॥ योः क्रियावानू स पण्डितः ॥

# SAVITRIBAI PHULE PUNE UNIVERSITY

(सावित्रीबाई फुले पुणे विद्यापीठ)

Formerly University of Pune

## Syllabus Booklet

*For*

# B.E.

## COMPUTER SCIENCE AND ENGINEERING (DATA SCIENCE)

**2019 PATTERN**

With effect from Academic Year 2026-27

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## Preface

**Dear Students and Faculty,**

It is with great pleasure and honor that I share the syllabi for the Final Year of Computer Science and Engineering (Data Science) (2019 Course) on behalf of the 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 Science and Engineering(Data Science) 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 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.

Regards.

**Dr. Nilesh J. Uke**
Chairman, Board of Studies (Computer Engineering), SPPU, Pune

Links for First Year, Second Year and Third Year Curriculum:

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/Syllabus2024/S.%20E.%20Computer%20Science%20and%20Engineering%20(Data%20Science%20)%20Syllabus_19062024.pdf
3. http://collegecirculars.unipune.ac.in/sites/documents/Syllabus2025/TE%20-%20Computer%20Science%20and%20Engineering%20(Data%20Science)%20-%202019%20Pattern_30072025.pdf

## Table of Contents

**Savitribai Phule Pune University**

# Bachelor of Computer Science and Engineering( Data Science)

## 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 practices. |
| **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 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 write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO11** | **Project Management and Finance** | Demonstrate knowledge and understanding of 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) | |
|---|---|
| A graduate of the Computer Engineering Program will demonstrate- | |
| **PSO1** | **Professional Skills**<br>The ability to understand, analyze and develop computer programs in the areas related to Algorithms, System Software, Machine Learning, Artificial Intelligence, Web Applications, Big Data Analytics and Networking for efficient design of computer-based systems of varying complexity. |
| **PSO2** | **Problem-Solving Skills**<br>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**<br>The ability to employ modern computer languages, environments, and platforms in creating innovative career paths to be an entrepreneur, and a zest for higher studies. |

## Savitribai Phule Pune University
## Fourth Year of Computer Science and Engineering (Data Science) (2019 Course)

### 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/ Presentation | Total | Lecture | Practical | Tutorial | Total |
| 410640 | Deep Learning | 03 | - | - | 30 | 70 | - | - | - | 100 | 03 | -- | - | 03 |
| 410641 | Data Modeling & Visualization | 03 | - | - | 30 | 70 | - | - | - | 100 | 03 | - | - | 03 |
| 410642 | Elective III | 03 | - | - | 30 | 70 | - | - | - | 100 | 03 | - | - | 03 |
| 410643 | Elective IV | 03 | - | - | 30 | 70 | - | - | - | 100 | 03 | - | - | 03 |
| 410644 | Computer Laboratory I | - | 04 | - | - | - | 50 | 25 | - | 75 | - | 02 | - | 02 |
| 410645 | Computer Laboratory II | - | 04 | - | - | - | 50 | - | 25 | 75 | - | 02 | - | 02 |
| 410646 | Project Stage I | - | 04 | - | - | - | 50 | - | 50 | 100 | - | 02 | - | 02 |
| 410647 | MOOC | | | 02 | | | 50 | | | 50 | | | 02 | 02 |
| | Total | 12 | 12 | 02 | 120 | 280 | 200 | 25 | 75 | 700 | 12 | 06 | 02 | 20 |
| 410648 | Audit Course 7 | | | | | | | | | | | | | |
| | | | | | | | | | | **Total Credit** | **12** | **06** | **02** | **20** |

### Elective-III:
410642A: - Quantum Computing & AI
410642B: Enterprise Architecture and Components
410642C: Bioinformatics
410642D: Open Elective

### Elective-IV:
410643A: GPU Programming and Architecture
410643B: Design Thinking
410643C: Bio Inspired Algorithm
410643D: Open Elective

### Computer Laboratory-I: It is based on two compulsory courses:
- Deep Learning
- Data Modeling & Visualization

### Computer Laboratory-II: It is based on two Elective courses:
- Elective-III
- Elective-IV

### Audit Course 7:
- AC7-I Cyber Security
- AC7-II Professional Ethics and Etiquettes
- AC7-III Entrepreneurship Development
- AC7-IV Botnet of Things
- AC7-V MOOC- Learn New Skills

| Savitribai Phule Pune University<br>Fourth Year of Computer Science and Engineering (Data Science) (2019 Course)<br>Semester-VIII | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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/ Presentation | Total | Lecture | Practical | Tutorial | Total |
| 410649 | Block chain Technology | 03 | - | - | 30 | 70 | - | - | - | 100 | 03 | -- | - | 03 |
| 410650 | Distributed Computing | 03 | - | - | 30 | 70 | - | - | - | 100 | 03 | - | - | 03 |
| 410651 | Elective V | 03 | - | - | 30 | 70 | - | - | - | 100 | 03 | - | - | 03 |
| 410652 | Elective VI | 03 | - | - | 30 | 70 | - | - | - | 100 | 03 | - | - | 03 |
| 410653 | Computer Laboratory III | - | 02 | - | - | - | 50 | 25 | - | 75 | - | 01 | - | 01 |
| 410654 | Computer Laboratory IV | - | 02 | - | - | - | 50 | - | 25 | 75 | - | 01 | - | 01 |
| 410655 | Project II | - | 12 | - | - | - | 100 | - | 50 | 150 | - | 06 | - | 06 |
| | Total | 12 | 16 | - | 120 | 280 | 200 | 25 | 75 | 700 | 12 | 08 | | 20 |
| 410656 | Audit Course 8 | | | | | | | | | | | | | |
| | | | | | | | | | | **Total Credit** | **15** | **05** | **02** | **20** |

## Elective-V:

410651A: Virtual & Augmented Reality
410651B: Software Testing and Quality Assurance
410651C: Open Elective

## Elective-VI:

410652A: Virtual Reality in Game Development
410652B: Information System Management
410652C: Open Elective

**Computer Laboratory-III:** It is based on two compulsory Courses:

- Block chain Technology
- Distributed Computing

**Computer Laboratory-IV:** based on two Elective Courses:

- Elective-V
- Elective-VI

## Audit Course 8:

- AC8-I Usability Engineering
- AC8-II Conversation al Interfaces
- AC8-III Social Media and Analytics
- AC8-IV Emotional Intelligence
- AC8-V Learn New Skills - Software Development Using Agility Approach

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# General Guidelines

1. Outcome-based education is targeted at achieving desirable outcomes (in terms of knowledge, skills, attitudes and behavior etc.) at the end of the program. Teaching this awareness and making the associated effort constitutes outcome-based education. This entails a regular methodology for ascertaining the attainment of outcomes and benchmarking these against the **Program Outcomes (POs)** consistent with the objective of the program. 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 are categorically mentioned at the beginning of the curriculum (ref: NBA 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 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. For each unit, content attainment mapping is indicated with course outcome(s). Instructor may update the same.
3. @ CO & PO (Course Objectives and Program Outcomes) Attainment Mapping Table: The CO-PO mapping in the table 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 meaning of '-'is no correlation between CO and PO.
4. Exemplar/Case Studies are included at each unit to explore how the learned topics apply to real world situations and are to be designed so as to assist students to increase their understanding of particular skills, content or knowledge in any given situation and articulate. **One or two sample exemplar or case study are included for each unit, instructors may extend the same with more.**
5. Exemplar/Case Studies may be assigned as self-study by students and to be excluded from theory examinations.
6. For laboratory courses, a set of suggested assignments is provided for reference. Laboratory Instructors may design a 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 add to the perspective of the learners.
7. For each laboratory assignment, it is essential for students to draw/write/generate 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.
8. For laboratory, instructions have been included about the conduction and assessment of laboratory work. These guidelines are to be strictly followed. **Use of open-source software is appreciated.**
9. Set of suggested Laboratory assignments is provided for reference. Laboratory Instructor may design suitable set of assignments for respective institute.
10. Laboratory conduction and assessment guidelines are to be strictly followed.
11. **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 evidence 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. **It is recommended to conduct internal monthly practical examination as part of continuous assessment.**

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.

12. **Laboratory Journal-** 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 in the 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.

13. **Tutorial** -Tutorials can never be an individual course but an additional aid to the learners. Tutorials help the learners to inculcate the contents of the course with focused efforts on small group of the learners. Tutorial conduction should concentrate more on simplifying the intricacies converging to clear understanding and application. **Assessment of tutorial work is to be done in a manner similar to assessment of term-work; do follow same guidelines.**

14. **Audit Course-** The student registered for audit course shall be awarded the grade AP/PP (Audit Course Pass) and the grade 'AP'/'PP' shall be included 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'/'PP'' 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.

15. UGC has issued the UGC (Credit Framework for online learning courses through SWAYAM) Regulation 2016 advising the Universities to identify courses where credits can be transferred on to the academic record of the students for courses done on SWAYAM. AICTE has also put out gazette notification in 2016 and subsequently for adoption of these courses for credit transfer [2].

    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. This is done through a platform that facilitates hosting of the courses to be accessed by anyone, anywhere at any time. Courses delivered through SWAYAM are interactive, prepared by the best teachers in the country and are available, free of cost to any learner. However, learners wanting a SWAYAM certificate should register for the final proctored exams that come at a fee and attend in-person at designated center on specified dates. Eligibility for the certificate is generally announced on the course page. Universities/colleges approving credit transfer for these courses can use the marks/certificate obtained in these courses for the same.[2]

**Note: For Examination rules, pattern and assessment please refer [1]**

1. http://collegecirculars.unipune.ac.in/sites/documents/Syllabus%202019/Rules%20and%20Regulati ons%20F.E.%202019%20Patt_10.012020.pdf
2. https://swayam.gov.in/about

| Abbreviations | | |
|---|---|---|
| TW: Term Work | TH: Theory | PR: Practical |
| OR: Oral | TUT: Tutorial | Sem: Semester |

**Savitribai Phule Pune University**
**Fourth Year of Computer Science and Engineering (Data Science) (2019 Course)**
**410640: Deep Learning**

| Teaching Scheme: | Credit: | Examination Scheme: |
|---|---|---|
| TH: 03 Hours/Week | 03 | Mid_Semester(TH): 30 Marks<br>End Semester(TH): 70 Marks |

**Prerequisite Courses, if any:** Machine Learning

**Companion Course, if any:** --- Computer Laboratory I

**Course Objectives:**

CO1: To understand the basics of neural networks.
CO2: Comparing different deep learning models.
CO3: To understand the Recurrent and Recursive nets in Deep Learning
CO4: To understand the basics of deep reinforcement Learning models.
CO5: To analyze Types of Networks.
CO6: To Describe Reinforcement Learning.

**Course Outcomes:**

On completion of the course, learner 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 under fitting, 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 | (07Hours) |
|---|---|---|

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 Tensor Flow,
Keras, PyTorch, Caffe, Shogun.

| | |
|---|---|
| #Exemplar/Case Studies | Deep Mind, AlphaGo, Boston Dynamics |
| Mapping of Course Outcomes | CO1 |

| Unit II | Deep Neural Network(DNNs) | (06 Hours) |
|---|---|---|

**Introduction to Neural Networks** :The Biological Neuron, The Perceptron, Multilayer Feed-Forward Networks , **Training Neural Networks** :Backpropagation and Forward propagation **Activation Functions** :Linear ,Sigmoid, Tannh, Hard Tanh, Softmax, Rectified Linear,
**Loss Functions** :Loss Function Notation , Loss Functions for Regression , Loss Functions for Classification, Loss Functions for Reconstruction,
**Hyper parameters** : 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** | CO2 |

| | | |
|---|---|---|
| **Unit III** | **Convolution Neural Network(CNN)** | **(07 Hours)** |
| Introduction, CNN architecture overview, The Basic Structure of a Convolutional Network- Padding, Strides, 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** | **Recurrent Neural Network(CNN)** | **(08 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** | CO4 |

| | | |
|---|---|---|
| **Unit V** | **Deep Generative Models** | **(06 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** | **Data Warehousing And On-Line Analytical Processing** | **(08 Hours)** |
| Introduction of deep reinforcement learning, Markov Decision Process, basic framework of reinforcement learning, challenges of reinforcement learning, Dynamic programming algorithms for reinforcement learning Learning and Deep Q-Networks, Deep Q recurrent networks, Simple reinforcement learning for Tic-Tac-Toe. | | |

| | |
|---|---|
| **#Exemplar/Case Studies** | Self driving cars, Deep learning for chatbots |
| **Mapping of Course Outcomes** | 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

**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 :**

http://csis.pace.edu/ctappert/cs855-18fall/DeepLearningPractitionersApproach.pdf
https://www.dkriesel.com/_media/science/neuronalenetze-en-zeta2-1col-dkrieselcom.pdf

## The CO-PO mapping table

| | 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 | 3 | 2 | 2 | - | - | - | - | - | - | 1 |
| **CO6** | 1 | 2 | 2 | 2 | 2 | - | - | - | - | - | 2 | - |

## Savitribai Phule Pune University
## Fourth Year of Computer Science and Engineering (Data Science) (2019 Course)
## 410641: Data Modeling & Visualization

| Teaching Scheme: | Credit: | Examination Scheme: |
|---|---|---|
| TH: 03 Hours/Week | 03 | Mid_Semester(TH): 30 Marks<br>End_Semester(TH): 70 Marks |

**Companion Course, if any:** Computer Laboratory I

**Course Objectives:**

- Understand the fundamentals of data modeling concepts and data preparation techniques.
- Learn various data visualization principles and methods for effective data representation.
- Apply statistical and visual analytics techniques to explore, analyze, and interpret data.
- Use modern data visualization tools and libraries for real-world datasets.
- Develop skills to communicate data-driven insights clearly and effectively.
- Design interactive dashboards and visual stories that support data-driven decision making.

**Course Outcomes:**

On completion of the course, learners should be able to
**CO1:** Explain data modeling concepts and data types used in analytics
**CO2:** Perform data cleaning, transformation, and preparation
**CO3:** Apply appropriate visualization techniques for different data scenarios
**CO4:** Use visualization tools to analyze and interpret complex datasets
**CO5:** Design dashboards and visual stories for decision-making
**CO6:** Design interactive dashboards and visual stories to support data-driven decision-making in real-world applications.

