation, Least square design, Applications

*Exemplar Case	Demonstration of DT filter and FIR filter with suitable application

Studies	
***Mapping of Course Outcomes for Unit II**	CO2

Unit III	**Multirate DSP and applications**	**08 Hours**

Introduction, Decimation by a Factor D, Interpolation by a Factor I, Sampling Rate Conversion by a Rational Factor I/D, Filter Design and Implementation for sampling rate Conversion Multirate Digital Signal Processing Multistage Implementation of Sampling Rate Conversion, Applications of Multirate Signal Processing, Sampling Rate Conversion of Bandpass Signals Linear Prediction And Optimum Linear Filters, Innovations Representation of a Stationary Random Process, Forward and Backward linear prediction, Solution of the Normal Equations, Properties of linear prediction-Error Filter, All Lattice and ARMA Lattice-Ladder Filters

#Exemplar/Case Studies	Implementation for sampling rate Conversion Multi-rate Digital Signal Processing
***Mapping of Course Outcomes for Unit II**	CO3

Unit IV	**Spectral Estimation**	**08 Hours**

Spectral Estimation – Estimation of density spectrum, Nonparametric method, Parametric method, Evaluation ,DCT and WT – DCT and KL transform, STFT, WT, Haar Wavelet and Daubechies Wavelet, Applications of DCT and WT.

#Exemplar/Case Studies	A spectral estimation case study in frequency domain by nonparametric methods
***Mapping of Course Outcomes for Unit II**	CO4

Unit V	**Speech processing**	**08 Hours**

Speech processing - Speech coding: Phase Vocoder, LPC, Sub-band coding, Adaptive Transform Coding, Harmonic Coding, Vector Quantization based Coders. Fundamentals of Speech recognition, Speech segmentation, Text-to-speech conversion, speech enhancement, Speaker Verification, Applications

#Exemplar/Case Studies	Investigation of data augmentation techniques for disordered speech recognition
***Mapping of Course Outcomes for Unit II**	CO5

Unit VI	**Image Processing**	**08 Hours**

Image Processing – Image as 2D signal and image enhancement techniques, filter design- low pass, highpass and bandpass for image smoothing and edge detection, Optimum linear filter and order statistic filter, Examples – Wiener and Median filters, Applications

#Exemplar/Case Studies	Medical image processing for coronavirus (COVID-19) pandemic: A survey
***Mapping of Course Outcomes for Unit II**	CO6

Books

Text:

1. J. G. Proakis, D. G. Manolakis, " Digital Signal Processing: Principles, Algorithms, and Applications," Prentice Hall, 2007, 4th edition, ISBN: 10: 0131873741
2. Dr. Shaila D. Apte: " Advanced Digital Signal Processing," Wiley Publ., 2013, ISBN:10: 8126541245
3. S. K. Mitra, "Digital Signal Processing : A Computer Based Approach", McGraw Hill Higher Education, 2006, 3rd edition, ISBN:10: 0070402357
4. Rabiner and Juang, "Fundamentals of Speech Recognition", Prentice Hall, 1994, ISBN:0-13-015157-2
5. Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing and Analysis", Pearson Education, 1st Ed., 2007, ISBN: 81-7808-629-8

References:

1. Chanda, Majumdar, "Digital Image Processing and Analysis," Eastern Economy Edition,PHI, 2nd Ed., ISBN: 978-81-203-4956-1
2. Tamilarasi, "Digital Signal Processing", Oxford University Press, 2015, ISBN-10:0190696281
3. Roberto Crist, "Modern Digital Signal Processing," Thomson Brooks/Cole 2004,ISBN:978-03-00026-35-8.
4. Nelson Morgan and Ben Gold, " Speech and Audio Signal Processing: Processing andPerception Speech and Music", 1999, John Wiley and Sons, ISBN: 0197931547
5. Raghuveer M. Rao, Ajit S.Bopardikar, "Wavelet Transforms: Introduction to Theory and Applications," Pearson Education, Asia, 2000,Dale Grover and John R. (Jack) Duffer, "Digital Signal Processing and the Microcontroller", Prentice Hall, ISBN:0-13-734020-2

eE Books:

1. **Foundations of Signal Processing- http://fourierandwavelets.org/**
2. **http://www.sbc4.org/materials/lib/Articles-Books/Speech%20Recognition/advanced-digital-signal-processing-and-noise-reduction.9780470094945.26485.pdf**
3. **https://www.riverpublishers.com/pdf/ebook/RP_E9788792982933.pdf**
4. **https://fmipa.umri.ac.id/wp-content/uploads/2016/03/Andreas-Antoniou-Digital-signal-processing.9780073464047.31537.pdf**
5. **http://www-syscom.univ-mlv.fr/~saidi/teaching/dsp-esipe-sc2/Course-Notes_-Advanced-DSP.pdf**
6. **https://dlmdst.org/pdfs/files/2593b31b3887ba4eaa5384306334369a.pdf**

MOOC Courses Links:

- **https://onlinecourses.nptel.ac.in/noc21_ee84/preview**

[Click CO-PO Matrix Matrix]

course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	-	-	-	-	-	-	-
CO2	3	2	2	2	2	-	-	-	-	-	-	-
CO3	2	2	3	2	2	-	-	-	-	-	2	-
CO4	3	2	2	2	2	-	-	-	-	-	-	-
CO5	3	2	2	3	2	-	-	-	-	-	-	-
CO6	3	2	1	1	1	-	-	-	-	-	-	-



Savitribai Phule Pune University

Fourth Year of Computer Engineering (2019 Course)

Elective V

410253(E): Open Elective

Teaching Scheme:	Credit	Examination Scheme: In-Sem (Paper): 30 Marks
TH: 03 Hours/Week	03	End-Sem (Paper): 70 Marks

The open electives included, so as to give the student a wide choice of subjects from other Engineering Programs. To inculcate the out of box thinking and to feed the inquisitive minds of the learners the idea of open elective is need of the time. Flexibility is extended with the choice of open elective allows the learner to choose interdisciplinary course/future technology related courses to expand the knowledge horizons. With this idea learner opts for the course without any boundaries to choose the approved by academic council and Board of Studies.



Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
Elective VI
410253(A) : Pattern Recognition

Teaching Scheme:	Credit	Examination Scheme:
TH: 03 Hours/Week	03	In-Sem (Paper): 30 Marks
		End-Sem (Paper): 70 Marks

Prerequisite Courses: Fundamentals of Data Structures(210244), Data Structures and Algorithms(210252)

Companion Course: Laboratory Practice VI(410255)

Course Objectives:

- To learn the basic concepts of Pattern recognition
- To study different approaches of pattern recognition
- To learn various pattern classification techniques
- To survey on recent advances and applications in pattern recognition
- To implement Optimal Path Searching techniques
- To Illustrate Pattern Recognition Techniques

Course Outcomes:

On completion of the course, student will be able to–

CO1: Analyze various type of pattern recognition techniques

CO2: Identify and apply various pattern recognition and classification approaches to solve the problems

CO3: Evaluate statistical and structural pattern recognition

CO4: Perceptrecent advances in pattern recognition oriented to various applications

CO5: Implement **Bellman's optimality principle and** dynamic programming

CO6: Analyze Patterns using Genetic Algorithms & Pattern recognition applications.

Selection of Modules:

Kindly note that modules 1,2,3 and module 9 are compulsory and select any two (02) modules from remaining modules

Course Content:

Unit I — Pattern Recognition — 07 Hours

Introduction of Pattern Recognition with its applications, Pattern Recognition systems, Design cycle of pattern recognition, Learning and adaptions, Representation of Patterns and classes, Feature Extraction, pattern recognition models/approaches.

***Examples/Case Studies**	Prediction on spatial and temporal variations in water quality by pattern recognition techniques
***Mapping of Course Outcomes for Unit I**	CO1

Unit II — Error Estimation & Decision Theory — 07 Hours

Introduction, Error estimates methods, various distance measures (Euclidean, Manhattan, Minkowski, Mahalanobis) and distance based classifier, Feature selection based on statistical hypothesis testing, ROC curve.

Introduction, Bayesian decision theory-continuous and discrete features,two category classification, minimum error rate classification, discriminant functions,

Parametric Techniques:- Maximum Likelihood Estimation, Bayesian Parameter Estimation, Sufficient Statistics, Problems of Dimensionality.

Non-Parametric Techniques-Density estimation, Parzen Window, Metrics and Nearest-Neighbor classification, Fuzzy classification

***Exemplar/Case Studies**	Spatial and temporal air quality pattern recognition using various metric techniques
***Mapping of Course Outcomes for Unit II**	CO2

Unit III	**Structural pattern recognition**	**08 Hours**

Tree Classifiers Decision Trees, Random Forests, **Structural Pattern recognition:** Elements of formal grammars ,String generation as pattern description ,Recognition of syntactic description ,Parsing ,Stochastic grammars and applications ,Graph based structural representation. **Stochastic method:** Reinforcement Learning.