**Course Contents**

| Unit I | Introduction to Data Modeling | (06 Hours) |
|---|---|---|

Introduction to data and information, Types of data: structured, semi-structured, and unstructured data, Data modeling concepts and importance, Levels of data modeling: Conceptual data model, Logical data model, Physical data model, Entity–Relationship (ER) modeling, Entities, attributes, and relationships, Cardinality and participation constraints, Introduction to dimensional modeling, Star schema and snowflake schema,Use cases of data modeling in analytics systems.

| | |
|---|---|
| **#Exemplar/Case Studies** | A university wants to design a centralized Student Information System (SIS) to manage student details, courses, faculty, and examinations. |
| **Mapping of Course Outcomes for Unit I** | **CO1** |

| Unit II | Data Preparation and Transformation | (08 Hours) |
|---|---|---|

Data collection methods, Data integration from multiple sources, Data cleaning techniques, Handling missing data, Outlier detection and treatment, Data normalization and standardization, Data transformation techniques, Feature selection and feature engineering, Data quality issues and data consistency.

| | |
|---|---|
| **#Exemplar/Case Studies** | A retail company collects sales data from multiple stores, but the data contains missing values, duplicates, |
| **Mapping of Course Outcomes for Unit II** | **CO2** |

| Unit III | Principles of Data Visualization | (08 Hours) |
|---|---|---|
| Introduction to data visualization, Importance of visualization in data analytics, Human perception and visual cognition, Visual variables: position, size, shape, color, orientation, Principles of effective visualization design, choosing appropriate visualization techniques, Chart selection guidelines, Color theory and use of color in visualization, Common visualization errors and pitfalls, Ethical considerations in data visualization. | | |
| **#Exemplar/Case Studies** | health department needs to present COVID-19 case trends to policymakers and the public. | |
| **Mapping of Course Outcomes for Unit III** | **CO3** | |

| Unit IV | Visualization Techniques and Tools | (07 Hours) |
|---|---|---|
| Basic visualization techniques: Bar charts, Line charts, Pie charts, Scatter plots, Advanced visualization, techniques: Histograms, Box plots, Heat maps, Tree maps, Time-series data visualization, Multidimensional data visualization, Geospatial data visualization, Introduction to visualization tools: Tableau, Power BI,Python visualization libraries (Matplotlib, Seaborn – overview) | | |
| **#Exemplar/Case Studies** | A company wants to analyze monthly sales performance across regions using visualization tools. | |
| **Mapping of Course Outcomes for Unit IV** | **CO4** | |

| Unit V | Dashboards and Visual Analytics | (06 Hours) |
|---|---|---|
| Concept of visual analytics, Visual analytics process, Interactive visualization techniques, Dashboard design principles, Types of dashboards: Operational dashboards, Analytical dashboards, Strategic dashboards, Storytelling with data, Designing effective data stories, Case studies using real-world datasets, Visualization for business intelligence and decision making | | |
| **#Exemplar/Case Studies** | An e-commerce company wants a dashboard to track real-time metrics such as sales, customers, and inventory. | |
| **Mapping of Course Outcomes for Unit V** | **CO5** | |

| Unit VI | Advanced Visualization, Big Data & Emerging Trends | (07 Hours) |
|---|---|---|
| Advanced data visualization concepts, Visualization of large-scale and big data, Challenges in visualizing high-dimensional data, Dimensionality reduction techniques (PCA – overview), Network and graph visualization, Social network visualization, Streaming and real-time data visualization, Visualization for machine learning models, Model interpretation and explainable visualization (overview), Introduction to advanced visualization frameworks, Emerging trends in data visualization, Role of visualization in AI, IoT, and smart systems | | |
| **#Exemplar/Case Studies** | A smart city project collects real-time traffic data from IoT sensors installed across the city. | |
| **Mapping of Course Outcomes for Unit VI** | **CO6** | |

**Learning Resources**

**Text Books:**

1. Tamara Munzner, Visualization Analysis and Design, CRC Press, 2014.
2. Ben Fry, Visualizing Data, O'Reilly Media, 2008.
3. Andy Kirk, Data Visualization: A Handbook for Data-Driven Design, SAGE Publications, 2016.
4. Ralph Kimball and Margy Ross, The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling, Wiley, 3rd Edition, 2013.

**Reference Books:**

1. Edward R. Tufte, The Visual Display of Quantitative Information, Graphics Press, 2001.
2. Stephen Few, Show Me the Numbers: Designing Tables and Graphs to Enlighten, Analytics Press, 2012.
3. (Practical guide to effective chart design and interpreting data visuals)
4. Cole Nussbaumer Knaflic, Storytelling with Data: A Data Visualization Guide for Business Professionals, Wiley, 2015.(Focused on communicating insights and storytelling through visuals)
5. Nathan Yau, Data Points: Visualization That Means Something, Wiley, 2013.(Real-world examples of visualizing data effectively)
6. Christopher J. Date & Hugh Darwen, Databases, Types, and the Relational Model: The Third Manifesto, Morgan Kaufmann, 2011. 2. L. Peterson and B. Davie, "Computer Networks: A Systems Approach", 5th Edition, Morgan-Kaufmann, 2012.
7. Douglas E. Comer & M.S Narayanan,"Computer Network & Internet", Pearson Education
8. William Stallings, "Cryptography and Network Security: Principles and Practice", 4th Edition
9. Pachghare V. K., "Cryptography and Information Security", 3rd Edition, PHI,

**e-Books :**

Resources - Data Visualization - LibGuides at Chapman University
Data Visualization - Free Computer, Programming, Mathematics, Technical Books, Lecture Notes and Tutorials

**The CO-PO mapping table**

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

**Savitribai Phule Pune University**

**Fourth Year of Computer Science and Engineering (Data Science) (2019 Course)**

**410642A : Elective-III-Quantum Computing & AI**

| Teaching Scheme: | Credit: | Examination Scheme: |
|---|---|---|
| TH: 03 Hours/Week | 03 | Mid_Semester(TH): 30 Marks<br>End_Semester(TH): 70 Marks |

**Prerequisite Courses, if any:** Programming and Problem solving ,Data Structures and Algorithms

**Companion Course, if any:** Computer Laboratory II

- 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, learner will be able to–

**CO1:** To understand the concepts of Quantum Computing

**CO2:** To understand and get exposure to mathematical foundation and quantum mechanics

CO3: To understand and implement 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 Contents**

| Unit I | Introduction | (07 Hours) |
|---|---|---|

Fundamental Concepts of Quantum computing: Introduction and Overview, Global Perspective, Quantum Bits, Quantum Computation, Quantum Algorithms, Quantum information and Quantum information processing

| | |
|---|---|
| **#Exemplar/Case Studies** | Quantum Machine Learning for Drug Discovery |
| **Mapping of Course Outcomes for Unit I** | CO1, CO4 |

| 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

| | |
|---|---|
| **#Exemplar/Case Studies** | Quantum AI for Financial Portfolio Optimization |
| **Mapping of Course Outcomes** | CO2, CO4 |

| Unit III | Adversarial Search and Games | (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.

| | |
|---|---|
| **#Exemplar/Case Studies** | Quantum Computing in AI-Based Image Recognition |
| **Mapping of Course Outcomes** | CO3, CO4 |

| 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

| | |
|---|---|
| **#Exemplar/Case Studies** | Quantum AI for Smart Traffic Management |
| **Mapping of Course Outcomes** | 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.

| | |
|---|---|
| **#Exemplar/Case Studies** | Quantum Computing for Cybersecurity and AI Threat Detection |
| **Mapping of Course Outcomes** | CO4, 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, Swarm Robotics, Cyber security

| | |
|---|---|
| **#Exemplar/Case Studies** | Quantum AI in Climate Modeling and Prediction |
| **Mapping of Course Outcomes for Unit VI** | CO4, 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 Winchert, "Principles of Quantum Artificial Intelligence",Instituto Superior Técnico - Universidade de Lisboa, Portugal - World Scientific Publishing, British Library Cataloguing-in-Publication Data

**Reference Books:**

1. Press Stephen Kan, "MetricsandModelsinSoftwareQualityEngineering‖,Pearson,ISBN-10:0133988082; ISBN-13:978-0133988086
2. Michael A. Nielsen, "Quantum Computation and Quantum Information", Cambridge University PressStephen Kan, —Metrics and Models in Software Quality Engineering‖, Pearson, ISBN-10: 0133988082; ISBN-13: 978-0133988086
3. David McMahon, "Quantum Computing Explained", Wiley
4. Microsoft Quantum Development Kithttps://www.microsoft.com/enus/quantum/development-kit Forest SDK PyQuil: https://pyquil.readthedocs.io/en/stable/
5. Amazon Bracket Documentation on AWS:https://aws.amazon.com/braket/ 7 D-Wave Systems Documentation: https://docs.dwavesys.com/docs/latest/index.html

**e-Books :**

1. http://mmrc.amss.cas.cn/tlb/201702/W020170224608149940643.pdf
2. http://mmrc.amss.cas.cn/tlb/201702/W020170224608150244118.pdf

**MOOC Courses:**

· https://nptel.ac.in/courses/106/102/106102220/
· https://nptel.ac.in/courses/106/105/106105077/
· https://nptel.ac.in/courses/106/105/106105078/
· https://nptel.ac.in/courses/106/105/106105079/

**The CO-PO mapping table**

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

**Savitribai Phule Pune University**

**Fourth Year of Computer Science and Engineering (Data Science) (2019 Course)**

**410642B : Elective-III-Enterprise Architecture and Components**

| Teaching Scheme: | Credit: | Examination Scheme: |
|---|---|---|
| TH: 03 Hours/Week | 03 | Mid_Semester(TH): 30 Marks<br>End_Semester(TH): 70 Marks |

**Prerequisite Courses, if any:** NIL

**Companion Course, if any:** Computer Laboratory II

**Course Objectives**

- Understand the **fundamentals of Enterprise Architecture (EA)** and its role in aligning business and IT.
- Study **enterprise architecture frameworks**, standards, and reference models.
- Analyze **enterprise components, services, and integration mechanisms**.
- Apply EA concepts for **designing scalable, secure, and interoperable enterprise systems**.
- Develop skills to model and evaluate **enterprise-wide solutions** using architectural best practices.

**Course Outcomes:**

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

**CO1** Explain the concepts, evolution, and importance of Enterprise Architecture in organizations.
**CO2** Compare and analyze popular Enterprise Architecture frameworks and standards.
**CO3** Identify and design enterprise components and layered architectures.
**CO4** Apply service-oriented and component-based approaches for enterprise integration.
**CO5** Evaluate enterprise architectures with respect to scalability, security, and performance.
**CO6** Design a basic enterprise architecture solution for a real-world business scenario.

**Course Contents**

| Unit I | Fundamentals of Enterprise Architecture | (07 Hours) |
|---|---|---|

Definition and scope of Enterprise Architecture (EA),Enterprise vs traditional information systems, Business drivers for Enterprise Architecture, Challenges in large-scale enterprise systems, Alignment of Business Strategy, IT Strategy and Operations, Enterprise Architecture principles and goals, Stakeholders in enterprise architecture, Roles and responsibilities of an Enterprise Architect, EA governance and organizational maturity models, Benefits and limitations of Enterprise Architecture, Enterprise Architecture development lifecycle, Introduction to architecture repositories

| | |
|---|---|
| **#Exemplar/Case Studies** | Enterprise Resource Planning (ERP) architecture |
| **Mapping of Course Outcomes for Unit I** | CO1 |

| Unit II | Enterprise Architecture Frameworks and Reference Models | (07 Hours) |
|---|---|---|

Need for Enterprise Architecture frameworks, Zachman Framework Structure, perspectives, abstractions Strengths and limitations, TOGAF (The Open Group Architecture Framework),TOGAF architecture domains, Architecture Development Method (ADM) phases, Architecture artifacts and deliverables, Federal Enterprise Architecture Framework (FEAF) – overview Department of Defense Architecture Framework (DoDAF) –

| | |
|---|---|
| overview, IEEE 1471 / ISO/IEC/IEEE 42010 standard for architecture description, Comparison of EA frameworks, Selection of appropriate EA framework for organizations | |
| **#Exemplar/Case Studies** | Digital transformation of a large enterprise |
| **Mapping of Course Outcomes** | CO2 |

| **Unit III** | **Enterprise Architecture Frameworks and Standards** | **(07 Hours)** |
|---|---|---|
| Overview of layered architecture approach, Business Architecture: Business processes, functions, goals Value chains and capability models, Data Architecture: Enterprise data models, Data governance and data standards, Master data and metadata management, Application Architecture: Application portfolio management, Application integration patterns, Technology Architecture: Infrastructure components, Platforms, networks, and deployment environments, Architectural viewpoints and viewpoints vs views, Architecture modeling languages (overview of ArchiMate, UML), Architecture documentation and traceability | | |
| **#Exemplar/Case Studies** | Cloud adoption in enterprise systems | |
| **Mapping of Course Outcomes** | CO3 | |

| **Unit IV** | **Enterprise Components and Component-Based Architecture** | **(07 Hours)** |
|---|---|---|
| Concept of enterprise components, Characteristics of good enterprise components, Component-based software engineering (CBSE), Component interfaces and contracts, Reusability and maintainability in enterprise components, Enterprise Java Beans (EJB) – architecture and types, .NET components (overview), Component deployment and versioning, Monolithic architecture vs component-based architecture, Microservices architecture – concepts and comparison, Component orchestration and choreography | | |
| **#Exemplar/Case Studies** | Component-Based Architecture in an ERP System | |
| **Mapping of Course Outcomes** | CO4 | |

| **Unit V** | **Enterprise Integration and Services** | **(07 Hours)** |
|---|---|---|
| Need for enterprise integration, Types of integration:, Data integration, , Application integration, Business process integration, Service-Oriented Architecture (SOA), SOA principles and service lifecycle, Service contracts and service registry, Web services architecture, SOAP-based services, RESTful services, Enterprise Service Bus (ESB), Middleware technologies and messaging systems, API management and gateways, Cloud-based enterprise architectures, Hybrid and distributed enterprise systems | | |
| **#Exemplar/Case Studies** | SOA-Based Integration in Healthcare Enterprise | |
| **Mapping of Course Outcomes for Unit II** | CO5 | |

| **Unit VL** | **Enterprise Architecture Evaluation, Governance, and Case Studies** | **(07 Hours)** |
|---|---|---|

| | |
|---|---|
| Quality attributes of enterprise architectures, Scalability, Security, Reliability, Performance, Maintainability, Risk analysis in enterprise architecture, Cost–benefit analysis of EA initiatives, Architecture governance and compliance, Architecture review and validation techniques, Migration planning and roadmap development | |
| **#Exemplar/Case Studies** | Enterprise Architecture Evaluation for Cloud Migration |
| **Mapping of Course Outcomes** | CO6 |

**Text Books:**

1. Enterprise Architecture A to Z: Frameworks, Business Process Modeling, SOA, and Infrastructure Technology – 2. Daniel Minoli A comprehensive textbook covering EA frameworks (TOGAF, Zachman)
2. Cloud Enterprise Architecture – Pethuru Raj Focuses on the impact of cloud computing on enterprise architecture, covering business, information, application, integration, security, and technology architectures.
3. Enterprise Architecture and Cartography – Pedro Sousa & Andre Vasconcelos A modern book on EA modeling, methods, principles, and maintaining EA artifacts over time; includes examples and techniques for real-world enterprise modeling.
4. Enterprise Architect's Handbook – Dr. J. S. Vishwakarma Practical guide to EA strategy, frameworks (including TOGAF), maturity assessment, design modeling, and technology landscape alignment.

**Reference Books:**

1. Enterprise Architecture Planning: Developing a Blueprint for Data, Applications, and Technology By Steven H. Spewak & Steven C. Hill

2. Enterprise Architecture Frameworks Compendium By Dirk Matthes

**3. Handbook on Enterprise Architecture** *Edited by Peter Bernus, Laszlo Nemes & Günter J. Schmidt*

E-Books:

https://www.ncbi.nlm.nih.gov/books

https://www.ncbi.nlm.nih.gov/books

**The CO-PO mapping table**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 1 | 1 | 2 | - | - | 1 | - | - | - | 1 |
| **CO2** | 3 | 3 | 2 | 2 | 3 | - | - | 1 | - | - | - | 2 |
| **CO3** | 2 | 3 | 3 | 3 | 3 | - | - | 1 | 1 | - | - | 2 |
| **CO4** | 2 | 3 | 3 | 3 | 3 | - | - | 1 | 1 | - | 1 | 2 |
| **CO5** | 2 | 2 | 2 | 2 | 3 | - | - | 1 | 1 | - | 1 | 2 |
| **CO6** | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | - | 1 | 3 |

**Savitribai Phule Pune University**

**Fourth Year of Computer Science and Engineering(Data Science) (2019 Course)**

**410642C : Elective-III-Bioinformatics**

| Teaching Scheme: | Credit: | Examination Scheme: |
|---|---|---|
| TH: 03 Hours/Week | 03 | Mid_Semester(TH): 30 Marks<br>End_Semester(TH): 70 Marks |

**Prerequisite Courses :** Computer Networks and Security (310244)

**Companion Course :** Computer Laboratory II

**Course Objectives:**

- Introduce the fundamentals of bioinformatics and computational biology.
- Understand biological databases and methods for biological data retrieval.
- Apply sequence alignment and analysis techniques.
- Learn tools and algorithms for genomics and proteomics.
- Develop the ability to analyze biological data using computational approaches.
- Understand applications of bioinformatics in medicine, agriculture, and research.

**Course Outcomes:**

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

**CO1:** Explain fundamental concepts of molecular biology and bioinformatics.

**CO2:** Identify and utilize biological databases for data retrieval and analysis.

**CO3**: Apply sequence alignment techniques for DNA and protein analysis.

**CO4:** Analyze genomic and proteomic data using bioinformatics tools.

**CO5:** Interpret biological data and derive meaningful biological insights.

**CO6:** Apply bioinformatics techniques to real-world problems in healthcare and biotechnology.

**Course Contents**

| Unit I | Introduction | (07 Hours) |
|---|---|---|

Definition, history, and scope of Bioinformatics, Interdisciplinary nature: Biology , Computer Science Mathematics, Central Dogma of Molecular Biology, DNA, RNA, and Protein structure basics, Overview of genome organization, Biological databases introduction, Primary vs Secondary databases

| | |
|---|---|
| **#Exemplar/Case Studies** | Genomics and Bioconductor |
| **Mapping of Course Outcomes** | CO1 |

| Unit II | Biological Databases & Data Retrieval | (07 Hours) |
|---|---|---|

Nucleotide sequence databases: GenBank, European Molecular Biology Laboratory, Protein sequence databases: UniProt, Structural databases: Protein Data Bank, Data formats: ASTA, GenBank format, PDB format, Database searching techniques, Introduction to BLAST

| | |
|---|---|
| **#Exemplar/Case Studies** | Genomic Data Visualization |
| **Mapping of Course Outcomes** | CO2 |

| Unit III | Sequence Alignment & Phylogenetics | (07 Hours) |
|---|---|---|
| Pairwise Sequence Alignment: Global Alignment (Needleman–Wunsch algorithm), Local Alignment (Smith–Waterman algorithm), Scoring matrices (PAM, BLOSUM), Multiple Sequence, Alignment, Phylogenetic Tree Construction, Distance-based methods, Maximum Parsimony method | | |
| **#Exemplar/Case Studies** | Structural Bioinformatics, Cross-cell line Transcriptomic Signature Predictions | |
| **Mapping of Course Outcomes** | CO3 | |

| Unit IV | Structural Bioinformatics | (07 Hours) |
|---|---|---|
| Protein Structure Levels (Primary to Quaternary): Secondary Structure Prediction, Ramachandran Plot, Protein folding basics, Structure classification systems, Molecular visualization tools | | |
| **#Exemplar/Case Studies** | AstraZeneca | |
| **Mapping of Course Outcomes for Unit II** | CO4 | |

| Unit V | Genomics and Proteomics | (07 Hours) |
|---|---|---|
| Genome sequencing technologies: Next Generation Sequencing (NGS) overview, Genome assembly concepts, Gene prediction methods, Functional genomics, Proteomics basics, Mass spectrometry overview, Gene Ontology and pathway databases | | |
| **#Exemplar/Case Studies** | DeepChem and Facial Emotion Recognition | |
| **Mapping of Course Outcomes for Unit II** | CO5 | |

| Unit VI | Applications & Modern Trends | (07 Hours) |
|---|---|---|
| Quality attributes of enterprise architectures, Scalability, Security, Reliability, Performance, Maintainability, Risk analysis in enterprise architecture, Cost–benefit analysis of EA initiatives, Architecture governance and compliance, Architecture review and validation techniques, Migration planning and roadmap development | | |
| **#Exemplar/Case Studies** | Awesome Bioinformatics | |
| **Mapping of Course Outcomes for Unit II** | CO6 | |

**Text Books:**

1. Bioinformatics: Sequence and Genome Analysis – David W. Mount
2. Essential Bioinformatics – Jin Xiong
3. Introduction to Bioinformatics – Arthur M. Lesk

**Reference Books:**


1. **Baxevanis, A. D., & Ouellette, B. F. F. (Eds.). (2005).** *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins* (3rd ed.). Wiley-Interscience.
2. **Pevzner, P. A., & Skiena, S. S. (2014).** *Bioinformatics Algorithms* (2nd ed.). Active Learning Publishers.
3. **Durbin, R., Eddy, S. R., Krogh, A., & Mitchison, G. (1998).** *Biological Sequence Analysis*. Cambridge University Press.
4. **Lesk, A. M. (2019).** *Introduction to Bioinformatics* (5th ed.). Oxford University Press.
5. **Xiong, J. (2006).** *Essential Bioinformatics*. Cambridge University Press.
6. **Mount, D. W. (2004).** *Bioinformatics: Sequence and Genome Analysis* (2nd ed.). Cold Spring Harbor Laboratory Press.
7. **Jones, N. C., & Pevzner, P. A. (2004).** *An Introduction to Bioinformatics Algorithms*. MIT Press.


E-Books:

https://www.opengroup.org/togaf-standard-10th-edition-downloads?utm_source=chatgpt.com

https://openlibrary.org/books/OL51275235M/Enterprise_integration_patterns?utm_source=chatgpt.com

**The CO-PO mapping table**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | - | - | - | - | 1 | - | - | - | - | 2 |
| **CO2** | 3 | 3 | 2 | - | 1 | - | - | - | - | - | - | 2 |
| **CO3** | 2 | 3 | 3 | - | 2 | - | - | - | - | - | - | 1 |
| **CO4** | 2 | 3 | 3 | - | 3 | - | - | - | - | - | - | 1 |
| **CO5** | 2 | 3 | 2 | 2 | 2 | 1 | - | - | - | - | - | 2 |
| **CO6** | 2 | 3 | 3 | 2 | 3 | 1 | 2 | - | - | - | 2 | 2 |

**Savitribai Phule Pune University**

**Fourth Year of Computer Science and Engineering(Data Science) (2019 Course)**

**410642D : Elective-III-Open Elective**

| Teaching Scheme | Credit Scheme | Examination Scheme |
|---|---|---|
| Lecture: 03 Hours/Week | 03 | Mid_Semester(TH): 30 Marks<br>End_Semester(TH): 70 Marks |

**Prerequisite Courses :**

**Companion Course :** Computer Laboratory II

The open elective included, 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/exotic/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 Science and Engineering(Data Science) (2019 Course)**

**410643A : Elective-IV- GPU Programming and Architecture**

| Teaching Scheme | Credit Scheme | Examination Scheme and Marks |
|---|---|---|
| Lecture: 03 Hours/Week | 03 | Mid_Semester(TH): 30 Marks<br>End_Semester(TH): 70 Marks |

**Prerequisite Courses :** Computer Graphics, Software Engineering

**Companion Course :** Computer Laboratory II

**Course Objectives:**

- Understand the evolution and significance of GPU computing and differentiate between CPU and GPU architectures.
- Explain the internal architecture of modern GPUs, including execution models, thread hierarchy, and scheduling mechanisms.
- Analyze GPU memory hierarchy and access patterns to achieve efficient parallel computation.
- Develop parallel programs using CUDA and OpenCL frameworks for general-purpose GPU computing.
- Apply performance optimization techniques to improve execution efficiency and scalability of GPU programs.
- Evaluate and implement GPU-based solutions for real-world applications such as artificial intelligence, image processing, and scientific computing.

Course Outcomes:

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

**CO1:** Explain the fundamentals, evolution, and applications of GPU computing.

**CO2**: Describe GPU architecture, execution models, and thread organization.

**CO3**: Analyze GPU memory hierarchy and apply appropriate memory access strategies.

**CO4:** Design and implement parallel programs using CUDA/OpenCL.

**CO5:** Optimize GPU applications using profiling and performance enhancement techniques.

**CO6:** Apply GPU programming concepts to solve real-world engineering and scientific problems.

**Course Contents**

| Unit I | Introduction to GPU Computing | (07 Hours) |
|---|---|---|

Evolution of graphics hardware,CPU vs GPU architecture comparison, Parallel computing concepts, SIMD and SIMT execution models, GPGPU overview and applications, Role of GPUs in AI, ML, and HPC

| | |
|---|---|
| **#Exemplar/Case Studies** | CPU vs GPU for Image Processing |
| ***Mapping of Course Outcomes** | CO1, CO6 |

| Unit II | GPU Architecture and Execution Model | (07 Hours) |
|---|---|---|

Overview of modern GPU architecture, Streaming Multiprocessors (SMs), CUDA cores, warps, and threads, Grid, block, and thread hierarchy, Instruction scheduling and occupancy, GPU execution pipeline

| | |
|---|---|
| **#Exemplar/Case Studies** | Thread & block optimization |
| ***Mapping of Course Outcomes** | CO1,CO2 |

| Unit III | GPU Memory Hierarchy | (07 Hours) |
|---|---|---|

| | |
|---|---|
| Types of GPU memory,Global, shared, local, constant, texture, Memory latency and bandwidth, Memory coalescing, Bank conflicts and shared memory optimization, Unified memory concept | |
| **#Exemplar/Case Studies** | Shared vs global memory |
| ***Mapping of Course Outcomes** | CO1,CO3,CO5 |

| **Unit IV** | **GPU Programming using CUDA and OpenCL** | **(07 Hours)** |
|---|---|---|
| CUDA programming model,Kernel definition and invocation, Thread indexing and synchronization, Atomic operations, Introduction to OpenCL platform and execution model, Error handling and debugging | | |
| **#Exemplar/Case Studies** | Matrix multiplication | |
| ***Mapping of Course Outcomes for Unit IV** | CO1,CO3 | |

| **Unit V** | **Performance Optimization Techniques** | **(07 Hours)** |
|---|---|---|
| GPU performance metrics, profiling tools (Nsight, nvprof), Memory optimization techniques, Reducing thread divergence, Loop unrolling and instruction optimization, Introduction to multi-GPU programming | | |
| **#Exemplar/Case Studies** | Profiling & divergence reduction | |
| ***Mapping of Course Outcomes for Unit IV** | CO1,CO3,CO4 | |

| **Unit VI** | **GPU-Based Applications and Case Studies** | **(07 Hours)** |
|---|---|---|
| GPU acceleration for deep learning, Image and video processing using GPU, Scientific simulations and numerical computing, Graph processing on GPUs, Case studies: real-time analytics, medical imaging, autonomous systems | | |
| **#Exemplar/Case Studies** | GPU in deep learning | |
| ***Mapping of Course Outcomes for Unit V** | CO3,CO5,CO6 | |

**Learning Resources**

**Text Books:**

1. David B. Kirk and Wen-mei W. Hwu, Programming Massively Parallel Processors, Morgan Kaufmann
2. Shane Cook, CUDA Programming: A Developer's Guide to Parallel Computing, Morgan Kaufmann

**Reference Books:**

1. John Nickolls and William J. Dally, The GPU Computing Era, IEEE
2. Benedict Gaster et al., Heterogeneous Computing with OpenCL, Morgan Kaufmann

**E-books:**

- https://www.onlineprogrammingbooks.com/cuda-succinctly/?utm_source=chatgpt.comhttps://www.ecse.rpi.edu/~nagy/PDF_chrono/2005_Zou_Nagy_complexity_05.pdf
- https://github.com/moocf/cuda-by-example.book?utm_source=chatgpt.com
- https://docs.nvidia.com/cuda/cuda-programming-guide/pdf/cuda-programming-guide.pdf?utm_source=chatgpt.com

**MOOC/ Video Lectures available at:**

- https://www.classcentral.com/course/swayam-gpu-architectures-and-programming-17622?utm_source=chatgpt.com
- https://archive.nptel.ac.in/courses/106/105/106105220/?utm_source=chatgpt.com

**The CO-PO mapping table**

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

**Savitribai Phule Pune University**
**Fourth Year of Computer Science and Engineering (Data Science) (2019 Course)**
**410643B : Elective-IV-Design Thinking**

| Teaching Scheme | Credit Scheme | Examination Scheme and Marks |
|---|---|---|
| Lecture: 03 Hours/Week | 03 | Mid_Semester(TH): 30 Marks<br>End_Semester(TH): 70 Marks |

**Prerequisite Courses :** Software Engineering

**Companion Course :** Computer Laboratory II

**Course Objectives:**

- To understand the fundamentals of Software Project Management
- To investigate software project planning and management tools
- To learn software project scheduling and tracking
- To discuss about the agile project management
- To know people management in software project

**Course Outcomes:**

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

1. Comprehend Project Management Concepts.
2. Use various tools of Software Project Management.
3. Schedule various activities in software projects.
4. Track a project and manage changes.
5. Apply Agile Project Management.
6. Analyze staffing process for team building and decision making in Software Projects and Management.

**Course Contents**

| Unit I | Introduction to Project Management | (07 Hours) |
|---|---|---|

Project Definition, Project versus Flow type work, Project Lifecycle, Processes and Knowledge Areas in Project Management (PM), Build or Buy decision, Work Breakdown Structure (WBS) and its types, Introduction to PMBOK, Program and Portfolio Management.

| | |
|---|---|
| **#Exemplar/Case Studies** | Analysis of a project using PMBOK concepts. |
| ***Mapping of Course Outcomes for Unit I** | CO1 |

| Unit II | Project Planning and Project Management Tools | (07 Hours) |
|---|---|---|

project Planning: Steps for Project Planning, PERT and Gantt Charts, Gantt Project, Microsoft Project and Primavera Project Management Software, Objectives of Activity planning, Project Schedules, Activities, Sequencing and Scheduling, Network Planning Models, Formulating Network Model.

| | |
|---|---|
| **#Exemplar/Case Studies** | Create software project plan using any tool. |
| ***Mapping of Course Outcomes for Unit II** | CO2 |

| Unit III | Activity based Scheduling | (07 Hours) |
|---|---|---|
| Introduction, Objectives of Activity Planning, Project Schedules. Activities: Sequencing and Scheduling, Network Planning Models, Formulating Network Model, Activity relationships (FS, SF, SS, FF), Forward Pass and Backward Pass techniques, Critical Path concept and remedies. | | |
| **#Exemplar/Case Studies** | Apply the critical path technique to the project | |
| ***Mapping of Course Outcomes for Unit III** | CO3 | |

| Unit IV | Project Tracking and Control | (07 Hours) |
|---|---|---|
| Introduction, Collection of Project data, Visualizing progress, Cost monitoring, Earned Value Analysis, Project tracking, Change Control, Software Configuration Management, Managing contracts, Contract Management. | | |
| **#Exemplar/Case Studies** | Analyze the effect of a major requirement change on the schedule | |
| ***Mapping of Course Outcomes for Unit IV** | CO4 | |

| Unit V | Agile Project Management | (07 Hours) |
|---|---|---|
| Predictive versus Empirical Management, Comparison between Non-Agile and Agile Project, Three stages of Agile Project, Estimation, Scope Management, Roles and Responsibilities, Scheduling and Tracking. | | |
| **#Exemplar/Case Studies** | Analyse the same project using Agile. Create the three stages of the project. | |
| ***Mapping of Course Outcomes for Unit V** | CO5 | |

| Unit VI | Staffing in Software Projects | (07 Hours) |
|---|---|---|
| Managing People, Organizational behaviour, Best methods of Staff Selection, Motivation, The Oldham, Hackman job characteristic Model, Stress, Health and Safety, Ethical and Professional concerns, Working in Teams, Decision Making, Organizational structures, Dispersed and Virtual Teams, Communications Genres, Communication Plans. | | |
| **#Exemplar/Case Studies** | Analyse a case study for a distributed team and comment | |
| ***Mapping of Course Outcomes for Unit II** | CO6 | |

## Learning Resources

**Text Books:**


1. Bob Hughes, Mike Cotterell and Rajib Mall, "Software Project Management", Sixth Edition, Tata McGraw Hill, New Delhi, 2017
2. Robert K. Wysocki, "Effective Software Project Management", Wiley Publication, 2011


**Reference Books:**


1. Ken Schwaber, "Agile Project Management", Microsoft Press, 2004
2. Walker Royce, "Software Project Management", Addison-Wesley, 1998
3. Jalote Pankaj, "Software Project Management in Practice", Addison-Wesley Professional,2002 4. PMBOK Guide

**E-books:**

- https://www.kornevonline.net/ITIL/Mcgraw.Hill.Software_Project_Management_2nd_Edition.pdf
- http://library.lol/main/B96E3B122326F8D2C6FBD35A5E978422

**MOOC/ Video Lectures available at:**

- https://onlinecourses.nptel.ac.in/noc19_cs70/preview
- Software Project Management By Prof. Rajib Mall & Prof. Durga Prasad Mohapatra | IIT Kharagpur
- Agilealliance.org, Scrum.org, Scrumalliance.org

**The CO-PO mapping table**

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

**Savitribai Phule Pune University**

**Fourth Year of Computer Science and Engineering (Data Science) (2019 Course)**

**410643C: Elective-IV- Bio Inspired Algorithms**

| Teaching Scheme | Credit Scheme | Examination Scheme and Marks |
|---|---|---|
| Lecture: 03 Hours/Week | 03 | Mid_Semester(TH): 30 Marks<br>End_Semester(TH): 70 Marks |

**Prerequisite Courses :** Data Structures and Algorithms

**Companion Course :** Computer Laboratory II

**Course Objectives:**

- To introduce the fundamental concepts of bio-inspired computing and natural evolutionary systems.
- To understand optimization techniques based on biological evolution.
- To study Genetic Algorithms and their application in solving optimization problems.
- To analyze swarm intelligence algorithms inspired by collective behavior of natural systems.
- To design and implement bio-inspired algorithms for solving engineering problems.
- To evaluate and compare the performance of different bio-inspired optimization techniques.