***Exemplar/Case Studies**	Case Study on spoken word recognition
***Mapping of Course Outcomes for Unit III**	CO3

Unit IV	**Clustering:**	**08 Hours**

Introduction, Hierarchical Clustering, agglomerative clustering algorithm, the single linkage, **complete, linkage and average, linkage algorithm. Ward's method ,Partition clustering** , K- means algorithm, clustering algorithms based on graph theory(Minimum spanning tree algorithm),Optimization methods used in clustering: clustering using simulating Annealing

***Exemplar/Case Studies**	Case Study on disease recognition from a list of symptoms
***Mapping of Course Outcomes for Unit IV**	CO1

Unit V	**Template Matching and Unsupervised Learning**	**07 Hours**

Measures based on Optimal Path Searching **techniques: Bellman's optimality principle and** dynamic programming. The Edit distance, Dynamic time Warping, Measures based on correlations, Deformable template models.

***Exemplar/Case Studies**	Pattern recognition in time series database: A case study on financial database.
***Mapping of Course Outcomes for Unit V**	CO4

Unit VI	**Fuzzy Logic and Pattern Recognition**	**07 Hours**

Fuzzy logic,Fuzzy pattern classifiers, Pattern classification using Genetic Algorithms Pattern recognition applications: Application of pattern recognition techniques in object recognition, biometrics, facial recognition, IRIS scanner, Finger prints, 3D object recognition

Exemplar/Case Studies	Study of fingerprint recognition
Mapping of Course Outcomes for Unit VI	CO5

Learning Resources

Text Books:

1. R. O. Duda, P. E. Hart, D. G. Stork, "Pattern Classification", 2nd Edition, Wiley-Inter- science, John Wiley &Sons, 2001
2. S. Theodoridis and K. Koutroumbas, "Pattern Recognition", 4th Edition, Elsevier Academic Press, ISBN: 978-1-59749-272-0
3. B.D. Ripley, "Pattern Recognition and Neural Networks", Cambridge University Press, ISBN 0-521-46086-7

Reference Books:

1. Dave V. S., Murty, M. N. (2011) Pattern Recognition: An Introduction, Universities Press, Hyderabad.
2. David G. Stork and Elad Yom-Tov, "Computer Manual in MATLAB to accompany Pattern Classification", Wiley Inter-science, 2004, ISBN-10: 0471429775
3. Malay K. Pakhira, "Digital Image Processing and Pattern Recognition", PHI, ISBN-978-81-203-4091-6
4. eStudio at NPTEL: http://nptel.ac.in/courses/106106046/

e-Books::

1. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.720.4987&rep=rep1&type=pdf
2. https://ashutoshtripathi.com/files/2018/07/10732_TOC.pdf
3. https://computer.howstuffworks.com/pattern-recognition1.htm
4. https://mathfirst.com/docs/download/pattern-recognition-and-machine-learning.pdf

MOOC Courses Links:

- https://nptel.ac.in/courses/117105101/

The CO-PO Mapping Matrix

Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
Elective VI
410253(8): Soft Computing

Teaching Scheme:	Credit	Examination Scheme:
TH: 03 Hours/Week	03	In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Prerequisite Courses: Computer Graphics(210244)
Companion Course: Laboratory Practice VI(410255)

Course Objectives:

- To study the various soft computing approaches.
- To understand the soft computing techniques and algorithms for problem solving
- To be familiar with the various application areas of soft computing.
- To apply the soft computing techniques for developing intelligent systems
- To Explore and solve problems using genetic Algorithms.
- To Understand hybrid systems paradigm and Application Areas of Soft Computing

Course Outcomes:

On completion of the course, student will be able to–

CO1: Understand requirement of soft computing and be aware of various soft computing techniques.
CO2: Understand Artificial Neural Network and its characteristics and implement ANN algorithms
CO3: Understand and Implement Evolutionary Computing Techniques
CO4: Understand the Fuzzy logic and Implement fuzzy algorithms for solving real life problems
CO5: Apply knowledge of Genetic algorithms for problem solving.
CO6: Develop hybrid systems for problem solving

Course Content:

Unit I — Introduction To Soft Computing — 07 Hours

Introduction to Soft Computing and Computational Intelligence. Characteristics of Soft computing, Comparison Soft Computing Vs Hard Computing, Requirements of Soft Computing. Soft Computing Techniques – Artificial Neural Network, Fuzzy Logic, Evolutionary computing and
Hybrid systems, Applications of Soft Computing

Examples/Case Studies

1. Study of Soft Computing techniques for Waste Water Management
2. Study of IBM Research Neuro-symbolic AI- a new look for neuromorphic computing

Mapping of Course Outcomes for Unit

CO1

Unit II	Artificial Neural Network	07 Hours

Neuron, Nerve structure and synapse, Artificial Neuron and its model, activation, functions, Neural network architecture: single layer and multilayer feed forward networks, recurrent networks. Various learning techniques, perception and convergence rule, Auto-associative and hetro-associative memory, perception model, single layer artificial neural network, multilayer perception model: back propagation learning methods, effect of learning rule coefficient, back propagation algorithm, factors affecting backpropagation training, applications.

#Exemplar/Case Studies	Study of Handwriting recognition using ANN.
***Mapping of Course Outcomes for Unit II**	CO2

Unit III	Evolutionary Computing	07 Hours

Problem Solving as A Search Task, Hill Climbing And Simulated Annealing, Evolutionary Computing, Evolution Strategies, Evolutionary Programming, Genetic Programming, Selected Applications From The Literature: A Brief Description, Scope Of Evolutionary Computing, Introduction to Evolutionary Single-Objective Optimization, Particle Swarm Optimization: Introduction, inspiration, mathematical model, standard and binary PSO. Artificial hummingbird algorithm.

#Exemplar/Case Studies	Study of Engineering application of Artificial hummingbird algorithm
***Mapping of Course Outcomes for Unit III**	CO3

Unit IV	Fuzzy logic	08 Hours

Introduction to Fuzzy Logic, Classical Set, Fuzzy Set- Introduction, Operations on classical sets, properties of classical sets, fuzzy set operations, properties of fuzzy sets, Classical Relation, Fuzzy Relation, **Fuzzy Inference process** – Membership functions, Fuzzification, Membership value Assignment- Inference, Rank ordering, defuzzification – Weighted Average Method, Mean-Max Membership, Fuzzy Bayesian Decision Making, **Developing a Fuzzy Control** – System Architecture and Operation of FLC System, FLC System Models, Application of FLC System

#Exemplar/Case Studies	Study of Object Detection Robot Using Fuzzy Logic Controller
***Mapping of Course Outcomes for Unit IV**	CO4

Unit V	Genetic Algorithm	07 Hours

Introduction To Basic Terminologies in Genetic Algorithm: Individuals, Genes, Fitness, Populations; **Simple GA; General Genetic Algorithm; Operators in Genetic Algorithm;** Encoding, Selection, Crossover (Recombination), Mutation; **Stopping Condition for GA Flow; Constraints in Genetic Algorithms; Problem Solving Using Genetic Algorithm; Holland Classifier System:** The Production System, The Bucket Brigade Algorithm and Rule Generation; **Advantages and Limitations of Genetic Algorithms; Applications of Genetic Algorithms.**

#Exemplar/Case Studies	Use Genetic Algorithm to design a solution to the Traveling Salesman Problem. **Solution** 1. Use Permutation Encoding 2. Define Objective Function. 3. Apply Selection Method 4. Crossover 5. Mutation 6. Repeat until stopping criteria is met. 7.Stop
***Mapping of Course Outcomes for Unit V**	CO5

Unit VI	Hybrid System and Application Areas of Soft Computing	07 Hours

Hybrid System towards comprehensive Soft Computing: The hybrid systems paradigm, Hybrid connectionist production systems, Hybrid connectionist logic programming systems, Hybrid fuzzy connectionist production systems, Hybrid systems for speech and language processing, Hybrid systems for decision making.

Application Areas of Soft Computing: Fuzzy-filtered Neural Networks-Plasma Spectrum Analysis, Hand-written Numeral Recognition, Fuzzy sets and Genetic Algorithms in Game Playing, Soft Computing for Color Recipe Prediction.

#Exemplar/Case Studies Study of Hybrid models for disease prediction.