**Course Outcomes:**

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

1. To explain the concepts of biological inspiration and natural computing techniques.
2. To analyze optimization problems using evolutionary computation principles.
3. To apply Genetic Algorithms for solving complex optimization problems.
4. To analyze swarm intelligence techniques such as Particle Swarm Optimization and Ant Colony Optimization.
5. To implement bio-inspired algorithms to solve real-world engineering problems.
6. To evaluate and compare different bio-inspired optimization algorithms.

**Course Contents**

| Unit I | Introduction to Bio-Inspired Computing | (07 Hours) |
|---|---|---|

Introduction to Natural Computing, Biological Inspiration in Computing, Evolutionary principles in nature, Optimization problems and search techniques, Classification of bio-inspired algorithms, Population-based vs single solution algorithms, Advantages and limitations of bio-inspired algorithms, Applications in engineering, robotics, machine learning and network optimization.

| | |
|---|---|
| **#Exemplar/Case Studies** | Optimization in Delivery Route Planning |
| ***Mapping of Course Outcomes** | CO1 |

| Unit II | Genetic Algorithms | (07 Hours) |
|---|---|---|

| | | |
|---|---|---|
| Introduction to Genetic Algorithms, Biological foundations of Genetic Algorithms.<br>**Chromosome representation techniques:** Binary representation, Real-valued representation<br>Fitness evaluation and objective functions.<br>**Genetic operators:** Selection methods (Roulette wheel, Tournament selection), Crossover techniques (Single point, Two point, Uniform crossover), Mutation operators.<br>Elitism and replacement strategies, Convergence and termination criteria, Applications of Genetic Algorithms in optimization and scheduling problems | | |
| **#Exemplar/Case Studies** | Genetic Algorithm for Job Scheduling | |
| ***Mapping of Course Outcomes for Unit II** | CO2 | |
| | | |
| **Unit III** | **Evolutionary Algorithms** | **(07 Hours)** |
| Introduction to Evolutionary Computation, Evolutionary Programming (EP), Evolutionary Strategies (ES), Differential Evolution (DE), Self-adaptation mechanisms, Fitness landscape analysis, Exploration vs exploitation in evolutionary algorithms, Applications in engineering design and optimization problems. | | |
| **#Exemplar/Case Studies** | Differential Evolution for Engineering Design | |
| ***Mapping of Course Outcomes for Unit III** | CO3 | |
| | | |
| **Unit IV** | **Naming and Distributed File Systems** | **(07 Hours)** |
| Introduction to swarm intelligence, Collective behavior in biological systems.<br>**Particle Swarm Optimization (PSO):** Velocity and position update equations, Global best and local best models<br>**Ant Colony Optimization (ACO):** Pheromone update rules, Path finding optimization<br>Artificial Bee Colony Algorithm, Firefly Algorithm, Applications of swarm intelligence in routing, scheduling and clustering. | | |
| **#Exemplar/Case Studies** | Ant Colony Optimization for Network Routing | |
| ***Mapping of Course Outcomes for Unit IV** | CO4 | |
| | | |
| **Unit V** | **Advanced Bio-Inspired Algorithms and Applications** | **(07 Hours)** |
| Hybrid bio-inspired algorithms, Memetic algorithms, Multi-objective optimization, Bio-inspired algorithms in machine learning, Feature selection using evolutionary algorithms,Bio-inspired approaches for data mining, Applications in robotics, control systems, cloud computing and network optimization, Performance comparison of bio-inspired algorithms | | |
| **#Exemplar/Case Studies** | Feature Selection in Machine Learning Using PSO | |
| ***Mapping of Course Outcomes for Unit IV** | CO5 | |
| | | |
| **Unit VI** | **Emerging Bio-Inspired Algorithms and Real-World Applications** | **(07 Hours)** |
| **Hybrid Bio-Inspired Algorithms:** Concept of hybrid optimization techniques, Combination of Genetic Algorithms with Swarm Intelligence, Hybrid GA–PSO models, Benefits of hybrid algorithms in complex optimization problems<br>**Memetic Algorithms:** Introduction to Memetic Algorithms, Local search and global search integration, | | |

| | |
|---|---|
| Advantages over traditional evolutionary algorithms, Applications in optimization problems<br>**Multi-Objective Optimization:** Concept of multi-objective problems, Pareto optimality and Pareto front, Multi-objective evolutionary algorithms, Applications in engineering design problems<br>**Bio-Inspired Algorithms in Machine Learning:** Feature selection using evolutionary algorithms, Parameter tuning in machine learning models, Optimization in neural networks, Bio-inspired approaches for deep learning<br>**Real-World Applications:** Network routing optimization, Robotics path planning, Cloud computing resource allocation, Data mining and big data analytics, Smart grid and energy optimization<br>**Performance Evaluation of Bio-Inspired Algorithms:** Convergence analysis, Computational complexity, Benchmark optimization problems, Comparison of different bio-inspired techniques | |
| **#Exemplar/Case Studies** | Cloud Resource Allocation Using Hybrid Bio-Inspired Algorithms |
| ***Mapping of Course Outcomes for Unit V** | CO6 |

**Learning Resources**

**Text Books:**

1. Eiben A. E. and Smith J. E., Introduction to Evolutionary Computing, Springer.
2. Xin-She Yang, Nature-Inspired Optimization Algorithms, Elsevier.

**Reference Books:**

1. David Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning, Addison-Wesley.
2. James Kennedy and Russell Eberhart, Swarm Intelligence, Morgan Kaufmann.
3. Marco Dorigo and Thomas Stützle, Ant Colony Optimization, MIT Press.

**E-books:**

- Bio-Inspired Computational Algorithms and Their Applications

**MOOC/ Video Lectures available at:**

- https://onlinecourses.nptel.ac.in/

**The CO-PO mapping table**

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

**Savitribai Phule Pune University**

**Fourth Year of Computer Science and Engineering(Data Science) (2019 Course)**

**410643D : Elective-IV-Open Elective**

| Teaching Scheme | Credit Scheme | Examination Scheme |
|---|---|---|
| Lecture: 03 Hours/Week | 03 | Mid_Semester(TH): 30 Marks<br>End_Semester(TH): 70 Marks |

**Prerequisite Courses :**

**Companion Course :** Computer Laboratory Practice II

The open elective included, 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/exotic/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 Science and Engineering (Data Science) (2019 Course)**

**410644: Computer Laboratory I**

| Teaching Scheme: | Credit | Examination Scheme: |
|---|---|---|
| Practical: 04 Hrs. / week | 02 | Practical: 25 Marks<br>Termwork: 50 Marks |

**Prerequisite Courses, if any:** Fundamental knowledge of programming language and basics of algorithms.

**Companion Course, if any:** Deep Learning, Data Modeling & Visualization

**Course Objectives**

- To provide hands-on experience in data preprocessing and exploratory data analysis.
- To implement machine learning and deep learning models using modern tools.
- To apply data modeling techniques for predictive analytics.
- To visualize data insights using visualization libraries and dashboards.
- To evaluate model performance using appropriate metrics.
- To develop problem-solving and experimentation skills in AI-based systems.

**Course Outcomes**

**CO1:** Perform data cleaning, preprocessing and exploratory data analysis using programming tools

**CO2:** Build and train machine learning models for classification and regression problems

**CO3:** Design and implement deep learning models using neural networks.

**CO4:** Visualize datasets and model outputs using appropriate visualization techniques.

**CO5:** Evaluate and compare model performance using statistical metrics.

**CO6:** Develop complete AI workflows integrating data modeling and visualization.

**Guidelines for Instructor's Manual**

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

**Guidelines for Student's Laboratory Journal**

1. The laboratory assignments are to be submitted by students in the form of journal. Journal consists of prologue, Certificate, table of contents, and **handwritten write-up** of each assignment (Title, Objectives, Problem Statement, Outcomes, software & Hardware requirements, Date of Completion, 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.
2. **Program codes with sample output of all performed assignments are to be submitted as softcopy.**
3. 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.
4. 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 at Laboratory.

**Guidelines for Laboratory /Term Work Assessment**

Continuous assessment of laboratory work is done based on overall performance and Laboratory assignments performance of student. Each Laboratory assignment assessment will assign grade/marks based on parameters with appropriate weightage. Suggested parameters for overall assessment as well as each Laboratory assignment assessment include- timely completion, performance, innovation, efficient codes, punctuality and neatness.

| 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 need to address the average students and inclusive of an element to attract and promote the intelligent students. The instructor may set multiple sets of assignments and distribute among batches of students. It is appreciated if the assignments are based on real world problems/applications. Encourage students for appropriate use of Hungarian notation, proper indentation and comments. Use of open-source software is to be encouraged.<br>In addition to these, instructor may assign one real life application in the form of a mini-project based on the concepts learned. Instructor may also set one assignment or mini-project that is suitable to respective branch beyond the scope of syllabus.<br>Set of suggested assignment list is provided in groups- A, B, C, D, and E. Each student must perform at least 12 assignments as at least 02 from group A, 03 from group B, 03 from group C, 2 from group D, 02 from group E.<br>**Operating System recommended:** - 64-bit Open-source Linux or its derivative<br>**Programming tools recommended**: - Open-Source Python, C++ Programming tool like G++/GCC, Jupyter Notebook, PyCharm, Spyder. |

| Suggested List of Laboratory Experiments/Assignments | |
|---|---|
| **Sr. No.** | **Group A(Any 5 from 1-7)** |
| 1 | Study and installation of Python, Anaconda, Jupyter Notebook. |
| 2 | Data preprocessing: Handling missing values, normalization, encoding categorical variables. |
| 3 | Exploratory Data Analysis (EDA) using Pandas and NumPy. |
| 4 | Implementation of Linear Regression |
| 5 | Implementation of Decision Tree and Random Forest. |
| 6 | K-Means Clustering for unsupervised learning. |
| 7 | Model evaluation using confusion matrix, accuracy, precision, recall, F1-score. |
| **Sr. No.** | **Group B (Any 3 from 1-5)** |
| 1 | Introduction to TensorFlow / Keras / PyTorch framework. |
| 2 | Implementation of Artificial Neural Network (ANN). |
| 3 | Implementation of Convolutional Neural Network (CNN) for image classification. |
| 4 | Implementation of Recurrent Neural Network (RNN) / LSTM for sequence prediction. |
| 5 | Hyperparameter tuning and model optimization. |
| **Sr. No.** | **Group C (Mini Project: In Team of 3-4 Students)** |
| 1 | Student Performance Prediction |
| 2 | Customer Churn Prediction |
| 3 | Sentiment Analysis using LSTM |
| 4 | Handwritten Digit Recognition |
| 5 | IPL Data Analysis Dashboard |

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

## Savitribai Phule Pune University
## Fourth Year of Computer Science and Engineering (Data Science) (2019 Course)
## 410645 : Computer Laboratory II

| Teaching Scheme: | Credit: | Examination Scheme: |
|---|---|---|
| PR: 04 Hours/Week | 02 | Term Work: 50 Marks<br>Oral Exam: 25 Marks |

**Companion Course, if any:** Elective III & Elective IV

**Course Objectives:**

- Understand fundamentals of Quantum Computing and AI concepts through simulation tools.
- Apply GPU programming techniques for parallel problem solving.
- Analyze enterprise architecture components and model enterprise systems.
- Apply Design Thinking methodology to solve real-world problems.
- Implement basic bioinformatics tools and biological data analysis.
- Develop and test bio-inspired optimization algorithms for engineering problems.

**Course Outcomes:**

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

**CO1** Implement basic quantum circuits and AI models using simulation platforms
**CO2** Develop and execute GPU-based parallel programs
**CO3** Design enterprise architecture models using standard frameworks
**CO4** Apply Design Thinking tools to generate innovative solutions
**CO5** Perform biological data analysis using bioinformatics tools
**CO6** Implement and evaluate bio-inspired algorithms for optimization problems

**Guidelines for Instructors 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 Students 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, punctuality |
| **Guidelines for Oral Examination** |
| Oral examination should be jointly conducted by the internal examiner and external examiner. Relevant questions may be asked at the time of evaluation to test the student‘s understanding of the fundamentals, effective and efficient implementations in term work. 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 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 or mini-project that is suitable to respective branch beyond the scope of syllabus. Operating System recommended: -64-bit Open-source Linux or its derivative Programming tools recommended: - Open-Source /C/C++/JAVA Programming tool like G++/GCC, Wireshark/Ethereal and Packet Tracer | |
| | **Suggested List of Laboratory Experiments/Assignments from all Groups (A, B, C) are compulsory.** |
| **Sr. No.** | **Group A Quantum Computing & AI (Attempt any Four Experiment from Sr. No. 1 to 5. )** |
| 1 | Installation and setup of Qiskit / quantum simulator. |
| 2 | Implementation of basic quantum gates (Hadamard, Pauli-X, CNOT). |
| 3 | Design and simulation of quantum circuits. |
| 4 | Implementation of a simple AI model using quantum concepts |
| 5 | Hybrid Quantum-Classical ML model demonstration. |
| **Group B Enterprise Architecture & Components(Attempt any Four Experiment from Sr. No. 1 to 5.)** | |
| 1 | Study of Enterprise Architecture frameworks (TOGAF/Zachman). |
| 2 | Modeling Business Architecture using UML. |
| 3 | Designing Application Architecture diagram. |
| 4 | Data Architecture modeling. |
| 5 | Case study on enterprise system integration. Prototype development (Low-fidelity model). |
| **Group C Bioinformatics(Attempt any Four Experiment from Sr. No. 1 to 5.)** | |
| 1 | Study of primary and secondary biological databases |
| 2 | To perform sequence similarity search using BLAST. |
| 3 | To construct and analyze a phylogenetic tree. |
| 4 | To visualize 3D structure of a protein. |
| 5 | To design primers for a selected gene sequence. |
| **Group D GPU Programming & Architecture (Attempt any Four Experiment from Sr. No. 1 to 5.)** | |

| | |
|---|---|
| 1 | Study of GPU architecture (CUDA cores, memory hierarchy). |
| 2 | Installation and configuration of CUDA toolkit |
| 3 | Vector addition using CUDA. |
| 4 | Matrix multiplication using GPU. |
| 5 | Performance comparison: CPU vs GPU execution. |
| **Group D Design Thinking (Attempt any Four Experiment from Sr. No. 1 to 5.)** | |
| 1 | To convert user insights into a clear problem statement. |
| 2 | To generate innovative solutions using structured ideation methods. |
| 3 | To create user personas based on collected data. |
| 4 | To analyze business feasibility of the solution. |
| 5 | To present the complete Design Thinking solution cycle. |
| **Group E Bio-inspired Algorithm (Attempt any Four Experiment from Sr. No. 1 to 5.)** | |
| 1 | Study of evolutionary and swarm intelligence concepts. |
| 2 | Implement Genetic Algorithm |
| 3 | Apply GA to optimize mathematical benchmark functions |
| 4 | Implement Ant Colony Optimization |
| 5 | Implement Artificial Bee Colony Algorithm |

**The CO-PO mapping table**

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

## Savitribai Phule Pune University
## Fourth Year of Computer Science and Engineering (Data Science) (2019 Course)
## 410646 : Project Stage I

| Teaching Scheme: | Credit: | Examination Scheme: |
|---|---|---|
| PR: 04 Hours/Week | 02 | Term Work: 50 Marks<br>Oral Exam: 50 Marks |

**Companion Course, if any:** Elective III & Elective IV

**Course Objectives:**

- The practical implementation of theoretical knowledge gained during the study from FE to TE.
- The student should be able implement their ideas/real time industrial problem/ current application of their engineering branch which they have studied in curriculum.
- To build confidence in the student what he has learnt theoretically.
- The dependent study of the state of the art topics in a broad area of his/her specialization.

**Course Outcomes:**

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

1. Analyze a real-world engineering problem through a comprehensive literature survey to clearly define the problem scope, objectives, and constraints.
2. Analyze existing solutions and technologies to formulate system requirements and feasibility, considering technical, economic, and societal factors.
3. Design an appropriate system architecture and methodological framework, including selection of tools, platforms, and algorithms for the proposed solution.
4. Create a complete project proposal and preliminary system model, and communicate the design effectively through technical documentation and presentations.

**Guidelines & Contents**

**Project Based Seminar (PBS)** helped students to gather, organize, summarize and interpret technical literature with the purpose of formulating a project proposal in third year as part of course **314456 : Seminar& Technical Communication Laboratory.** They also submitted a technical report summarizing state-of-the-art on an identified topic.

**B.E. Projects can be two types: Projects based on implementation of any application oriented problem, which will be more or less experimental in nature, and the others will be based on some innovative/ theoretical work.**

In Project Phase-I the student will undertake same project over the academic year, which will involve the analysis, design of a system or sub system in the area identified earlier in the field of Information Technology and Computer Science and Engineering. In some cases; if earlier identified project is not feasible; a new topic must be formulated in consultation with the guide and project coordinator.

The project will be undertaken preferably by a group of **3-4 students** who will jointly work and implement the project. The group will select a project with approval from a committee formed by the department of senior faculty to check the feasibility and approve the topic.

**Review Committee:**

The Head of the department/Project coordinator shall constitute a review committee for project work for project group; project guide would be one member of that committee by default. There shall be at least two reviews in semester-I and semester-II by the review committee. The students or project group shall make presentation on the progress made by them before the committee. The record of the remarks/suggestions of the review committee should be properly maintained and should be made available at the time of examination.

Each student/group is required to give presentation as part of review for 10 to 15 minutes followed by a detailed discussion.

**The CO-PO mapping table**

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

**Savitribai Phule Pune University**

**Fourth Year of Computer Science and Engineering (Data Science) (2019 Course)**

**410647 : MOOC**

| Teaching Scheme: | Credit: | Examination Scheme: |
|---|---|---|
| TUT: 02 Hours/Week | 02 | Term Work: 50 Marks |

**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, learner will be able to–

**CO1:** To acquire additional knowledge and skill

**CO2:** Explore new areas of interest in a relevant field

**Course Contents**

MOOCs (Massive Open Online Courses) provide affordable and flexible ways 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 enhance active learning for improving lifelong learning skills by providing easy access to global resources. SWAYAM is a programme initiated by the Government of India and designed to achieve the three cardinal principles of Education Policy viz., access, equity and quality. The objective of this effort 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 are generally in 4 quadrants – (1) video lecture, (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 multimedia and state of the art pedagogy / technology. In order to ensure best quality content is produced and delivered, seven National Coordinators have been appointed: They are NPTEL for engineering and UGC for postgraduation 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. Learning can also be more interesting by knowledge sharing through different blogs, learning communities and social media platforms.

**References**:

1. https://swayam.gov.in/
2. https://onlinecourses.nptel.ac.in/
3. https://www.edx.org
4. https://www.mygreatlearning.com/academy
5. https://www.simplilearn.com

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

| | |
|---|---|
| • Lectures/ Guest Lectures<br>• Visits (Social/Field) and reports<br>• Demonstrations | • Surveys<br>• Mini-Project<br>• Hands on experience on focused topic |

A report of 15-20 pages contains any of the activity details mentioned above.

# Savitribai Phule Pune University
## Fourth Year of Computer Science and Engineering (Data Science) (2019 Course)
## 410648 : 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
- 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
- Presentations, IPR/Publication and Report

**Audit Course 3 Options**

| Audit Course Code | Audit Course Title |
|---|---|
| **AC7-I** | Cyber Security |
| **AC7-II** | Professional Ethics and Etiquettes |
| **AC7-III** | Entrepreneurship Development |
| **AC7-IV** | Botnet of Things |
| **AC7-V** | MOOC- Learn New Skills |

Note: It is permitted to opt one of the audit courses listed at SPPU website too, if not opted earlier.
http://collegecirculars.unipune.ac.in/sites/documents/Syllabus%202017/Forms/AllItems.aspx
http://www.unipune.ac.in/university_files/syllabi.htm

## Savitribai Phule Pune University
## Fourth Year of Computer Science and Engineering(Data Science) (2019 Course)
## 410648: Audit Course 7
### AC7-I: Cyber Security

**Prerequisites:** Computer Network and Security (310244)

**Course Objectives:**

1. To motivate students for understanding the various scenarios of cybercrimes
2. To increase awareness about the cybercrimes and ways to be more secure in online activities
3. To learn about various methods and tools used in cybercrimes
4. To analyze the system for various vulnerabilities

**Course Outcomes:**

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

**CO1:** Understand and classify various cybercrimes

**CO 2:** Understand how criminals plan for the cybercrimes

**CO 3:** Apply tools and methods used in cybercrime

**CO 4:** Analyze the examples of few case studies of cybercrimes

**Course Contents**

1. Introduction to Cybercrime: Introduction, Cybercrime: Definition and Origins of the Word, Cybercrime and Information Security, Cybercriminals, Classifications of Cybercrimes, Cybercrime: The Legal Perspectives, Cybercrimes: An Indian Perspective.
2. Cyber offenses: How Criminals Plan Them: Introduction, How Criminals Plan the Attacks, Social Engineering, Cyber stalking, Cyber cafe and Cybercrimes, Botnets: The Fuel for Cybercrime, Attack Vector, Cloud Computing.
3. Tools and Methods Used in Cybercrime : Introduction, Proxy Servers and Anonymizers, Phishing, Password Cracking, Key loggers and Spywares, Virus and Worms, Trojan Horses and Backdoors, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Overflow, Attacks on Wireless Networks (Expected to cover the introduction to all these terms).
4. Cybercrime: Illustrations, Examples and Mini-Case: Introduction, Real-Life Examples, Mini-Cases, Illustrations of Financial Frauds in Cyber Domain, Digital Signature-Related Crime Scenarios, Digital Forensics Case Illustrations, Online Scams.

**Team Projects:**

Students will be formed into groups to research green construction and design in a particular construction context and report their results to the class. What are the particular obstacles and opportunities to integrating green construction techniques into the following sectors? Be sure to consider technical, social, political and economic issues:

Hotels (economy, luxury, resorts ), Hospitals, Retail( big box, malls, small scale downtown retail), Office, Government, ,Schools, Universities, Housing, Transportation Stations (Airport Terminals, Train Stations).

**Text Books :**

1. Nina Godbole, Sunit Belapure , “Cyber Security- Understanding Cyber Crimes”, Computer Forensics and Legal Perspectives, Wiely India Pvt. Ltd, ISBN- 978-81-265-2179-1
2. William Stallings, “Computer Security: Principles and Practices”, Pearson 6thEd, ISBN 978-013-335469-0

**Reference Books :**

1. Berouz Forouzan, “Cryptography and Network Security”, TMH, 2 edition, ISBN -978-00-7070208-0. 5.
2. Mark Merkow, “Information Security-Principles and Practices”, Pearson Ed., ISBN- 978-81317-1288-7
3. CK Shyamala et el., “Cryptography and Security”, Wiley India Pvt. Ltd, ISBN-978-81-2652285-9

## Savitribai Phule Pune University
## Fourth Year of Computer Science and Engineering(Data Science) (2019 Course)
## 410648: Audit Course 7
### AC7-II: Professional Ethics and Etiquettes

**Prerequisites:** Business Communication Skill

**Course Objectives:**

1. To learn importance of ethics and the rules of good behavior for today's most common social and business situations.
2. To acquire basic knowledge of ethics to make informed ethical decisions when confronted with problems in the working environment.
3. To develop an understanding towards business etiquettes and the proper etiquette practices for different business scenarios.
4. To learn the etiquette requirements for meetings, entertaining, telephone, email and Internet business interaction scenario.

**Course Outcomes:**

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

**CO1:** Summarize the principles of proper courtesy as they are practiced in the workplace.

**CO2:** Apply proper courtesy in different professional situations.

**CO3:** Practice and apply appropriate etiquettes in the working environment and day to day life.

**CO4:** Build proper practices personal and business communications of Ethics and Etiquettes.

**Course Contents**

1. **Introduction to Ethics:** Basics, Difference Between Morals, Ethics, and Laws, Engineering Ethics: Purpose of Engineering Ethics-Professional and Professionalism, Professional Roles to be played by an Engineer, Uses of Ethical Theories, Professional Ethics, Development of Ethics.
2. **Professional Ethics:** IT Professional Ethics, Ethics in the Business World, Corporate Social Responsibility, Improving Corporate Ethics, Creating an Ethical Work Environment, Including Ethical Considerations in Decision Making, Ethics in Information Technology, Common Ethical issues for IT Users, Supporting the Ethical Practices of IT users.
3. **Business Etiquette:** ABC's of Etiquette, Developing a Culture of Excellence, The Role of Good Manners in Business, Enduring Words Making Introductions and Greeting People: Greeting Components, The Protocol of Shaking Hands, Introductions, Introductory Scenarios, Addressing Individuals Meeting and Board Room Protocol: Guidelines for Planning a Meeting, Guidelines for Attending a Meeting.
4. **Professional Etiquette:** Etiquette at Dining, Involuntary Awkward Actions, How to Network, Networking Etiquette, Public Relations Office(PRO)'s Etiquettes, Technology
   Etiquette : Phone Etiquette, Email Etiquette, Social Media Etiquette, Video Conferencing Etiquette, interview Etiquette, Dressing Etiquettes : for interview, offices and social functions.

**References Books:**


1. Ghillyer, “Business Ethics Now”, 3rd Edition, McGraw-Hill.
2. George Reynolds, “Ethics in information Technology”, Cengage Learning, lSBN- 10:1285197151.
3. Charles E Harris, Micheat J. Rabins, “Engineering Ethics”, Cengage Learning, ISBN-13:9781133934684,4th Edition.

# Savitribai Phule Pune University
## Fourth Year of Computer Science and Engineering(Data Science) (2019 Course)
## 410648: Audit Course 7
### AC7-III: Learn New Skills- Full Stack Developer

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–

1. Implement security as a culture and show mistakes that make applications vulnerable to attacks.
2. Understand various attacks like DoS, buffer overflow, web specific, database specific, web spoofing attacks.
3. Demonstrate skills needed to deal with common programming errors that lead to most securityproblems 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 Senosors 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

**Reference 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-01.ibm.com/marketing/iwm/dreMike Kuniavsky, “Smart Things: Ubiquitous Computing User Experience Design,” Morgan Kaufmann Publishers.

## Savitribai Phule Pune University

## Final Year of Computer Science and Engineering in Data Science(2019 Course)

## 410648: Audit Course 7

### AC7-IV: Engineering Economics

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/ end 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/ end use product for 3D Printing

**Course Contents**

1. **Getting Started with 3D Printing:** How 3D Printers Fit into Modern Manufacturing, Exploring theTypes 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:** Commoditizing 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 RepEap of Your Own.

**Reference Books:**


1. Richard Horne, Kalani Kirk Hausman, " 3D Printing for Dummies", Taschenbuch, ISBN: 9781119386315
2. Greg Norton, "3D Printing Business - 3D Printing for Beginners - How to 3D Print",ISBN:9781514785669
3. Liza Wallach Kloski and Nick Kloski, " 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

## Fourth Year of Computer Science and Engineering(Data Science) (2019 Course)

## 410648: Audit Course 7

### AC7-V: MOOC- Learn New Skills

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 open up more doors and job opportunities
- To introduce to Japanese society, culture and entertainment

**Course Outcomes:**

On completion of the course learner will able to

**CO1:** Apply language to communicate confidently and clearly in the Japanese language

**CO2:** Understand and use Japanese script to read and write

**CO3:** Apply knowledge for next advance level reading, writing and listening skills

**CO4:** Develop interest to pursue further study, work and leisure

**Course Contents**

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'reinterested in learning for yourself, advancing your career or leveraging online courses to educate your workforce, SWYAM, 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 effortis 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 lecture, (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:**

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:**


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

# Semester VIII

## Savitribai Phule Pune University
## Fourth Year of Computer Science and Engineering (Data Science) (2019 Course)
## 410649: Block chain Technology

| Teaching Scheme: | Credit: | Examination Scheme: |
|---|---|---|
| TH: 03 Hours/Week | 03 | Mid_Semester(TH): 30 Marks<br>End_Semester(TH): 70 Marks |

**Prerequisite Courses, if any:** Discrete Mathematics (210241), Database Management Systems (310341)

**Companion Course, if any:** Computer Laboratory-III

**Course Objectives:**

- Explain the fundamental concepts, architecture, and working principles of blockchain technology.
- Describe cryptographic techniques such as hashing, digital signatures, and consensus mechanisms used in blockchain.
- Demonstrate the working of distributed ledger systems and analyze different blockchain platforms.
- Develop smart contracts and decentralized applications (DApps) using suitable blockchain frameworks.
- Evaluate real-world blockchain use cases in finance, supply chain, healthcare, and governance.
- Evaluate blockchain applications in domains such as finance, supply chain, healthcare, and governance.

**Course Outcomes:**

On completion of the course, learner will be able to–
**CO1:** Interpret fundamentals and basic concepts of Blockchain.
**CO2**: Describe different blockchain platforms and consensus mechanisms.
**CO3:** Apply crypto wallets to perform cryptocurrency-based transactions.
**CO4:** Describe blockchain-based solutions for real-world problems.
**CO5:** Interpret smart contracts on Ethereum using Solidity tools/platform.
**CO6:** Discuss application domains where blockchain technology can be effectively deployed.

**Course Contents**

| 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 | (06 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** | CO2 |

| 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, What is Ethereum, Types of Ethereum Networks, EVM (Ethereum Virtual Machine) | | |
| **#Exemplar/Case Studies** | Create your own wallet for crypto currency using any of the Blockchain Platforms. | |
| **Mapping of Course Outcomes for Unit IV** | CO4, CO2 | |

| Unit V | Blockchain Ethereum Platform using Solidity | (06 Hours) |
|---|---|---|
| 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, CO2 | |

| 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 uses cases of Blockchain and write a detailed report on every aspect implemented in the same | |
| **Mapping of Course Outcomes for Unit V** | 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 PublishingPlatform, 15-May-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 Dhameja, Priyansu Sekhar Panda, "Beginning Blockchain ABeginner's Guide to Building Blockchain Solutions",2018
2. Chris Dannen, "Introducing Ethereum and Solidity", Foundations of Crypto currency andBlockchain 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


**MOOCs Courses links:**

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

**The CO-PO mapping table**

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

## Savitribai Phule Pune University
## Fourth Year of Computer Science and Engineering(Data Science) (2019 Course)
## 410650: Distributed Computing

| Teaching Scheme: | Credit: | Examination Scheme: |
|---|---|---|
| TH: 03 Hours/Week | 03 | Mid_Semester(TH): 30 Marks<br>End_Semester(TH): 70 Marks |

**Prerequisite Courses, if any:** Computer Networks, Operating Systems, Data Structures, Database Management Systems (Desirable)

**Companion Course, if any:** Computer Laboratory-III

**Course Objectives:**

1. To learn the fundamentals of web essentials and markup languages
2. To use the Client side technologies in web development
3. To use the Server side technologies in web development
4. To understand the web services and frameworks

**Course Outcomes:**

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

**CO1:** Describe the models, architecture, and characteristics of distributed systems.
**CO2:** Implement communication and synchronization mechanisms in distributed environments
**CO3:** Apply distributed algorithms for mutual exclusion, election, and consensus.
**CO4:** Analyze consistency models, replication strategies, and distributed transactions.
**CO5:** Evaluate fault tolerance, recovery mechanisms, and performance issues in distributed systems
**CO6:** Design scalable and secure distributed applications using appropriate frameworks and middleware.