***Mapping of Course Outcomes for Unit VI** CO6

Learning Resources

Text Books:

1. S.N. Sivanandam, "**Principles of Soft Computing**", Wiley India. ISBN: 9788126527274(1)
2. Jyh-Shing Roger Jang, Chuen-**Tsai Sun, Eiji Mizutani, "Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence"**, Prentice Hall, ISBN: 978-0132610667
3. L. N. de Castro, "Fundamentals of Natural Computing: Basic Concepts, Algorithms, and Applications", 2006, CRC Press, ISBN-13: 978-1584886433 (Chapter 3)
4. S.Rajasekaran and G. A. Vijayalakshmi Pai, "**Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications**", Prentice Hall of India

Reference Books

Reference Books :

1. Nikola K. Kasabov "Foundations of Neural Networks, Fuzzy Systems and Knowledge Engineering", MIT Press, ISBN: 978-0-262-11212-3
2. Swagatam Mirjalili, Evolutionary Algorithms and Neural Networks Theory and Applications, Studies in Computational **Intelligence**", Vol 780, Springer, 2010, ISBN 978-3-319-93024-4
3. Timothy J. Ross, "**Fuzzy Logic with Engineering Applications**", Wiley India. ISBN: 978-0-470-74376-8

e-Books::

1. https://kanopy.bibliu.com/files/sandipcoe.com/2016/01/gnu-cobc-3006.pdf
2. http://www.dubstat.ac.in/sdnaitFiles/ComputIntelligenceBook.pdf
3. https://dl.dsu.ac.kr/Files/%D9%89%D9%AF%20%D9%8A%D9%88%D8%B3%D9%AA%20%D9%8A%D8%B3%D9%AA%D8%B1%D8%A7%D9%AA%D8%AC%D8%AF/Fuzzy%20logic%20and%20Neural%20Networks%20Application%20Examples.pdf
4. http://www.cookcliff.edu.pk/01_Sami/soft%20Computing.pdf
5. https://www.cengage.com/cgi-wadsworth/course_products_wp.pl?fid=M20b&product_isbn_issn=9780534376887&discipline_number=22&c2theme=0

MOOC Courses Links :

- NPTEL Course – Introduction of Soft Computing, IIT Kharagpur by Prof. Debidas Samantahttps://nptel.ac.in/courses/106105173
- NPTEL Course – Neural Network and Applications, IIT Kharagpur by Prof. Somnath Sengupta https://nptel.ac.in/courses/117105084
- NPTEL Course – Fuzzy Logic and Neural Networks, IIT Kharagpur by Dilip Kumar Pratihar https://nptel.ac.in/courses/127105006

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CO1	3	2	1	2	-	1	-	-	-	-	-	1
CO2	3	2	2	3	1	2	-	-	-	-	-	2
CO3	3	2	2	3	1	2	-	-	-	-	-	2
CO4	3	2	2	3	1	2	-	-	-	-	-	2
CO5	3	2	2	3	1	2	-	-	-	-	-	2
CO6	3	2	2	3	1	2	-	-	-	-	-	3



Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
410253A: Elective-VI Business Intelligence

Teaching Scheme:	Credit:	Examination Scheme:
TH: 03	03	Mid-Semester (TH) : 30 Marks
Hours/Week		End-Sem (TH): 70 Marks

Prerequisites Courses: 310241: Database Management System,310251:Data Science & Big data Analytics,410242: Machine Learning

Companion Course: 410256:Laboratory Practice VI

- **Course Objectives:**

1. To introduce the concepts and components of Business Intelligence (BI)
2. To evaluate the technologies that make up BI (data warehousing, OLAP)
3. To identify the technological architecture of BI systems
4. To explain different data preprocessing techniques
5. To identify machine learning model as per business need
6. To understand the BI applications in marketing, logistics, finance and telecommunication sector

- **Course Outcomes:** On completion of this course, the students will be able to

CO1: Differentiate the concepts of Decision Support System & Business Intelligence
CO2:Use Data Warehouse & Business Architecture to design a BI system
CO3:Build graphical reports
CO4:Apply different data preprocessing techniques on dataset
CO5:Implement machine learning algorithms as per business needs
CO6:Identify role of BI in marketing, logistics, and finance and telecommunication sector

Course Contents

Unit I	Introduction to Decision support systems and Business intelligence	07 Hours

Decision support systems: Definition of system, representation of the decision-making process, evolution of information systems, Decision Support System, Development of a decision support system, the four stages of Simon's decision-making process, and common strategies and approaches of decision makers

Business Intelligence: BI, its components & architecture, previewing the future of BI, ending a better experience for all business users, End user assumptions, setting up data for BI, data, information and knowledge, The role of mathematical models, Business intelligence architectures, Ethics and business intelligence

***Exemplar/Case Studies**	Decision support system in business intelligence: https://www.afcerlogic.com/blog/five-decision-support-system-examples
***Mapping of Course Outcomes for Unit I**	CO1

Unit II	The Architecture of DW and BI	07 Hours

BI and DW architectures and its types - Relation between BI and DW - OLAP (Online analytical processing) definitions - Different OLAP Architectures-Data Models-Tools in Business Intelligence-Role of DSS, EIS, MIS and digital Dash boards – Need for Business Intelligence.

Difference between OLAP and OLTP - Dimensional analysis - What are cubes? Drill-down and roll-up - slice and dice or rotation - OLAP models / ROLAP versus MOLAP – defining schemas: Stars, snowflakes and fact constellations.

*Exemplar/Case Studies	A case study on Retail Industry : https://www.ukessays.com/essays/retail/data-warehouse-retail-industry-case-study-essay.php
*Mapping of Course Outcomes for Unit II	CO2

Unit III	Reporting Authoring	07 Hours

Building reports with relational vs Multidimensional data models. Types of Reports – List, crosstabs, Matrices, Chart, map, financial etc. Data Grouping & Sorting, Filtering Reports, Adding Calculations to Reports, Conditional formatting, Adding Summary Lines to Reports. Drill up, drill- down, drill-through capabilities. Run or schedule report, different output forms – PDF, excel, csv, xml etc.

*Exemplar/Case Studies	Power BI Case Study – How the world's most Successful Brands of Healthcare & Fitness: https://data-flair.training/blogs/power-bi-case-study/
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	Data preparation	07 Hours

Data validation: Incomplete data , Data affected by error. **Data transformation**: Standardization , Feature extraction. **Data reduction** : Sampling, Feature selection, Principal component analysis, Data discretization. **Data exploration** : **1.Univariate analysis** :Graphical analysis of categorical attributes ,Graphical analysis of numerical attributes , Measures of central tendency for numerical attributes , Measures of dispersion for numerical attributes, Identification of outliers for numerical attributes **2.Bivariate analysis**: Graphical analysis , Measures of correlation for numerical attributes , Contingency tables for categorical attributes, **3.Multivariate analysis**: Graphical analysis , Measures of correlation for numerical attributes

*Exemplar/Case Studies	Case study on Data preparation phase of BI system https://blog.panoply.io/load-and-transform-how-to-prepare-your-data-for-business-intelligence
*Mapping of Course Outcomes for Unit IV	CO4

Unit V	Impact of Machine learning in Business Intelligence Process	07 Hours

Classification: Classification problems, Evaluation of classification models, Bayesian methods, Logistic regression. **Clustering:** Clustering methods, Partition methods, Hierarchical methods, Evaluation of clustering models. **Association Rule:** Structure of Association Rule, Apriori Algorithm

*Exemplar/Case Studies	Business applications for comparing the performance of a stock over a period of time. https://chartist.io/stock-market-analysis/
*Mapping of Course Outcomes for Unit V	CO5

Unit VI	BI Applications	07 Hours

Tools for Business Intelligence, Role of analytical tools in BI, Case study of Analytical Tools: WEKA, KNIME, Rapid Miner, R.

Data analytics, Business analytics, ERP and Business Intelligence, BI and operation management, BI in inventory management system, BI and human resource management, BI Applications in CRM, BI Applications in Marketing, BI Applications in Logistics and Production, Role of BI in Finance, BI Applications in Banking, BI Applications in Telecommunications, BI in salesforce management

*Exemplar/Case Studies	Logistics planning in the food industry https://www.4intelligence.com/case-studies https://www.clustdatamining.com/food-distribution-case-study
*Mapping of Course Outcomes for Unit: VI	CO6

Learning Resources

Text Books:

1. Fundamentals of Business Intelligence, Grossmann W, Rinderle-Ma, Springer,2015
2. R. Sharda, D. Delen, & E. Turban, Business Intelligence and Analytics: Systems for Decision Support, 10th Edition, Pearson Prentice Hall, 2015

Reference Books :

1. PrajaPrentice, "Data Warehousing Fundamentals", John Willey
2. Introduction to business Intelligence and data warehousing, IBM, PHI
3. Business Intelligence: Data Mining and Optimization for Decision Making, Carlo Vercellis, Wiley,2010
4. Data Mining for Business Intelligence, WILEY
5. EMC Educational Services, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, Wiley ISBN-13:978-1118876138
6. Ken W. Collier, Agile Analytics: A value driven Approach to Business Intelligence and Data Warehousing, Pearson Education,2012. ISBN-13:978-0321788828

e-Books :

1. https://www.kimballgroup.com/wp-content/uploads/2013/08/Kimball_Group_Data_Warehousing_Fundamentals_Intro_Course_KNIME_guidebook.pdf
2. www.cs.ccsu.edu/~markov/weka-tutorial.pdf
3. http://www.bwmodeshop.com/Magnitude_Clinic_EMC_Notes/html/data%20science%20and%20big%20data%20analytics%20-%20discovering,%20analyzing,%20visualizing%20and%20presenting%20data.pdf
4. https://downloads.hindawi.com/journals/jhe/2016/3791061.f3-000017919x-00023596x26.pdf

NPTEL/YouTube video lecture links:

- Business Analytics for management decision : https://nptel.ac.in/courses/110105089
- Business analytics and data mining modeling using R : https://nptel.ac.in/courses/110107092
- Business Analysis for Engineers : https://nptel.ac.in/courses/110106050

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	1	2	-	-	-	-	-	-	-
CO2	1	1	1	1	1	-	-	-	-	-	-	-
CO3	1	2	1	1	1	-	-	-	-	-	-	-
CO4	2	2	2	1	1	-	-	-	-	-	-	-
CO5	2	2	2	2	1	-	-	-	-	-	-	-
CO6	-	1	-	1	1	-	-	-	-	-	-	-

Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
410353(D) Quantum Computing

Teaching Scheme:	Credit	Examination Scheme:
TH: 03 Hours/Week	03	In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Prerequisite Course: Data Structures and Algorithms(210254), Data Science and Big Data Analytics (310251)
Companion Course: Laboratory Practice IV (410247)

Course Objectives:

- To provide introduction and necessary expertise to the learner in the upcoming discipline of Quantum Computing and Machine Learning.
- To enable the students to learn Quantum Computing and Quantum Machine Learning in practical-oriented learning sessions so that he/she can independently use existing open-source Quantum Computing Hardware and Software Frameworks
- To teach the students to develop hybrid solutions by applying Quantum Machine Learning to potential business application areas.
- To study Quantum Information Theory and Quantum Computing Programming Model of Computation.
- To study Quantum Algorithms and apply these to develop hybrid solutions.
- To study Quantum Concepts necessary for understanding the Quantum Computing Paradigm and compare the available hardware and software infrastructure and frameworks made available open source by major players in the Industry and Academia.

Course Outcomes:

On completion of the course, student will be able to–
CO1: To understand the concepts of Quantum Computing
CO2: To understand and get exposure to mathematical foundations and quantum mechanics
CO3: To understand and implement basic building blocks of Quantum circuits.
CO4: To understand quantum information, its processing and Simulation tools.
CO5: To understand basic signal processing algorithms FT, DFT and FFT
CO6 : To study and solve examples of Quantum Fourier Transforms and their applications

Course Content:

Unit I — Introduction to Quantum Computing — 07 Hours

Fundamental Concepts of Quantum computing:
Introduction and Overview, Global Perspective, Quantum Bits, Quantum Computation, Quantum Algorithms, Quantum information and Quantum information processing.

Mapping of Course Outcomes for Unit I: CO1

Unit II — Mathematical Foundation of Quantum Computing — 07 Hours

Quantum Mechanics
Linear Algebra and Quantum mechanics, Postulates of Quantum mechanics, state space, evolution, Quantum measurement, distinguishing quantum states, projective measurements, POVM measurements, Phase, Composite systems, Global view and applications, Density operator

***Mapping of Course Outcomes for Unit II**	CO2

Unit III	Building Blocks for Quantum Program	07 Hours

Quantum Computations: Quantum circuits, Quantum algorithms and qubit operations, Controlled operations, Principal deferred and Principal implicit Measurements, Universal Quantum Gates, Two level unitary gates, single qubit and CNOT , discrete set of universal operations, Quantum computational complexity

***Mapping of CourseOutcomes for Unit III**	CO3

Unit IV	Quantum Simulation Algorithms and Fourier Transform	07 Hours

Simulation of Quantum Systems, Simulation in action,exponential complexity growth of quantum systems., Quantum simulation algorithm, examples of quantum simulations, perspectives of quantum simulation,

Understanding Basics of Fourier transform, Discrete Fourier Transform, Fast Fourier Transform, Definitions, mathematical representations of FT, DFT and FFT

***Mapping of CourseOutcomes for Unit IV**	CO3,CO4

Unit V	Quantum Fourier Transform and Applications	07 Hours

Quantum Fourier Transform., Phase estimation performance and requirements, order finding application, factoring application, General applications of Quantum Fourier transform, period finding, discrete algorithms, Other Quantum Algorithms.

***Mapping of CourseOutcomes for Unit V**	CO5

Unit VI	Quantum Machine Learning	07 Hours

Quantum Machine Learning and Quantum AI, Quantum Neural Networks, Quantum Natural Language Understanding, Quantum Cryptography, Application Domains for Quantum Machine Learning: Chemistry/Material Science, Space Tech, Finance related Optimization Problems, Smart Robotics, Cyber security

***Mapping of CourseOutcomes for Unit VI**	CO6

Learning Resources

Text Books:

1. Michael A. Nielsen, "Quantum Computation and Quantum Information", Cambridge University
2. Wittek, "Quantum Machine Learning (What Quantum Computing Means to Data Mining)", Peter University of Boras, Sweden - Elsevier Publications
3. Andreas Wichert, "Principles of Quantum Artificial Intelligence",Institute Superior Técnico - Universidade de Lisboa, Portugal - World Scientific Publishing, British Library Cataloguing-in-Publication Data

Reference Books:

1. Prem Stephen Kan, "Metrics and Models in Software Quality Engineering", Pearson, ISBN-10: 0133988002, ISBN-13: 978-0133988006
2. Michael A. Nielsen, "Quantum Computation and Quantum Information", Cambridge University Press Stephen Kan, "Metrics and Models in Software Quality Engineering", Pearson, ISBN-10: 0133988002, ISBN-13: 978-0133988006
3. David McMahon, "Quantum Computing Explained", Wiley
4. Microsoft Quantum Development Kit https://www.microsoft.com/en-us/quantum/development-kit Forest SDK PyQuil: https://pyquil.readthedocs.io/en/stable/
5. Amazon Bracket Documentation on AWS https://www.amazon.com/bracket/ 7 D-Wave Systems Documentation: https://docs.dwavesys.com/docs/latest/index.html

e-Books :

1. http://www.amss.cas.cn/tlb/201702/W020170224608149940043.pdf
2. http://www.amss.cas.cn/tlb/201702/W020170224608150244118.pdf

MOOC Courses Links:

1. https://online.cours.ipt.ac.in/wsa21_ca19/preview
2. https://www.coursera.org/learn/introduction-to-quantum-information

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	2	2	-	-	-	2	-	2	2
CO2	1	3	3	2	3	-	-	-	2	-	2	-
CO3	1	3	3	2	3	-	-	-	2	-	2	-
CO4	1	3	3	2	3	-	-	-	2	-	2	-
CO5	1	3	3	2	3	-	-	-	-	-	2	1
CO6	3	2	1	3	1	-	-	-	-	-	-	-

Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
Elective II
410253(E): Open Elective

Teaching Scheme:	Credit	Examination Scheme:
TH: 03Hours/Week	03	In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Companion Course: Laboratory Practice VI (410254)

The open elective included, so as to give the student a wide choice of subjects from other Engineering Programs. To inculcate the out of box thinking and to feed the inquisitive minds of the learners the idea of open elective is need of the time.

Flexibility is extended with the choice of open elective allows the learner to choose interdisciplinary courses/latest technology related courses to expand the knowledge horizons.

With this idea learner opts for the course without any boundaries to choose the approved by academic council and Board of Studies.



Savitribai Phule Pune University
Name
Fourth Year of Computer Engineering (2019 Course)
410255: Laboratory Practice V

Teaching Scheme:	Credit	Examination Scheme:
Practical: 2 Hours/Week	01	Term Work: 50 marks Practical: 50 Marks

Companion Course: High Performance Computing(410250), Deep Learning(410251)

Course Objectives:

- To understand and implement searching and sorting algorithms.
- To learn the fundamentals of GPU Computing in the CUDA environment.
- To illustrate the concepts of Artificial Intelligence/Machine Learning(AI/ML).
- To understand Hardware acceleration.
- To implement different deep learning models.

Course Outcomes:

CO1: Analyze and measure performance of sequential and parallel algorithms.
CO2: Design and Implement solutions for multicore/Distributed parallel environment.
CO3: Identify and apply the suitable algorithm to solve AI/ML problems.
CO4: Apply the technique of Deep Neural network for implementing Linear regression and classification.
CO5: Apply the technique of Convolution (CNN) for implementing Deep Learning models.
CO6: Design and develop Recurrent Neural Network (RNN) for prediction.

Guidelines for Instructor's Manual

Laboratory Practice V is for practical hands on for more towards High Performance Computing and Deep Learning. The instructor's manual is to be developed as a hands-on resource and as ready reference. The instructor's manual need to include prologue (about University/program/institute/department/foreword/ preface etc), University syllabus, conduction and Assessment guidelines, topics under consideration-concept, objectives, outcomes, set of typical applications/assignments/ guidelines, references among others.

Guidelines for Student's Laboratory Journal

The laboratory assignments are to be submitted by student in the form of journal. Journal may

consists of prologue, Certificate, table of contents, and handwritten write-up of each assignment (Title, Objectives, Problem Statement, Outcomes, software and Hardware requirements, Date of Completion, Assessment grade/marks and assessor's sign, Theory- Concept in brief, Algorithm/Database design, test cases, conclusion/analysis). Program codes with sample output of all performed assignments are to be submitted as softcopy.