**Course Contents**

| Unit I | Introduction to Distributed Systems | (07 Hours) |
|---|---|---|

Definition and Characteristics, Goals: Resource sharing, transparency, openness, scalability, Challenges: Heterogeneity, security, fault tolerance, Distributed System Models: Physical Models, Architectural Models (Client–Server, Peer-to-Peer, Multi-tier),Fundamental Models (Interaction, Failure, Security models),Middleware: Role of Middleware, Middleware Architectures, Examples: CORBA, RMI

| | |
|---|---|
| **#Exemplar/Case Studies** | Distributed Infrastructure of Google |
| **Mapping of Course Outcomes for Unit I** | CO1 |

| Unit II | Communication in Distributed Systems | (07 Hours) |
|---|---|---|

Interprocess Communication (IPC): Message Passing. Sockets, Datagram and Stream Communication,Remote Parameter Passing Mechanisms, Group Communication: Multicast Communicationn: Publish–Subscribe Model

| | |
|---|---|
| **#Exemplar/Case Studies** | Communication Model in Apache Hadoop |

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

| **Unit III** | **Time, Global State & Coordination** | **(07 Hours)** |
|---|---|---|
| Time in Distributed Systems: Physical Clocks, Clock Synchronization (Cristian's Algorithm, Berkeley Algorithm), Logical Clocks: Lamport Timestamps, Vector Clocks, Global State Consistent Global States, Chandy–Lamport Snapshot Algorithm, Distributed Mutual Exclusion, Centralized Algorithm, Ricart–Agrawala Algorithm, Token Ring Algorithm, Leader: Election Algorithms, Bully Algorithm, Ring Algorithm | | |
| **#Exemplar/Case Studies** | Mutual Exclusion in Distributed Databases – Ricart–Agrawala Algorithm | |
| **Mapping of Course Outcomes for Unit III** | CO3 | |

| **Unit IV** | **Consistency, Replication & Transactions** | **(07 Hours)** |
|---|---|---|
| Consistency Models: Strict Consistency, Sequential Consistency, Causal Consistency, Eventual Consistency, Data Replication: Active & Passive Replication, Primary-Backup Protocol, Distributed Transactions, ACID Properties: Two-Phase Commit (2PC), Three-Phase Commit (3PC) | | |
| **#Exemplar/Case Studies** | Distributed Databases in Amazon Web Services | |
| **Mapping of Course Outcomes for Unit IV** | CO3, CO4 | |

| **Unit V** | **Fault Tolerance & Consensus** | **(07 Hours)** |
|---|---|---|
| Failure Models: Crash Failures, Omission Failures, Byzantine Failures, Fault Tolerance Techniques: Replication Checkpointing and Recovery, Rollback Recovery, Consensus Algorithms: Paxos (Overview),Raft (Overview),Byzantine Fault Tolerance | | |
| **#Exemplar/Case Studies** | Consensus Algorithm in Google – Paxos in Distributed Services | |
| **Mapping of Course Outcomes for Unit V** | CO5, CO6 | |

| **Unit VI** | **Security, Distributed File Systems & Cloud** | **(07 Hours)** |
|---|---|---|
| Security in Distributed Systems: Authentication, Authorization, Confidentiality & Integrity, Public Key Infrastructure (PKI), Distributed File Systems: Design Principles, Case Study: Google File System (GFS), Cloud Computing Basics: Virtualization, Containerization, Microservices Architecture | | |
| **#Exemplar/Case Studies** | Architecture of Microsoft Azure | |
| **Mapping of Course Outcomes for Unit VI** | CO6 | |

## Learning Resources

**Text Books:**

1. Andrew S. Tanenbaum & Maarten Van Steen, Distributed Systems: Principles and Paradigms, Pearson.
2. George Coulouris, Jean Dollimore, Tim Kindberg, Distributed Systems: Concepts and Design, Pearson.

**Reference Books:**

1. Ajay D. Kshemkalyani & Mukesh Singhal, Distributed Computing: Principles, Algorithms, and Systems, Cambridge University Press.
2. Maarten van Steen & Andrew S. Tanenbaum, Distributed Systems, 3rd Edition (Online Open Book).

**MOOC Courses:**

- **Distributed Systems** by Prof. Rajiv Misra (IIT Patna) Distributed Systems – NPTEL Course Page
- **Distributed Computing Systems** (classic NPTEL archived course) Distributed Computing Systems – Archived NPTEL
- **Cloud Computing and Distributed Systems** by Prof. Rajiv Misra (IIT Patna) Cloud Computing and Distributed Systems – NPTEL

**The CO-PO mapping table**

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

**Savitribai Phule Pune University**

**Fourth Year of Computer Science and Engineering (Data Science) (2019 Course)**

**Elective V:410651A: Virtual & Augmented Reality**

| Teaching Scheme: | Credit: | Examination Scheme: |
|---|---|---|
| TH: 03 Hours/Week | 03 | Mid_Semester(TH): 30 Marks<br>End_Semester(TH): 70 Marks |

**Prerequisite Courses, if any:** Computer Graphics, Data Structures

**Course Objectives:**

- Explain fundamental concepts and components of Virtual Reality (VR) and Augmented Reality (AR).
- Describe hardware devices and tracking technologies used in VR/AR systems.
- Apply 3D graphics and interaction techniques in immersive environments.
- Develop VR/AR applications using appropriate development platforms.
- Analyze user interaction, usability, and performance issues in immersive systems.
- Evaluate real-world applications and future trends in VR/AR technologies.

**Course Outcomes:**

After completion of the course, student will be able to

**CO1:** Describe VR/AR system components and architectures.

**CO2:** Explain tracking, rendering, and interaction techniques.

**CO3**: Apply 3D modeling and graphics principles in VR/AR environments.

**CO4:** Develop immersive VR/AR applications using modern tools.

**CO5:** Analyze usability, latency, and performance constraints in VR systems.

**CO6:** Design real-world VR/AR solutions for education, healthcare, gaming, or industry.

**Course Contents**

| Unit I | Introduction to Virtual Reality | (06 Hours) |
|---|---|---|

Defining Virtual Reality, History of VR, Human Physiology and Perception, Key Elements of Virtual Reality Experience, Virtual Reality System, Interface to the Virtual World-Input & output- Visual, Aural & Haptic Displays, Applications of Virtual Reality. Representation of the Virtual World, Visual Representation in VR, Aural Representation in VR and Haptic Representation in VR

| | |
|---|---|
| **#Exemplar/Case Studies** | Study the use of Virtual Reality at NASA |
| ***Mapping of Course Outcomes for Unit VI** | CO1 |

| Unit II | The Geometry of Virtual Worlds &The Physiology of Human Vision | (07Hours) |
|---|---|---|

| | |
|---|---|
| Geometric Models, Changing Position and Orientation, Axis-Angle Representations of Rotation, Viewing Transformations, Chaining the Transformations, Human Eye, eye movements & implications for VR. Visual Perception - Perception of Depth, Perception of Motion, Perception of Color, Combining Sources of Information Visual Rendering -Ray Tracing and Shading Models, Rasterization, Correcting Optical Distortions, Improving Latency and Frame Rates | |
| **#Exemplar/Case Studies** | Automatic stitching of panoramas in Virtual Reality |
| ***Mapping of Course Outcomes for Unit VI** | CO2 |

| **Unit III** | **Motion ,Tracking with Interaction & Audio** | **(06 Hours)** |
|---|---|---|
| Motion in Real and Virtual Worlds- Velocities and Accelerations, The Vestibular System, Physics in the Virtual World, Mismatched Motion and Vection Tracking- Tracking 2D & 3D Orientation, Tracking Position and Orientation, Tracking Attached Bodies, Interaction - Motor Programs and Remapping, Locomotion, Manipulation, Social Interaction. Audio -The Physics of Sound, The Physiology of Human Hearing, Auditory Perception, Auditory Rendering. | | |
| **#Exemplar/Case Studies** | A virtual Study Use Case- NICE, An Educational Experience | |
| ***Mapping of Course Outcomes for Unit VI** | CO3 | |

| **Unit IV** | **Introduction to Augmented Reality (A.R)** | **(08Hours)** |
|---|---|---|
| What Is Augmented Reality - Defining augmented reality, history of augmented reality, The Relationship Between Augmented Reality and Other Technologies-Media, Technologies, Other Ideas Related to the Spectrum Between Real and Virtual Worlds, applications of augmented reality Augmented Reality Concepts- How Does Augmented Reality Work? Concepts Related to Augmented Reality, Ingredients of an Augmented Reality Experience.. | | |
| **#Exemplar/Case Studies** | Timeline of evolution of AR from VR | |
| ***Mapping of Course Outcomes for Unit VI** | CO4 | |

| **Unit V** | **Computer Vision for Augmented Reality & A.R. Software** | **(07 Hours)** |
|---|---|---|
| Computer Vision for Augmented Reality - Marker Tracking, Multiple-Camera Infrared Tracking, Natural Feature Tracking by Detection, Simultaneous Localization and Mapping, Outdoor Tracking Augmented Reality Software - Introduction, Major Software Components for Augmented Reality Systems, Software used to Create Content for the Augmented Reality Application. | | |
| **#Exemplar/Case Studies** | Environmental monitoring and conservation, Epidemiological analysis and disease surveillance. | |
| ***Mapping of Course Outcomes for Unit V** | CO5 | |

| **Unit VI** | **AR Devices & Components** | **(07 Hours)** |
|---|---|---|
| AR Components – Scene Generator, Tracking system, monitoring system, display, Game scene AR Devices – Optical See- Through HMD, Virtual retinal systems, Monitor bases systems, Projection displays, Video see-through systems, Introduction to mixed reality, Applications of mixed reality, Input and Output in Mixed reality, Computer Vision and Mixed Reality, simultaneous localization and mapping (SLAM) | | |

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

**Learning Resources**

**Text Books:**

1. Allan Fowler-AR Game Development‖, 1st Edition, A press Publications, 2018, ISBN 978-1484236178
2. Augmented Reality: Principles & Practice by Schmalstieg / Hollerer, Pearson Education India; First edition (12 October 2016),ISBN-10: 9332578494

**Reference Books:**

1. Designing for Mixed Reality, Kharis O'Connell Published by O'Reilly Media, Inc., 2016, ISBN: 9781491962381
2. Sanni Siltanen- Theory and applications of marker-based augmented reality. Julkaisija –Utgivare Publisher. 2012. ISBN 978-951-38-7449-0

**MOOC Courses:**

- Foundation for Virtual and Augmented Reality Systems Overview & Videos: https://onlinecourses.nptel.ac.in/noc26_cs03/preview

**The CO-PO mapping table**

| | 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 Science and Engineering (Data Science) (2019 Course)**

**Elective V 410651B : Software Testing and Quality Assurance**

| Teaching Scheme: | Credit | Examination Scheme: |
|---|---|---|
| TH: 03 Hours/Week | 03 | Mid_Semester(TH): 30 Marks<br>End_Semester(TH): 70 Marks |

**Prerequisite Courses, if any:** Computer Networks and Security (310244)

**Companion Course, if any:** Computer Laboratory Practice IV

**Course Objectives:**

**CO1:** To understand the fundamental approaches, principles and apply these concepts in Information Security

**CO2:** To acquire the knowledge of mathematics for cryptography, understand the concepts of basic cryptography

**CO3:** To learn standard algorithms and protocols employed to provide confidentiality, integrity and authenticity

**CO4:** To acquire the knowledge of security protocol deployed in web security

**CO5:** To study Information Security tools

**Course Outcomes:**

On completion of the course, learners should be able to

**CO1:** Model the cyber security threats and apply formal procedures to defend the attacks

**CO2:** Apply appropriate cryptographic techniques by learning symmetric and asymmetric key cryptography

**CO3:** Design and analyze web security solutions by deploying various cryptographic techniques along with data integrity algorithms

**CO4:** Identify and Evaluate Information Security threats and vulnerabilities in Information systems and apply security measures to real time scenarios

**CO5:** Demonstrate the use of standards and cyber laws to enhance Information Security in the development process and infrastructure protection

**Course Contents**

| Unit I | Introduction to Information Security | (05 Hours) |
|---|---|---|

Foundations of Security, Computer Security Concepts, The OSI Security Architecture, Security attacks, Security services, Security mechanism, A Model for Network Security.

| #Exemplar/Case Studies | Open Source/ Free/ Trial Tools: Clam AV antivirus engine, Anti Phishing, Anti Spyware, Wireshark |
|---|---|
| Mapping of Course Outcomes for Unit I | CO1 |

| Unit II | Symmetric Key Cryptography | (07 Hours) |
|---|---|---|

Classical Encryption Techniques: Stream Ciphers, Substitution Techniques: Caesar Cipher, Mono alphabetic Ciphers, Play fair Cipher, Hill Cipher, Poly alphabetic Ciphers, Transposition Techniques, Block Ciphers and Data Encryption standards, 3DES, Advanced Encryption standard.

| #Exemplar/Case Studies | Open Source/ Free/ Trial Tools: crypt tool |
|---|---|

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

| **Unit III** | **Asymmetric Key Cryptography** | **(07 Hours)** |
|---|---|---|

Number theory: Prime number, Fermat and Euler theorems , Testing for primality, Chinese reminder theorem, discrete logarithm, Public Key Cryptography and RSA, Key Management, DiffieHellman key exchange, El Gamal algorithm, Elliptic Curve Cryptography

| | |
|---|---|
| **#Exemplar/Case Studies** | Open Source/ Free/ Trial Tools: crypt tool |
| **Mapping of Course Outcomes for Unit III** | CO3 |

| **Unit IV** | **Data Integrity Algorithms And Web Security** | **(07 Hours)** |
|---|---|---|

Cryptographic Hash Functions: Applications of Cryptographic Hash Functions, Two Simple Hash Functions, Requirements and Security, Hash Functions Based on Cipher Block Chaining, Secure Hash Algorithm (SHA), SHA-3, MD4, MD5. Message Authentication Codes: Message Authentication Requirements, Message Authentication Functions, Requirements for Message Authentication Codes, Security of MACs. Digital Signatures: Digital Signatures, Schemes, Digital Signature standard, PKI X.509 Certificate. Web Security issues, HTTPS, SSH, Email security: PGP, S/MIME, IP Security : IPSec

| | |
|---|---|
| **#Exemplar/Case Studies** | Open Source/ Free/ Trial Tools: Open SSL, Hash Calculator Tool : MD5, SHA1, SHA256, SHA 512 |
| **Mapping of Course Outcomes for Unit IV** | CO4 |

| **Unit V** | **Network and System Security** | **(07 Hours)** |
|---|---|---|

The OSI Security architecture, Access Control, Flooding attacks, DOS, Distributed DOS attacks Intrusion detection, Host based and network based Honeypot, Firewall and Intrusion prevention system, Need of firewall, Firewall characteristics and access policy, Types of Firewall, DMZ networks, Intrusion prevention system: Host based, Network based, Hybrid. Operating system Security, Application Security, Security maintenance, Multilevel Security, Multilevel Security for role based access control, Concepts of trusted system, Trusted computing.

| | |
|---|---|
| **#Exemplar/Case Studies** | Open Source/ Free/ Trial Tools: DOS Attacks, DDOS attacks, Wireshark, Cain and Abel, iptables/ Windows Firewall, Suricata, fail2ban, Snort. |
| **Mapping of Course Outcomes for Unit V** | CO5 |

| **Unit VI** | **Cyber Security and Tools** | **(07 Hours)** |
|---|---|---|

| | |
|---|---|
| Introduction, Cybercrime and Information Security, Classification of Cybercrimes, The legal perspectives-Indian perspective, Global perspective, Categories of Cybercrime, Social Engineering, Cyber stalking, Proxy servers and Anonymizers, Phishing, Password Cracking, Key-loggers and Spywares, The Indian IT Act-Challenges, Amendments, Challenges to Indian Law and Cybercrime Scenario in India, Indian IT Act. | |
| **#Exemplar/Case Studies** | Study of any two network security scanners: Nmap, Metasploit, Open VAS, Aircrack, Nikito, Samurai,Safe3etc. |
| **Mapping of Course Outcomes for Unit VI** | CO6 |

**Learning Resources**

**Text Books:**


1. William Stallings, "Cryptography and Network Security Principals and Practice", Seventh edition, Pearson , ISBN : 978-1-292-15858
2. William Stallings, Lawrie Brown, "Computer Security Principles and Practice", 3rd_Edition, Pearson , ISBN : 978-0-13-3777392-7 3.
3. Nina Godbole, Sumit Belapure, "Cyber Security", Wiley, ISBN: 978-81-265-2179-1


**Reference Books:**


1. Atul Kahate, "Cryptography and Network Security", 3e, McGraw Hill Education
2. V.K. Pachghare, "Cryptography and Information Security", PHI Learning
3. Bernard Menezes, "Network Security and Cryptography", Cengage Learning India, 2014, ISBN No.: 81315134914. JosephKizza, "Computer Network Security and Cyber Ethics", McFarland & Company, Inc., Publishers , Fourth Edition
4. Michael Whitman and Herbert Matford, "Principles of Information Security", Course Technnology Ink, 7th edition
5. Neena Godbole, "Information Systems Security, 2ed: Security Management, Metrics, Frameworks and Best Practices" , Wiley publication, ISBN: 9788126564057


**MOOC Courses:**

1. NPTEL course on https://nptel.ac.in/courses/106/106/106106129/(IIT Madras, Prof. V.Kamakoti) •
2. Introduction to cyber security, "https://swayam.gov.in/nd2_nou19_cs08/preview" by Dr. Jeetendra Pande | Uttarakhand Open University, Haldwani

**The CO-PO mapping table**

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

**Savitribai Phule Pune University**

**Fourth Year of Computer Science and Engineering(Data Science) (2019 Course)**

**410651C Elective-V- Open Elective**

| Teaching Scheme: | Credit | Examination Scheme: |
|---|---|---|
| TH: 03 Hours/Week | 03 | Mid_Semester(TH): 30 Marks<br>End_Semester(TH): 70 Marks |

**Prerequisite Courses, if any:**

**Companion Course, if any:** Laboratory Practice IV ()

The open elective included, 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/exotic/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 Science and Engineering (Data Science) (2019 Course)**

**410652A:Elective-VI- Virtual Reality in Game Development**

| Teaching Scheme: | Credit | Examination Scheme: |
|---|---|---|
| TH: 03 Hours/Week | 03 | Mid_Semester(TH): 30 Marks<br>End_Semester(TH): 70 Marks |

**Prerequisite Courses, if any:** Computer Networks and Security (310244), Distributed System (310245C)

**Companion Course, if any:** Computer Laboratory Practice IV

**Course Objectives:**

- Understand the fundamental concepts of Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), and game development principle
- Explain the hardware and software components of immersive systems, including HMDs, sensors, tracking systems, and rendering pipelines.
- Apply 3D modeling, animation, and interaction techniques to develop immersive environments.
- Develop interactive VR applications and games using modern engines such as Unity and Unreal Engine.
- Analyze user experience (UX), usability, physics simulation, and performance optimization in VR/game systems.
- Design and implement a complete VR/game project addressing real-world problems, considering ethical, societal, and business aspects.