Guidelines for Laboratory /Term Work Assessment

Continuous assessment of laboratory work is to be done based on overall performance and lab assignments performance of student. Each lab assignment assessment will assign grade/marks based on parameters with appropriate weightage. Suggested parameters for overall assessment as well as each lab assignment assessment include- timely completion, performance, innovation, efficient codes, punctuality and neatness reserving weightage for successful mini-project completion and related documentation.

Guidelines for Practical Examination

- Both internal and external examiners should jointly frame suitable problem statements for practical examination based on the term work completed.
- During practical assessment, the expert evaluator should give the maximum weightage to the satisfactory implementation of the problem statement.
- The supplementary and relevant questions may be asked at the time of evaluation to test the **student's for advanced learning, understa**tanding of the fundamentals, effective and efficient implementation.
- Encouraging efforts, transparent evaluation and fair approach of the evaluator will not create any uncertainty or doubt in the minds of the students. So adhering to these principles will communicate our team efforts to the promising boost to the student's academics.

Guidelines for Laboratory Conduction

- List of recommended programming assignments and sample mini-projects is provided for reference.
- Referring these, Course Teacher or Lab Instructor may frame the assignments/mini-project by understanding the prerequisites, technological aspects, utility and recent trends related to the respective courses.
- Preferably there should be multiple sets of assignments/mini-project and distribute among batches of students.
- Real world problems/application based assignments/mini-projects create interest among learners serving as foundation for future research or startup of business projects.
- Mini-project can be completed in group of 2 to 3 students.

- Software Engineering approach with proper documentation is to be strictly followed.
- Use of open source software is to be encouraged.
- Instructor may also set one assignment or mini-project that is suitable to respective course beyond the scope of syllabus.

Operating System recommended :- 64-bit Open source Linux or its derivative

Programming Languages: Object Oriented Languages

C++/JAVA/PYTHON/R

Programming tools recommended: Front End: Java/.Net/PHP/Python/Ruby on rails Backend: Mongo DB/MYSQL/Oracle. Database Connectivity : ODBC/JDBC

Suggested List of Laboratory Experiments/Assignments

410255: High Performance Computing

Any 4 Assignments and 1 Mini Project is Compulsory

Group 1

1.	Design and implement Parallel Breadth First Search and Depth First Search based on existing algorithms using OpenMP. Use a Tree or an undirected graph for BFS and DFS .
2.	Write a program to implement Parallel Bubble Sort and Merge sort using OpenMP. Use existing algorithms and measure the performance of sequential and parallel algorithms.
3.	Implement Min, Max, Sum and Average operations using Parallel Reduction.
4.	Write a CUDA Program for 1. Addition of two large vectors 2. Matrix Multiplication using CUDA C
5.	Implement HPC application for AI/ML domain.

Group 2

6.	Mini Project: Evaluate performance enhancement of parallel Quicksort Algorithm using MPI
7.	Mini Project: Implement Huffman Encoding on GPU
8.	Mini Project: Implement Parallelization of Database Query optimization
9.	Mini Project: Implement Non-Serial Polyadic Dynamic Programming with GPU Parallelization

410251: Course Code : Deep Learning

Any 5 Assignments and 1 Mini Project is Compulsory

Group 1

1.	Linear regression by using Deep Neural network: Implement Boston housing price prediction problem by Linear regression using Deep Neural network. Use Boston House price prediction dataset.
2.	**Classification using Deep neural network** (Any One from the following) 1. Multiclass classification using Deep Neural Networks Example: Use the OCR letter recognition dataset https://archive.ics.uci.edu/ml/datasets/letter+recognition 2. Binary classification using Deep Neural Networks Example: Classify movie reviews into positive" reviews and "negative" reviews, just based on the text content of the reviews. Use IMDB dataset
3.	Convolutional neural network (CNN) (Any One from the following) • Use any dataset of plant disease and design a plant disease detection system using CNN. • Use MNIST Fashion Dataset and create a classifier to classify fashion clothing into categories.
4.	**Recurrent neural network (RNN)**: Use the Google stock prices dataset and design a time series analysis and prediction system using RNN.
Group 2	
5.	Mini Project: Human Face Recognition
6.	Mini Project: Gender and Age Detection: predict if a person is a male or female and also their age
7.	Mini Project: Colorizing Old B&W Images: color old black and white images to colorful images.

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	1	1	-	2	1	-	-	-	-	-
CO2	1	2	1	-	-	1	-	-	-	-	-	1
CO3	-	1	1	1	1	1	-	-	-	-	-	-
CO4	1	1	1	-	1	-	-	-	-	-	-	-
CO5	1	1	1	1	1	-	-	-	-	-	-	-
CO6	1	1	1	1	1	-	-	-	-	-	-	-
CO7	1	1	1	1	1		-	-	-	-	-	-

Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
410256: Laboratory Practice VI

Teaching Scheme Practical: 02 hours/Week	Credit 01	Examination Scheme and Marks Term Work: 50 Marks

Companion Course: Elective Courses 410252, 410253

Course Objectives:

- To understand the fundamental concepts and techniques of natural language processing (NLP)
- To understand Digital Image Processing Concepts
- To learn the fundamentals of software definedsetworks
- Explore the knowledge of adaptive filtering and Multi-rate DSP
- To be familiar with the various application areas of soft computing
- To introduce the concepts and components of Business Intelligence (BI)
- To study Quantum Algorithms and apply these to develop hybrid solutions

Course Outcomes:

On completion of this course, the students will be able to

CO1: Apply basic principles of elective subjects to problem solving and modeling.

CO2: Use tools and techniques in the area of software development to build mini projects.

CO3: Design and develop applications on subjects of their choice.

CO4: Generate and manage deployment, administration & security.

Guidelines for Instructor's Manual

List of recommended programming assignments and sample mini-projects is provided for reference. Referring to these, Course Teacher or Lab Instructor may frame the assignments/mini-project by understanding the prerequisites, technological aspects, utility and recent trends related to the respective courses. Preferably there should be multiple sets of assignments/mini-project and distributed among batches of students. Real world problems/application based assignments/mini-projects create interest among learners serving as foundation for future research or startup of business projects. Mini-project can be completed in group of 2 to 3 students. Software Engineering approach with proper documentation is to be strictly followed. Use of open source software is to be encouraged. Instructor may also set one assignment or mini-project that is suitable to the respective course beyond the scope of syllabus.

Operating System recommended :- 64-bit Open source Linux or its distribution. **Programming Languages**: C/C++/JAVA/PYTHON/R

Programming tools recommended: Front End: Java/Perl/PHP/Python/Ruby/.net; **Backend**: MongoDB/MYSQL/Oracle; Database Connectivity: ODBC/JDBC; **Additional Tools**: Octave, Matlab, WEKA/gnuplot.

Guidelines for Student's Laboratory Journal

The laboratory assignments are to be submitted by students in the form of a journal. Journal may consists of prologue, Certificate, table of contents, and handwritten write-up of each assignment (Title, Objectives, Problem Statement, Outcomes, software and Hardware requirements, Date of Completion, Assessment grade/marks and assessor's sign, Theory- Concept in brief, Algorithm/Database design, test cases, conclusion/analysis). Program codes with sample output of all performed assignments are to be submitted as softcopy.

As a continuous effort and little contribution towards Green IT and environment awareness, printing printed papers as part of write-ups and program listing to journal may be avoided. Use of digital storage media/DVD containing students programs maintained by lab In-charge is highly encouraged. For reference one or two journals may be maintained with program prints at Laboratory.

Guidelines for Laboratory /Term Work Assessment

Continuous assessment of laboratory work is to be done based on overall performance and lab Home

Faculty of Engineering, Savitribai Phule Pune University

Syllabus for Fourth Year of Computer Engineering assignments performance of student. Each lab assignment assessment will assign grade/marks based on parameters with appropriate weightage. Suggested parameters for overall assessment as well as each lab assignment assessment include- timely completion, performance, innovation, efficient codes, punctuality and neatness reserving weightage for successful mini-project completion and related documentation.

Guidelines for Practical Examination

It is recommended to conduct examination based on Mini-Project(s) Demonstration and related skill learned. Team of 2 to 3 students may work on mini-project. During the assessment, the expert evaluator should give the maximum weightage to the satisfactory implementation and software engineering approach followed. The supplementary and relevant questions may be asked at the time of evaluation to **test the student's for advanced learning, understanding, effective** and efficient implementation and demonstration skills. Encouraging efforts, transparent evaluation and fair approach of the evaluator will not create any uncertainty or doubt in the minds of the students. So adhering to these principles will consummate our team efforts to the promising start of the student's academics.

Guidelines for Laboratory Conduction

The instructor's manual is to be developed as a hands-on resource and as ready reference. The instructor's manual need to include prologue (about University/program/institute/department/foreword/preface etc), University syllabus, conduction and Assessment guidelines, topics under consideration: concept, objectives, outcomes, set of typical applications/assignments/ guidelines, references among others.

PART-I: 410252 : Elective V

Recommended : Sample set of assignments and mini projects for reference for four courses offered for Elective III and for four courses offered for Elective IV. Respective Student has to complete laboratory work for elective III and IV that he/she has opted.

410252(A) : Natural Language Processing

Any 4 Assignments and 1 Mini Project is Compulsory

Group I

1.	Perform tokenization (Whitespace, Punctuation-based, Treebank, Tweet, MWE) using nltk library. Use porter stemmer and snowball stemmer for stemming. Use any technique for lemmatization. **Input : Dataset –use any sample sentence**
2	Perform bag-of-words approach (count occurrence, normalized term occurrence, tf-idf) on data. Create embeddings using Word2Vec. **Dataset to be used:** https://www.kaggle.com/datasets/CooperUnion/cardataset
3	Perform text cleaning, perform lemmatization (any method), remove stop words (any method), label encoding. Create representations using TF-IDF. Save outputs. **Dataset: https://github.com/PICT-NLP/BE-NLP-Elective/blob/main/3-Preprocessing/News_dataset.pickle**
4	Create a transformer from scratch using the Pytorch library.

5	Morphology is the study of the way words are built up from smaller meaning bearing units. Study and understand the concepts of morphology by the use of add-delete table
6	Mini Project (Fine tune transformers on your preferred task) Fine tune a pretrained transformer for any of the following tasks on any relevant dataset of your choice: • Neural Machine Translation • Classification • Summarization

Virtual Lab: https://nlp-iitbh.vlabs.ac.in

410252(B) : Image Processing

Any 5 Assignments and 1 Mini Project is Compulsory

Group 1

Implement any five assignments from 1 to 7. Assignment no. 8 is compulsory within a group of 2 to 3 students.
Programming language: Python/C/C++ using OpenCV

1	Consider any image with size 1024*1024. Modify the image to the sizes 512*512, 256*256, 128*128, 64*64 and 32*32 using subsampling technique. Create the original image from all the above subsampled images using resampling technique. Read any image. Display the histogram, Equalized histogram, and image with equalized histogram.
2	Consider any image with size 1024*1024. Modify the image to the sizes 512*512, 256*256, 128*128, 64*64 and 32*32 using subsampling technique. Create the original image from all the above subsampled images using resampling technique.
3	Read any image. Display the histogram, Equalized histogram, and image with equalized histogram.
4	Read any image. Display the outputs of contrast stretching, intensity level slicing.
5	Compare the results of any three edge detection algorithms on the same image dataset and do the analysis of the result.
6	Compare the result of any two image segmentation algorithm on the same image data set.
7	Write a program for image compression using any three compression techniques and compare the results.

Group 2:

8	Mini project: Implement visual surveillance applications and detect moving objects using object detection and tracking algorithm Or Implement any medical image processing application for freely available medical image dataset

410252(C) : Software Defined Networks

Any 3 Assignments and 1 Mini Project is Compulsory

Group 1

1.	Prepare setup for Mininet network emulation environment with the help of Virtualbox and Mininet. Demonstrate the basic commands in Mininet and emulate different custom network topology(Simple, Linear, and Tree) View flow tables.
2	After studying open source POX and Floodlight controller, Install controller and run custom topology using remote controller like POX and floodlight controller. Recognize inserted flows by controllers.
3	Create a SDN environment on Mininet and configure a switch to provide a firewall functionality using POX controller. Ref: https://github.com/mininet/openflow-tutorial/wiki/Create-Firewall
4	Using Mininet as an Emulator and POX controller: build your own internet router. Write simple router with a static routing table. The router will receive raw Ethernet frames and process the packet forwarding them to correct outgoing interface. You must check the Ethernet frames are received and the forwarding logic is created so packets go to the correct interface. Ref:https://github.com/mininet/mininet/wiki/SimpleRouter
5	Emulate and manage a Data Center via a Cloud Network Controller: create a multi-rooted tree like (Clos) topology in Mininet to emulate a data center. Implement specific SDN applications on top of the network controller in order to orchestrate multiple network tenants within a data center environment, in the context of network virtualization and management. Ref:https://openconnect.uoc.gr/courses/plugin/file.php/1337/mod_resource/content/2/exercise5.pdf
6	Study Experiment: Study in details CloudS ecfs automates IaaS using SDN and a high-performance network from Juniper SDN Framework.

410252(D) : Advanced Digital Signal Processing

Any 5 Assignments and 1 Mini Project is Compulsory

Group 1

Use

A] MATLAB or other equivalent software working with speech and image signals/files and for analysis purpose.

B] C++ or JAVA for working with sampled data (n – point data samples of DT/Digital signals)

C] JAVA or other for image processing assignments

1.	Apply 1-D DFT to observe spectral leakage and frequency analysis of different window sequences, plot the frequency spectrums.
2	Adaptive FIR and IIR filter design: A] Steepest descent and Newton method, LMS method. B] Adaptive IIR Filter design: Pade Approximation, Least square design
3.	Power spectrum estimation and analysis: Take a speech signal and perform A] Non parametric method: DFT and window sequences B] Parametric methods: AR model parameters
4	Multi-rate DSP and applications – Decimation, Interpolation, sampling rate conversion A] Take a speech signal with specified sampling frequency. Decimate by factor D(e.g. factor B] Take a speech signal with specified sampling frequency. Interpolate by factor I(e.g. factor) C] Sampling rate conversion by factor of I/D
5.	Write a program to calculate LPC coefficients, reflection coefficients using Levinson Durbin algorithm.
6	Feature Extraction of speech signal A] Using LPC and other methods B] Apply different coding methods: harmonic coding, vector quantization
Group 2:	
7	Mini-Project : Discrete Cosine Transform (DCT) A] To find DCT of NxN image block B] To plot spectrum of the speech signal using DCT and find the correlation of DCT transformed signal C] Image filtering using DCT : LPF, edge detection D] Image compression using DCT, Image resizing OR Mini-Project : Image Processing A] Histogram and Equalization B] Image Enhancement Techniques C] Image Filtering: LPF, HPF, Sobel/Prewitt Masks D] Image Smoothing with special filters: Median, Weiner, Homomorphic filters
410252(E) : Open Elective	

1.	Suitable set of programming assignments/Mini-projects for open elective Opted.

PART-II: 410253 : Elective VI

410253(A) : Pattern Recognition

Any 4 Assignments are Compulsory

1	For face Recognition • Implemented PCA and multiclass LDA. • Using EigenFaces and FisherFaces to recognise faces in the sel faces data set.
2	Perform sentiment analysis on the IMDB movie reviews dataset
3	Perform a classification task on a dataset of modulated radio signals
4	Perform image segmentation on the Berkley Segmentation dataset

410253(B) :Soft Computing

Any 4 Assignments and 1 Mini Project is Compulsory

Group 1

1	Design an X-OR Gate with feed-forward neural network (also popularly known as a Multilayer Perceptron) classifier.
2	Symmetric and Asymmetric implementation of Particle Swarm Optimization for Traveling Salesman Problem.
3	Implement Union, Intersection, Complement and Difference operations on fuzzy sets. Also create fuzzy relation by Cartesian product of any two fuzzy sets and perform max-min composition on any two fuzzy relations.
4	Implement Union, Intersection, Complement and Difference operations on fuzzy sets. Also create fuzzy relation by Cartesian product of any two fuzzy sets and perform max-min composition on any two fuzzy relations.
5	Implement genetic algorithm for benchmark function (eg. Square, Rosenbrock function etc) Initialize the population from the Standard Normal Distribution. Evaluate the fitness of all its individuals. Then you will do multiple generation of a genetic algorithm. A generation consists of applying selection, crossover, mutation, and replacement. Use: • **Tournament selection without replacement with tournament size s** • **One point crossover with probability Pc** • **bit-flip** mutation with probability Pm • **use full** replacement strategy

Group 2	
6	Mini Project : Create a small hybrid system for solving a chosen problem by following the given steps below. 1. Explain on one page the main characteristics of hybrid systems. 2. For the task chosen from the list below, create a multimodular block diagram of a possible solution to the problem. 3. Choose appropriate techniques for solving each sub problem represented as a module. What alternatives are there for each of them? 4. Create subsystems for solving each of the sub problems. Compile the whole hybrid system. 5. Make experiments with the hybrid system and validate the results. A) Handwritten digits recognition B) Bank loan approval decision-making system C) Stock market prediction D) Unemployment prediction E) Spoken words recognition, for example, "on"/"off", "yes"/"no", "stop"/"go." F) Loan approval
418253(C): Business Intelligence	
Any 5 Assignments and 1 Mini Project is Compulsory	
1	Import the legacy data from different sources such as (Excel , SqlServer, Oracle etc) and load in the target system. (You can download sample database such as Adventureworks, Northwind, foodmart etc)
2	Perform the Extraction Transformation and Loading (ETL) process to construct the database in the Sqlserver.
3	Create the cube with suitable dimension and fact tables based on ROLAP, MOLAP and HOLAP model.
4	Import the data warehouse data in Microsoft Excel and create the Pivot table and Pivot Chart
5	Perform the data classification using classification algorithm. Or Perform the data clustering using clustering algorithm.
6	Business Intelligence Mini Project: Each group of 4 students (max.) assigned one case study for this: A BI report must be prepared outlining the following steps. a) Problem definition, identifying which data mining task is needed. b) Identify and use a standard data mining dataset available for the problem.
418253(D): Quantum Computing	