**Course Outcomes:**

On completion of the course, learners should be able to

**CO1:** Explain concepts of Virtual Reality, Augmented Reality, and game design principles.
**CO2:** Illustrate hardware and software components of VR systems.
**CO3:** Develop basic VR applications and 3D interactive games using game engines.
**CO4:** Analyze user interaction, physics, and animation in immersive environments.
**CO5:** Analyze usability, physics simulation, and performance optimization in immersive systems.
**CO6:** Design and evaluate a complete VR/game project considering societal, ethical, and business aspects.

**Course Contents**

| Unit I | Virtual Reality in a Nutshell | (07 Hours) |
|---|---|---|

What is virtual reality?, Types of head-mounted displays, The difference between virtual 6reality and augmented reality, Applications versus games, How virtual reality really works, Types of VR experiences, Technical skills that are important to VR

| | |
|---|---|
| **#Exemplar/Case Studies** | Study about VR device interaction and working with OS (Windows/Linux) and IDE's (Unity/Unreal) |
| **Mapping of Course Outcomes for Unit I** | CO1 |

| Unit II | Content Creation & Interaction | (07 Hours) |
|---|---|---|
| High-Level Concepts of Content Creation, Environmental Design, Affecting Behavior, Transitioning to VR Content Creation, Content Creation: Design Guidelines,Human-Centered Interaction, VR Interaction Concepts, Input Devices, Interaction Patterns and Techniques, Interaction: Design Guidelines | | |
| **#Exemplar/Case Studies** | Case study of a developed VR game in Unity with the above mentioned features | |
| **Mapping of Course Outcomes for Unit II** | CO2 | |
| | | |
| **Unit III** | **Iterative design** | **(07 Hours)** |
| Philosophy of Iterative Design, The Define Stage, The Make Stage, The Learn Stage, Iterative Design: Design Guidelines | | |
| **#Exemplar/Case Studies** | Study of Iterative design of any VR game. | |
| **Mapping of Course Outcomes for Unit III** | CO3 | |
| | | |
| **Unit IV** | **Security in Cloud Computing** | **(07 Hours)** |
| Overview, Building Your Project and Character, Getting Animated, The Town View, Working with Unity's UI System, NPCs and Interactions, The World Map, Encountering Enemies and Running Away | | |
| **#Exemplar/Case Studies** | Animation in Unreal Engine vs Unity Engine | |
| **Mapping of Course Outcomes for Unit IV** | CO4 | |
| | | |
| **Unit V** | **Game Development in Unity** | **(07 Hours)** |
| Getting Ready to Fight, The Battle Begins, Shopping for Items, Sound and Music, Putting a Bow on It, Deployment and Beyond | | |
| **#Exemplar/Case Studies** | Case study on considering windows mixed reality for game development in Unity | |
| **Mapping of Course Outcomes for Unit V** | CO5 | |
| | | |
| **Unit VI** | **Adverse Health Effects** | **(07 Hours)** |
| Motion Sickness, Eye Strain, Seizures, and Aftereffects, Hardware Challenges, Latency, Measuring Sickness, Summary of Factors That Contribute to Adverse Effects, Examples of Reducing Adverse Effects, Adverse Health Effects: Design Guidelines | | |
| **#Exemplar/Case Studies** | Effect of any VR game on health.( Beat Saber/Rick and Morty: Virtual Rick-Ality/<br>Cloudlands VR Minigolf). | |

| Mapping of Course Outcomes for Unit VI | CO6 |
|---|---|

**Learning Resources**

**Text Books:**


1. Jason Jerald- The VR Book: Human- Centered Design for Virtual Reality, Association for Computing Machinery and Morgan & Claypool Publishers (Aug. 5 2016), ISBN- B01JV1LAZW
2. Mastering Unity 2D Game Development - Second Edition,AshleyGodbold, Simon Jackson, Packt Publishing, October 2016, ISBN: 9781786463456
3. Jonathan Linowes – Unity Virtual Reality Projects: Explore the world of virtual reality by building immersive and fun VR projects using Unity 3D Paperback‖, 1st Edition, Packt Publications, 2015, ISBN 978-1783988556


**Reference Books:**


1. Tony Parisi – Learning Virtual Reality, O'Reilly Media, Inc., 2015, ISBN- 9781491922835
2. Virtual Reality with VRTK4, Create Immersive VR Experiences Leveraging Unity3D and Virtual Reality Toolkit, Authors: Baruah, Rakesh, ISBN 978-1-4842-5488-2


**MOOC Courses:**

- https://learn.unity.com/course/teaching-game-design-and-development
- https://www.coursera.org/specializations/unity-xr
- https://www.coursera.org/learn/making-virtual-reality-game

**The CO-PO mapping table**

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

## Savitribai Phule Pune University
## Fourth Year of Computer Science and Engineering (Data Science) (2019 Course)
## 410652 B: Elective-VI-Information System Management

| Teaching Scheme: | Credit | Examination Scheme: |
|---|---|---|
| TH: 03 Hours/Week | 03 | Mid_Semester(TH): 30 Marks<br>End_Semester(TH): 70 Marks |

**Prerequisite Courses, if any:** Fundamentals of Database Management Systems,Basic knowledge of Software Engineering

**Companion Course, if any:** Computer Laboratory Practice IV

**Course Objectives:**

- Understand the fundamental concepts of Information Systems and their role in business organizations.
- Explain different types of Information Systems (TPS, MIS, DSS, ESS) and enterprise systems.
- Analyze strategic use of Information Systems for decision-making and competitive advantage.
- Understand Information System planning, development, implementation, and maintenance.
- Evaluate security, ethical, and governance issues related to Information Systems.
- Apply management principles in designing and managing enterprise information systems.

**Course Outcomes:**

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

**CO1:** Describe components, types, and functions of Information Systems.

**CO2:** Explain enterprise systems such as ERP, SCM, CRM and their business applications.

**CO3:** Analyze business processes and decision-making models using Information Systems.

**CO4:** Apply system development life cycle (SDLC) methodologies for IS implementation**.**

**CO5:** Evaluate security, ethical, and governance challenges in Information Systems.

**CO6:** Design and propose Information System solutions for organizational needs.

**Course Contents**

| Unit I | Introduction to Information Systems | (07 Hours) |
|---|---|---|

**Introduction to Information Systems:** Definition of Data, Information and Knowledge, Information as a Strategic Resource, Characteristics and Quality of Information, Information System vs Information Technology Components of Information Systems: Hardware, Software, Database, Telecommunications & Networks, People and Procedures

**Types of Information Systems:** Transaction Processing Systems (TPS), Management Information Systems (MIS), Decision Support Systems (DSS), Executive Support Systems (ESS), Knowledge Management Systems (KMS) Functional Area Information Systems: Marketing Information System, Financial Information System, Human Resource Information System, Production/Operations Information System

| | |
|---|---|
| **#Exemplar/Case Studies** | Digital Banking Transformation at State Bank of India<br>Background: |
| **Mapping of Course Outcomes for Unit I** | CO1 |

| Unit II | Information Systems in Organizations | (07 Hours) |
|---|---|---|
| **Organizations and Information Systems:** Organizational Structure and Culture, Business Processes and Reengineering (BPR), Impact of IS on Organizational Performance<br>**Enterprise Applications:** Enterprise Resource Planning (ERP), Supply Chain Management (SCM), Customer Relationship Management (CRM), Integration of Enterprise Systems<br>**E-Business and Digital Enterprise:** E-Commerce Models (B2B, B2C, C2C), Digital Markets and Digital Goods, online Payment Systems, Mobile Commerce<br>**Emerging Technologies in IS:** Cloud Computing, Internet of Things (IoT), Artificial Intelligence in IS, Blockchain Applications | | |
| **#Exemplar/Case Studies** | ERP Implementation at Tata Motors | |
| **Mapping of Course Outcomes for Unit II** | CO2 | |

| Unit III | System Development and Project Management | (07 Hours) |
|---|---|---|
| **System Development Life Cycle (SDLC)Phases:** Planning, Analysis, Design, Implementation, Maintenance, Feasibility Study (Technical, Economic, Operational), Cost-Benefit Analysis<br>**System Analysis and Design:** Requirements Gathering Techniques, Structured vs Object-Oriented Analysis, Data Flow Diagrams (DFD), Entity Relationship Diagrams (ERD)<br>**Alternative Development Approaches:** Prototyping Model, Agile Methodology, Rapid Application Development (RAD), End-User Development<br>**Project Management in IS:** Project Planning and Scheduling (Gantt Charts, PERT/CPM), Risk Management, Change Management | | |
| **#Exemplar/Case Studies** | Development of IRCTC Online Booking System by Indian Railway Catering and Tourism Corporation | |
| **Mapping of Course Outcomes for Unit III** | CO3 | |

| Unit IV | Information System Security, Ethics and Controls | (07 Hours) |
|---|---|---|
| **Threats and Vulnerabilities:** Types of Security Threats (Malware, Phishing, Hacking), Insider vs External Threats, Data Breaches<br>**Security Controls:** Access Controls, Encryption, Firewall and Intrusion Detection Systems, Disaster Recovery Planning, Business Continuity Planning<br>**Ethical and Social Issues:** Privacy and Data Protection, Intellectual Property Rights, Cyber Ethics, Social Impact of Information Systems Legal Framework: IT Act (India), Cyber Laws, Global Data Protection Regulations (Overview) | | |
| **#Exemplar/Case Studies** | Data Privacy Concerns at Facebook (Now Meta) | |
| **Mapping of Course Outcomes for Unit IV** | CO4 | |

| Unit V | Strategic Information Systems and Decision Making | (07 Hours) |
|---|---|---|

**Information Systems for Competitive Advantage:** Strategic Role of IS, Porter's Competitive Forces Model, Value Chain Analysis

**Business Intelligence and Analytics:** Data Warehousing, Data Mining, Big Data Concepts, Visualization Tools

**Knowledge Management:** Knowledge Creation and Sharing, Knowledge Management Systems, Organizational Learning

**Future Trends in Information Systems:** Digital Transformation, Industry 4.0, Smart Enterprises

| | |
|---|---|
| **#Exemplar/Case Studies** | Competitive Advantage through IS at Amazon |
| **Mapping of Course Outcomes for Unit V** | CO5 |

| **Unit VI** | **Emerging Trends and Advanced Applications in Information Systems** | **(07 Hours)** |
|---|---|---|

**Digital Transformation:** Concept and Need for Digital Transformation, Role of Information Systems in Digital Strategy, Digital Business Models, Case Studies of Digital , Enterprises

**Artificial Intelligence and Machine Learning in IS:** Introduction to AI and ML, Applications of AI in Business Information Systems, Intelligent Decision Support Systems, Chatbots and Virtual Assistants

**Big Data and Advanced Analytics:** Characteristics of Big Data (5Vs), Big Data Architecture, Predictive and Prescriptive Analytics, Business Applications of Big Data

**Internet of Things (IoT) and Smart Systems:** Concept and Architecture of IoT, IoT in Industry (Smart Manufacturing, Smart Cities), Integration of IoT with Enterprise Systems

| | |
|---|---|
| **#Exemplar/Case Studies** | Digital Payments and UPI System by National Payments Corporation of India |
| **Mapping of Course Outcomes for Unit VI** | CO6 |

**Learning Resources**

**Text Books:**


1. Management Information Systems – Kenneth C. Laudon & Jane P. Laudon – Comprehensive coverage of IS fundamentals, digital technologies, and business impact, ideal for classroom teaching.

2. Management Information Systems – Dr. Nirmalaya Bagchi – Focused on MIS fundamentals, business application, and decision support aspects.

3. Management Information Systems – L.M. Prasad & Usha Prasad – Covers conceptual foundations, system development, controls, and security.

4. Management Information Systems – Indrajit Chatterjee – Practical and scenario-based approach suitable for BBA/MBA students.

5. Management Information Systems : A Concise Study – S.A. Kelkar – Concise and focused text covering basics with recent developments.
6. Information Systems for Business and Beyond – David T. Bourgeois – Open-access textbook giving a broad introduction to IS with development, trends, and ethics.

**Reference Books:**

1. Information Systems: A Manager's Guide to Harnessing Technology – A strategic view of IS for managers, covering tech trends, Internet, and security.
2. Management Information Systems – C.S.V. Murthy – Covers MIS components, development, database concepts, and resource management.
3. Management Information Systems – Gordon B. Davis & Margrethe H. Olson – Classic textbook often used for deeper conceptual clarity.
4. Management Information Systems – James A. O'Brien, George M. Marakas, Ramesh Behl – Broad coverage with case studies and applications.
5. Principles of Information Security – Whitman & Mattord – Useful for deeper study of IS security.

**MOOC Courses:**

Management Information System – NPTEL Course (IIT Kharagpur

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

**Savitribai Phule Pune University**

**Fourth Year of Computer Science and Engineering (Data Science) (2019 Course)**

**410652C :Elective-VI- Open Elective**

| Teaching Scheme: | Credit | Examination Scheme: |
|---|---|---|
| TH: 03 Hours/Week | 03 | Mid_Semester(TH): 30 Marks<br>End_Semester(TH): 70 Marks |

**Prerequisite Courses, if any:**

The open elective included, 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/exotic/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 Science and Engineering (Data Science) (2019 Course)
## 410653: Computer Laboratory III

| Teaching Scheme: | Credit | Examination Scheme: |
|---|---|---|
| Practical : 02 Hrs. / week | 01 | Teamwork: 50 Marks<br>Practical: 25 Marks |

**Prerequisite Courses, if any: -** Data Science and Big Data Analytics (310251)

**Course Objectives:**

- To understand and explore the working of Block chain technology and its applications
- To develop in depth understanding for implementation of the regression models.
- To understand the fundamental concepts and architecture of distributed computing systems.
- To apply distributed computing concepts for designing scalable and reliable distributed applications.