Any 5 assignments are compulsory	
1	Analyze simple states of superposition and the effect of doing the measurement in different basis states.
2	Build simple quantum circuits with single and two-qubit gates
3	Learn how to use the IBM infrastructure to write quantum programs in QASM (Quantum Assembly) language
4	Analyze quantum circuits with entanglement
5	Analyze the effectiveness of simple error correction scheme
6	Implement quantum programs in NISQ model of computing
41(QSSE) Open Elective	
1.	Suitable set of programming assignments/Mini-projects for open elective Opted.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	2	-	-	-	-	-	-	-
CO2	-	2	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	2	-	-	-	-	3	-	-	-
CO4	2	-	2	-	-	3	-	-	-	-	-	-



Savitribai Phule Pune University
Fourth Year of Computer Engineering (2019 Course)
410256: Project Work Stage II

Teaching Scheme:	Credit	Examination Scheme:
TH: 04 Hours/Week	04	Term work: 100 Marks Presentation: 50Marks

Prerequisite Courses:

Companion Course:

Course Objectives:

- To follow SDLC meticulously and meet the objectives of proposed work
- To test rigorously before deployment of system
- To validate the work undertaken
- To consolidate the work as finished report

Course Outcomes:

On completion of the course, student will be able to–

CO1: Show evidence of independent investigation

CO2: Critically analyze the results and their interpretation

CO3: Report and present the original results in an orderly way and placing the open questions in the right perspective.

CO4: Link techniques and results from literature as well as actual research and future research lines within the research

CO5: Appreciate practical implications and constraints of the specialist subject

Guidelines

In Project Work Stage–II, the student shall complete the remaining project work which consists of Selection of Technology and Tools, Installations, UML implementations, Testing, Results, performance discussions using data tables per parameter considered for the improvement with existing known algorithms/systems and comparative analysis and validation of results and conclusions. The student shall prepare and submit the report of Project work in standard format for satisfactory completion of the work that is duly certified by the concerned guide and head of the Department/Institute.

Follow guidelines and formats as mentioned in Project Workbook recommended by Board of Studies

Savitribai Phule Pune University
Fourth Year of Engineering (2019 Course)
410257: Audit Course 5

In addition to credits, it is recommended that there should be audit courses, preferably in each semester starting from second year in order to supplement students' knowledge and skills. Student will be awarded the bachelor's degree if he/she earns specified total credits [1] and clears all the audit courses specified in the curriculum. The student will be awarded grade as AP on successful completion of audit course. The student may opt for one of the audit courses per semester, starting in second year first semester. Though not mandatory, such a selection of the audit courses helps the learner to explore the subject of interest in greater detail resulting in achieving the very objective of audit course's inclusion. List of options offered is provided. Each student has to choose one audit course from the list per semester. Evaluation of audit course will be done at institute level itself. Method of conduction and method of assessment for audit courses are suggested.

Criteria

The student registered for audit course shall be awarded the grade AP (Audit Course Pass) and shall be included such AP grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory performance and secured a passing grade in that audit course. No grade points are associated with this 'AP' grade and performance in these courses is not accounted in the calculation of the performance indices SGPA and CGPA. Evaluation of audit course will be done at institute level itself [1].

Guidelines for Conduction and Assessment: Any one or more of following but not limited to:

- Lectures/ Guest Lectures
- Visits (Social/Field) and reports
- Demonstrations or presentations
- Surveys
- Mini-Project
- Hands on experience on focused topic

Course Guidelines for Assessment: Only one or more of following but not limited to:

- Written Test
- Demonstrations/ Practical Test
- Presentation or Report

Audit Course 5 Options

Audit Course Code:	Audit Course Title:
AC5-I	Usability Engineering
AC5- II	Conversational Interface
AC5-III	Social Media and Analytics
AC5-IV	MOOC-Learn New Skills
AC5-V	Emotional Intelligence

Savitribai Phule Pune University, Pune Fourth Year of Computer Engineering (2019 Course)

410257: Audit Course 3

ACS – I: Usability Engineering

In this course you will have a hands-on experience with usability evaluation and user-centered design. This course will not help to learn how to implement user interfaces, but rather how to design based on the needs of users, which you will determine, and learn how to evaluate your designs rigorously. This helps in knowing more about the usability, human computer interaction, the

psychological aspects of computing, evaluation.

Course Objectives:

- To understand the human centered design process and usability engineering process and their roles in system design and development.
- To know usability design guidelines, their foundations, assumptions, advantages, and weaknesses.
- Understand the user interface based on analysis of human needs and prepare a prototype system.

Course Outcomes:

On completion of the course, learner will be able to–

CO1: Describe the human centered design process and usability engineering process and their roles in system design and development.
CO2: Discuss usability design guidelines, their foundations, assumptions, advantages, and weaknesses.
CO3: Design a user interface based on analysis of human needs and prepare a prototype system.
CO4: Assess user interfaces using different usability engineering techniques.
CO5: Present the design decisions.

Course Contents:

1. What Is Usability? Usability and Other Considerations, Definition of Usability, Example: Measuring the Usability of Items, Usability Trade-Offs, Categories of Users and Individual User Differences
2. Usability in Software Development : The Emergence of Usability, Human Computer Interaction, Usability Engineering
3. The usability Engineering Lifecycle: Requirement Analysis, Design, Testing, Development
4. Usability Assessment Methods beyond Testing
5. International User Interfaces

Books:

1. Mary Beth Rosson, John Millar Carroll, "Usability Engineering: Scenario-based Development of Human-Computer Interaction"
2. Jakob Nielsen, "Usability Engineering"
3. Deborah J. Mayhew, " The usability engineering lifecycle"

Savitribai Phule Pune University, Pune
Fourth Year of Computer Engineering (2019 Course)
410257: Audit Course 5
ACS – II: Conversational Interfaces

Effective information security at the enterprise level requires participation, planning, and practice. It is an ongoing effort that requires management and staff to work together from the same script. Fortunately, the information security community has developed a variety of resources, methods, and best practices to help modern enterprises address the challenge. Unfortunately, employing these tools demands a high degree of commitment, understanding, and skill attributes that must be sustained through constant awareness and training.

Course Objectives:

- To understand the basics of conversations
- To know the interactive environments for conversational skills
- To acquaint with the speech to text and text to speech techniques

Course Outcome:

On completion of the course, learner will be able to–

CO1: Develop an effective interface for conversation

CO2: Explore advanced concepts in user interface

Course Contents:

1. **Introduction to Conversational Interface:** Preliminaries, Developing a speech based Conversational Interface, Conversational Interface and devices.
2. **A technology of Conversation:** Introduction, Conversation as Action, The structure of Conversation, The language of Conversation.
3. **Developing a Speech-Based Conversational Interface:** Implementing Text to Speech: Text Analysis, Wave Synthesis, Implementing Speech Recognition: Language Model, Acoustic Model, Decoding, Speech Synthesis Markup Language.
4. **Advanced voice user interface design**

Books:

1. Cathy Pearl, "**Designing** Voice User Interfaces: Principles of Conversational **Experiences**"
2. Michael McTear, Zoraida Callejas, David Griol, " The Conversational Interface: Talking to Smart Devices"
3. Martin Mitrevski, "**Developing** Conversational Interfaces for iOS: Add Responsive Voice **Control**"
4. Srinivasan Sankara, " Hands-On Chatbots and Conversational UI Development: Build **chatbots**"

Savitribai Phule Pune University, Pune
Fourth Year of Computer Engineering(2019Course)
410257: AudioCourse8
ACS–III: Social Media And Analytics

Prerequisite : Knowledge of Social Media Networking

Course Objectives:

- Get strategic understanding of Digital Marketing and Social Media Marketing.
- Understand how to use it for branding and sales.
- Understand its advantages& limitations.
- Become familiar with Best Practices, Tools &Technologies.
- Blend digital and social marketing with offline marketing.
- Plan and manage digital marketing budget.
- Manage Reporting & Tracking Metrics.
- Understand the future of Digital Marketing and prepare for it.

Course Outcome:

On completion of the course, learner will be able to–

CO1: Develop a far deeper understanding of the changing digital landscape.

CO2: Identify some of the latest digital marketing trends and skill sets needed for today's marketer.

CO3: Successful planning, prediction, and management of digital marketing campaigns.

CO4: Assess user interface using different usability engineering techniques.

CO5: Implement smart management of different digital assets for marketing needs.

CO6: Assess digital marketing as a long term career opportunity.

Course Concepts:

1. Digital Marketing, History of Digital Marketing, Importance of Digital Marketing, Effective use of Digital Marketing, Effects of wrong Digital Marketing, Digital Marketing to develop brands, Digital Marketing for sales, Digital Marketing for product and service development.
2. Techniques for effective Email Marketing and pitfalls, Various online email marketing platforms such as Campaign Monitor and Mail Chimp, Web content, web usability, navigation and design, Bookmarking and News Aggregators, Really Simple Syndication (RSS),Blogging, Live Chat, User Generated Content (Wikipedia etc),Multi-media – Video (Video Streaming, YouTube etc),Multi-media – Audio & Podcasting (iTunes etc),Multi-media - Photos/Images (Flickr etc),Google Alerts and Giga Alert (Brand, product and service monitoring online),Crowd sourcing,Virtual Worlds.
3. Search Engine Optimization (SEO), Search Engine Optimization (SEO) tips and techniques, Google Adwords, Google various applications such as 'Google Analytics', Maps, Places etc to enhance a brand's products, services and operations.

4.Facebook&LinkedInandotherSocialMediaforemailmarketing:UtilizingFacebookstall,inkedIn'sAdvertising functionality and Applications, Brand reputation management techniques, Systems for 'buzz monitoring' for brands, products and services, Effective Public Relations and Personal Branding for Individuals.

References:

1. Vandana Ahuja, "Digital Marketing", OxfordPress, ISBN: 9780199455447, 1st Edition.
2. Wiley, Jeanniey, Mullen, David Daniels, David Gilmour, "Email Marketing: An Hours Day," ISBN: 978-0-470-39677-6, 1st Edition.

Savitribai Phule Pune University
Fourth Year of Engineering (2019 Course)
410257: Audit Course 5
ACS – IV: MOOC-learn New Skill

This course aims to create awareness among the students regarding various courses available under MOOC and learn new skills through these courses.

Course Objectives:

- To promote interactive user forums to support community interactions among students, professors, and experts
- To promote learn additional skills anytime and anywhere
- To enhance teaching and learning on campus and online

Course Outcomes:

On completion of the course, student will be able to

CO1: To acquire additional knowledge and skill.

About Course:

MOOCs (Massive Open Online Courses) provide affordable and flexible way to learn new skills, pursue lifelong interests and deliver quality educational experiences at scale. Whether you're interested in learning for yourself, advancing your career or leveraging online courses to educate your workforce, SWAYAM, NPTEL, edx or similar **ones can help. World's largest SWAYAM MOOCs**, a new paradigm of education for anyone, anywhere, anytime, as per your convenience, aimed to provide digital education free of cost and to facilitate hosting of all the interactive courses prepared by the best more than 1000 specially chosen faculty and teachers in the country. SWAYAM MOOCs enhances active learning for improving lifelong learning skills by providing easy access to global resources.

SWAYAM is a programme initiated by Government of India and designed to achieve the three cardinal principles of Education Policy viz., access, equity and quality. The objective of this efforts to take the best teaching learning resources to all, including the most disadvantaged. SWAYAM seeks to bridge the digital divide for students who have hitherto remained untouched by the digital revolution and have not been able to join the mainstream of the knowledge economy. This is done through an indigenous developed IT platform that facilitates hosting of all the courses taught in classrooms from 9th class till post-graduation to be accessed by anyone, anywhere at any time. All the courses are interactive, prepared by the best teachers in the country and are available, free of cost to the residents in India. More than 1,000 specially chosen faculty and teachers from across the Country have participated in preparing these courses.

The courses hosted on SWAYAM is generally in 4 quadrants – (1) video lectures, (2) specially prepared reading material that can be downloaded/printed (3) self-assessment tests through tests and quizzes and (4) an online discussion forum for clearing the doubts. Steps have been taken to enrich the learning experience by using audio-video and multi-media and state of the art pedagogy / technology. In order to create best quality content are produced and delivered, seven National Coordinators have been appointed. They are NPTEL for engineering and UGC for post-graduation education.

Guidelines:

Instructors are requested to promote students to opt for courses (not opted earlier) with proper mentoring. The departments will take care of providing necessary infrastructural and facilities for the learners.

References:

4. https://swayam.gov.in/
5. https://onlinecourses.nptel.ac.in/
6. https://www.edx.org

Savitribai Phule Pune University, Pune
Fourth Year of Computer Engineering
(2019 Course)
410249: Audit Course 5
ACS – V: Emotional Intelligence

This Emotional Intelligence (EI) training course will focus on the five core competencies of emotional intelligence: self-awareness, self-regulation, motivation, empathy and interpersonal skills. Participants will learn to develop and implement these to enhance their relationships in work and life by increasing their understanding of social and emotional behaviours, and learning how to adapt and manage their responses to particular situations. Various models of emotional intelligence will be covered.

Course Objectives:

- To develop an awareness of EI models
- To recognize the benefits of EI
- To understand how you use emotion to facilitate thought and behavior
- To know and utilize the difference between reactive and considered response

Course Outcomes:

On completion of the course, learner will be able to–

CO1: Expand your knowledge of emotional patterns in yourself and others

CO2: Discover how you can manage your emotions, and positively influence yourself and others

CO3: Build more effective relationships with people at work and at home

CO4: Positively influence and motivate colleagues, team members, managers

CO5: Increase the leadership effectiveness by creating an atmosphere that enhances ethics

Course Content:

1. **Introduction to Emotional Intelligence (EI) :** Emotional Intelligence and various EI models, The EQ competencies of self-awareness, self-regulation, motivation, empathy, and interpersonal skills. Understand EQ and its importance in life and the workplace.
2. **Know and manage your emotions:** emotions, The different levels of emotional awareness, Increase your emotional knowledge of yourself, Recognize **„negative"** and **„positive"** emotions, The relationship between emotions, thought and behavior, Discover the importance of values, The impact of not managing and processing **„negative" emotions,** Techniques to manage your emotions in challenging situations
3. **Recognize emotions in others :**The universality of emotional expression, Learn tools to enhance your ability to recognize and appropriately respond to others' emotions, Perceiving emotions accurately in others to build empathy
4. **Relate to others**: Applying EI in the workplace, the role of empathy and trust in relationships,Increase your ability to create effective working relationships with others (peers, subordinates,managers, clients), Find out how to deal with conflict, Tools to lead, motivate others and create a high performing team

Books:

1. Daniel **Goleman**, "Emotional Intelligence – Why It Matters More Than IQ" , Bantam Books, ISBN-10: 0553383713, 978-0553383713
2. Steven Stein , "The EQ Edge" , Jossey-Bass, ISBN : 978-0-470-88161-3
3. Dave Bird , "The Leader's Guide to Emotional Intelligence" , ISBN: 9781533176802



Acknowledgement

It is with great pleasure and honor that I share the curriculum for Fourth Year of Computer Engineering (2019 Course) on behalf of Board of Studies (BoS), Computer Engineering. We, members of BoS are giving our best to streamline the processes and curricula design at both UG and PG programs.

It is always the strenuous task to balance the curriculum with the blend of core courses, current developments and courses to understand social and human values. By considering all the aspects with adequate prudence the contents are designed satisfying most of the necessities as per AICTE guidelines and to make the graduate competent enough as far as employability is concerned. I sincerely thank all the minds and hands who work adroitly to **materialize these tasks. I really appreciate everyone's contribution and suggestions in finalizing the contents.**

Success is sweet. But it's sweeter when it's achieved thorough co-ordination, cooperation and collaboration. I am overwhelmed and I feel very fortunate to be working with such a fabulous team- the Members of Board of Studies, Computer Engineering!

Even in these anxious situation, during the time of this unfortunate pandemic, each and every person, including the course coordinators and their team members, have worked seamlessly to come up with this all-inclusive curriculum for Fourth Year of Computer Engineering.

Thank you to all of you for delivering such great teamwork. I don't think it would have been possible to achieve the goal without each and every one of your efforts! I would like to express my deep gratitude to Dr. Pramod D. Patil (Dr. D. Y. Patil Institute of Technology, Pimpri), member BoS, Computer Engineering, for coordinating the complete activity and getting it to completion in a smooth manner.

I deeply appreciate and thank the managements of various colleges affiliated to SPPU for helping us in this work. These colleges have helped us by arranging sessions for preliminary discussion in the initial stage and at the same time in conducting Faculty Development Programs for various courses of the revised curriculum. All your support is warmly appreciated.

I sincerely appreciate the hard work put in by the course coordinators and their team members, without your intellectual work and creative mind, and it would have not been possible to complete this draft. You have been a valuable member of our team!

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Professor (Mrs.) Dr. Varsha H. Patil, Chairman, and Members- Dr. Shirish Sane, Dr. Sunil Bhirud, Dr. Manik Dhore, Dr. Pramod Patil, Dr. Girish Khilari, Dr. Sachin Lodha, Dr. Pankaja Mahalle, Dr. Venkateshwar, Dr. Geetanjali Kale, Dr. Subasini Sikar, Dr. R. V. Patil, Dr. P. M. Yawalkar, and Dr. Swati A. Bhavsar.

Board of Studies (BoS), Computer Engineering, Faculty of Science and Technology, Savitribai Phule Pune University

Task Force at Curriculum Design

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2. **Team Leader- Dr. Pramod D. Patil, Dr. D. Y. Patil Institute of Technology, Pimpri**

3. **Teams, Course Design-**

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		Prof.Gaurav	Prof.Shweta Ashish Kirpande
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