**Course Outcomes:**

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

**CO1:** Analyze the importance of blockchain in finding the solution to the real-world problems.

**CO2:** Interpret the basic concepts in Block chain technology and its applications

**CO3** Explain the fundamental principles, architecture, and characteristics of distributed computing systems.

**CO4:** Analyze distributed algorithms for synchronization, mutual exclusion, deadlock detection, and leader election**.**

**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, punctuality and

**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 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 or mini-project that is suitable to respective branch beyond the scope of syllabus.

Set of suggested assignment list is provided in groups- A and B. Each student must perform 13 assignments (10 from group A, 3 from group B), 2 mini project from Group C

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

Programming tools recommended: - JAVA/Python/R/Scala

**Virtual Laboratory:**

· "Welcome to Virtual Labs - A MHRD Govt of india Initiative"

· http://cse20-iiith.vlabs.ac.in/List%20of%20Experiments.html?domain=Computer%20Science

| Suggested List of Laboratory Experiments/Assignments<br>Assignments from all Groups (A,B,C) are compulsory. | |
|---|---|
| **Sr. No.** | **Group A : Block Chain Technology(Any 5)** |
| 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:<br>• Deposit money<br>• Withdraw Money<br>• Show balance |
| 4. | Write a program in solidity to create Student data. Use the following constructs:<br>• Structures<br>• Arrays<br>• Fallback<br>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. | Write a program to create a Business Network using Hyperledger |
| **Sr. No.** | **Group B- Distributed Computing(Any 5)** |
| 1 | Installation and configuration of distributed computing tools such as Apache Hadoop or Apache Spark in a single node environment. |
| 2 | Implement a distributed application using Java RMI to invoke methods on remote objects. |
| 3 | Write a program using Apache Hadoop MapReduce to perform a Word Count or Log Analysis application. |
| 4 | Implement basic data processing tasks using Apache Spark. |
| 5 | Simulate and analyze deadlock detection techniques in distributed environments. |
| 6 | Perform query execution on distributed databases and analyze performance. |
| 7 | Implement task scheduling techniques in a distributed environment and measure execution time. |
| **Sr. No.** | **Group C- Mini Projects (Any TWO Mini Project)** |
| 1 | Mini Project - Develop a Blockchain based application dApp (de-centralized app) for e- voting system |
| 2 | Mini Project - Develop a Blockchain based application for transparent and genuine charity |
| 3 | Mini Project - Develop a Blockchain based application for health related medical records |
| 4 | Mini Project - Develop a Blockchain based application for mental health |
| 5 | Mini Project - Distributed Log Analyzer using Hadoop/Spark |
| 6 | Mini Project - Distributed Social Media Data Analyzer |
| 7 | Mini Project - Peer-to-Peer Content Distribution Network |
| 8 | Mini Project - Distributed Traffic Monitoring System |

| The CO-PO mapping table | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** |
| **CO1** | 3 | 3 | 2 | 1 | 2 | - | - | - | - | - | - | 2 |
| **CO2** | 3 | 2 | 2 | - | 2 | - | - | - | - | - | - | 1 |
| **CO3** | 3 | 2 | 1 | - | 2 | - | - | - | - | - | - | 1 |
| **CO4** | 3 | 3 | 2 | 2 | 2 | - | - | - | - | - | - | 2 |

## Savitribai Phule Pune University
## Fourth Year of Computer Science and Engineering (Data Science) (2019 Course)
## 410654: Computer Laboratory IV

| Teaching Scheme: | Credit: | Examination Scheme: |
|---|---|---|
| Practical : 02 Hrs. / week | 01 | Teamwork: 50 Marks<br>Oral : 25 Marks |

**Prerequisite Courses, if any:**

**Companion Course, if any:** Elective-V & VI

**Course Objectives:**

- To understand the fundamentals of Virtual Reality (VR) and Augmented Reality (AR) technologies.
- To apply testing techniques to improve software reliability.
- To design interactive VR gaming environments.
- To explore applications of recommender systems in e-commerce and media platforms.

**Course Outcomes:**

On completion of the course, learners will be able to

**CO1:** Explain the concepts, components, and architecture of VR and AR systems.

**CO2:** Evaluate software quality using metrics and testing strategies.

**CO3:** Develop VR games using tools such as Unity.

**CO4:** Evaluate performance of recommender systems.

**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 Oral Examination |
|---|
| Oral examination should be jointly conducted by the internal examiner and external examiner. Relevant questions may be asked at the time of evaluation to test the student‘s understanding of the fundamentals, effective and efficient implementations in term work. 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 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. Mini project should be implemented by the students in a group of 2-3 students. |

| Suggested List of Laboratory Experiments/Assignments (All assignments are compulsory) | |
|---|---|
| **Sr. No** | **Assignment Title** |
| **Group A Virtual & Augmented Reality (Attempt any Four Experiment from Sr. No. 1 to 5. & 1 Mini project )** | |
| 1. | Installation of Unity and Visual Studio, setting up Unity for VR development, understanding documentation of the same. |
| 2. | Demonstration of the working of HTC Vive, Google Cardboard, Google Daydream and Samsung gear VR. |
| 3. | Develop a scene in Unity that includes a sphere and plane . Apply Rigid body component, material and Box collider to the game Objects. Write a C# program to grab and throw the sphere using vr controller. |
| 4. | Develop a simple UI(User interface ) menu with images, canvas, sprites and button. Write a C# program to interact with UI menu through VR trigger button such that on each successful trigger interaction display a score on scene .. |
| 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. | Include animation and interaction in the immersive environment created in Assignment 5 |
| 7. | Create a virtual environment for any use case. The application must include at least 4 scenes which can be changed dynamically, a good UI, animation and interaction with game objects. (e.g VR application to visit a zoo) |
| **Group B Software Testing and Quality Assurance (Attempt any Four & 1 Mini project )** | |
| 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 Web driver java eclipse (automation tools). |
| 6. | Prepare Software requirement specification for any project or problem statement |

| | |
|---|---|
| 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 testcases 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 |
| **Group C Virtual Reality in Game Development (Attempt any Four Experiment from Sr. No. 1 to 5. )** | |
| 1. | Develop a VR Ball Game. The scene should contain a play area surrounded by four walls and a ball that acts as a player. The objective of the game is to keep the ball rolling without colliding with the walls. If it collides with either of the walls, the wall color should change and a text should display on the screen indicating the collision. |
| 2. | Develop a VR Golf Game. The scene should contain a play area (golf course), which consists of a series of cups/holes each having different scores. Display the score card. |
| 3. | Develop a VR game in Unity such that on each gun trigger click, destroy the cubes placed on the plane and gain a score point. Make a score UI and display it on the screen |
| 4. | Develop a VR Basketball Game. The scene should contain a basketball court. The developed game should be a single player game. The objective of the game is to let the player put the ball in the basket maximum number of times. Display the score card. |
| 5. | Develop an AR bowling game with one image target. The image target should include 3d models as per requirement. Write a c# program to develop score point system for bowling game. Build an apk. (Note : Vuforia plugin should be installed in unity. ) |
| 6. | Develop a VR environment for flying helicopter/moving car simulation. |
| 7. | Create a multiplayer VR game (battlefield game). The game should keep track of score, no. of chances/lives, levels(created using different scenes), involve interaction, animation and immersive environment. |
| **Group D Information Systems Management (Attempt any Four Experiment from Sr. No. 1 to 5. )** | |
| 1. | Analyze different types of information systems used in organizations such as TPS, MIS, DSS, and ESS. |
| 2. | Create business process diagrams for an organization using modeling tools such as Microsoft Visio or Lucidchart. |
| 3. | Design database schema for an organizational information system using MySQL or Oracle Database. |
| 4. | Analyze security threats and propose security mechanisms for organizational information systems. |
| 5. | Design a simple decision support system for business data analysis using spreadsheet tools like Microsoft Excel. |
| 6. | Analyze cloud-based information system architecture using services such as Amazon Web Services. |
| 7. | Mini Project - Inventory Management Information System |
| 8. | Mini Project - Employee Information System |
| 9. | Mini Project - Online Retail Management System |
| 10. | Mini Project - College ERP System Prototype |

| The CO-PO mapping table | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** |
| **CO1** | 3 | 2 | - | - | 2 | - | - | - | - | - | - | 1 |
| **CO2** | 2 | 3 | 2 | 2 | 2 | - | - | - | - | - | - | 1 |
| **CO3** | 2 | 2 | 3 | - | 3 | - | - | - | - | - | - | 1 |
| **CO4** | 2 | 3 | 2 | 2 | 2 | - | - | - | - | - | - | 2 |

**Savitribai Phule Pune University**

**Fourth Year of Computer Science and Engineering(Data Science) (2019 Course)**

**410655: Project Stage II**

| Teaching Scheme: | Credit: | Examination Scheme: |
|---|---|---|
| PR: 12 Hours/Week | 06 | Term Work: 100 Marks<br>Oral Exam: 50 Marks |

**Companion Course, if any:**

**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 furnished report

**Course Outcomes:**

On completion of the course, learner 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 with the research.

**CO5:** Appreciate practical implications and constraints of the specialist subject

**Guidelines & Contents**

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 the 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 Computer Science and Engineering (Data Science) (2019 Course)
## 410656: Audit Course 8

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 student's 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 syllabus. 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
- 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
- Presentations, IPR/Publication and Report

**Audit Course 4 Options**

| Audit Course Code | Audit Course Title |
|---|---|
| **AC8-I** | Usability Engineering |
| **AC8-II** | Conversation al Interfaces |
| **AC8-III** | Social Media and Analytics |
| **AC8-IV** | Emotional Intelligence |
| **AC8-V** | Learn New Skills - Software Development Using Agility Approach |

Note: It is permitted to opt one of the audit courses listed at SPPU website too, if not opted earlier.

[1] http://collegecirculars.unipune.ac.in/sites/documents/Syllabus%202017/Forms/AllItems.aspx
http://www.unipune.ac.in/university_files/syllabi.htm

## Savitribai Phule Pune University
## Fourth Year of Computer Science and Engineering (Data Science) (2019 Course)
## 410656: Audit Course8
### AC8-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 help 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 andtheir 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 Outcome:**

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**

What Is Usability? Usability and Other Considerations, Definition of Usability, Example: Measuring the Usability of Icons, Usability Trade-Offs, Categories of Users and Individual User Differences. Usability in Software Development: The Emergence of Usability, Human Computer Interaction, Usability Engineering. The usability Engineering Lifecycle: Requirement Analysis, Design, Testing, Development. Usability Assessment Methods beyond Testing, 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" Deborah J. Mayhew, " The usability engineering lifecycle"


**@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 | - | - | - | - | - | - | - | 1 | - |
| CO3 | 2 | - | 2 | 2 | 2 | - | 1 | - | - | - | - | - |

## Savitribai Phule Pune University
## Fourth Year of Computer Science and Engineering(Data Science) (2019 Course)
### AC8-II: Conversation al 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 conversation
- 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”Michael McTear, ZoraidaCallejas, David Griol, “ The Conversational Interface: Talking to Smart Devices”
2. Martin Mitrevski, “Developing Conversational Interfaces for iOS: Add Responsive Voice Control”SriniJanarthanam, “ Hands-On Chatbots and Conversational UI Development: Build chatbots”


**@The CO-PO Mapping Matrix**

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

# Savitribai Phule Pune University
## Fourth Year of Computer Science and Engineering(Data Science) (2019 Course)
## 410656: Audit Course 8
### AC8-III: Social Media and Analytics

This course aims to create awareness among the students regarding social media and analytics.

**Course Objectives:**

- Get strategic understanding of Digital Marketing and Social Media Marketing.
- Understand how to use it for branding and sales.
- Blend digital and social marketing with offline marketing.
- Plan and manage digital marketing budget.

**Course Outcome:**

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

**CO1:** Develop a far deeper understanding of the changing digital land scape.
**CO2:** Identify some of the latest digital marketing trends and skill sets needed for today's marketer.
**CO3:** Assessuserinterfacesusingdifferentusabilityengineeringtechniques.
**CO4**: Implement smart management of different digital assets for marketing needs.

**Course Contents:**

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 & LinkedIn and other Social Media for areal marketing, Utilizing Facebook and LinkedIn's Advertising functionality and Applications, Brand reputation management techniques, Systems for 'buzzmonitoring'forbrands, products and services, Effective Public Relations (PR) online and business development.

**References:**


1. Paul Sloane, “The Leader's Guide to Lateral Thinking Skills Unlocking the Creativity and Innovation in You and Your Team”, 2006
2. Ronald Bennett, Elaine Millam,“Leadership for engineers : the magic of mindset”
3. Urmila Rai and S.M. Rai, “Business Communication”, Himalay Publication House
4. Baron R, Byrne D, Branscombe N, BharadwajG ( 2009), “Social Psychology, Indian adaptation” , Pearson , New Delhi
5. Baumgartner S.R, Crothers M.K. (2009) “Positive Psychology”, Pearson Education.

| @The CO-PO Mapping Matrix | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO\PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** |
| **CO1** | 1 | - | - | - | - | 2 | - | 1 | 1 | 3 | - | 2 |
| **CO2** | - | - | - | - | - | - | - | 1 | - | 2 | 1 | 2 |
| **CO3** | - | - | - | - | - | 1 | - | - | 2 | 1 | - | 1 |
| **CO4** | - | - | - | - | - | - | - | 1 | - | - | 2 | 1 |

## Savitribai Phule Pune University
## Fourth Year of Computer Science and Engineering(Data Science) (2019 Course)
## 410656: Audit Course8
### AC8-IV: 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 behaviors, 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 reaction 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: Increase the leadership effectiveness by creating an atmosphere that engages others

**Course Contents**

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," , BantamBooks, ISBN-10: 055338371X13: 978-0553383713
2. Steven Stein , "The EQ Edge" , Jossey-Bass, ISBN : 978-0-470-68161-9
3. Drew Bird , "The Leader"s Guide to Emotional Intelligence" , ISBN: 9781535176002

| @The CO-PO Mapping Matrix | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO\PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** |
| **CO1** | - | - | - | - | - | - | - | - | 1 | 3 | 1 | 1 |
| **CO2** | - | - | - | - | 1 | - | - | - | - | 3 | 1 | 1 |
| **CO3** | - | - | - | - | 1 | - | - | - | - | 3 | 2 | 2 |
| **CO4** | - | - | - | - | - | - | - | - | - | 1 | - | 1 |

## Savitribai Phule Pune University
## Fourth Year of Computer Science and Engineering (Data Science) (2019 Course)
## 410656: Audit Course8
### AC8-V: Learn New Skills - Software Development Using Agility Approach

With changing times, the competitiveness has gotten into the nerves and 'Being the Best' at all times is only the proof of it. Nonetheless, 'being the best differs significantly from 'Communicating the best'! The best can merely be communicated whilst using the best… suited Language!!

**Course Objectives:**

- To understand the principles and values of Agile software development methodologies.
- To study different Agile frameworks and practices used in software development.
- To learn techniques for Agile planning, estimation, and project management.

**Course Outcomes:**

On completion of the course learner will-

**CO1:** Explain the principles, values, and concepts of Agile software development.

**CO2:** Analyze different Agile methodologies such as Scrum and Extreme Programming (XP).

**CO3:** Apply Agile practices for project planning, estimation, and requirement management.

**Course Contents**

**Unit 1: Introduction to Agile Development**

Traditional vs Agile software development, Agile Manifesto and principles, Characteristics of Agile development, Benefits and challenges of Agile methodologies,

**Unit 2: Agile Methodologies**

Overview of Agile frameworks, Scrum methodology, Extreme Programming (XP) practices, Agile roles and responsibilities, Agile lifecycle and sprint planning.

**Unit 3: Agile Requirements and Planning**

User stories and backlog management, Agile estimation techniques (Planning Poker, Story Points), Release planning and iteration planning, Agile documentation practices

**Unit 4: Agile Development and Testing**

Test-driven development (TDD), Continuous integration, Automated testing in Agile, Code refactoring and pair programming, Tools used: Git, Jenkins, JUnit

**Unit 5: Agile Project Management and Metrics**

Agile project tracking, Burndown charts and velocity, Risk management in Agile projects, Agile quality assurance practices, Scaling Agile in large projects

**Books:**


1. Minna No Nihongo, "Japanese for Everyone", (Indian Edition), Goyal Publishers and Distributors Pvt. Ltd.
2. http://www.tcs.com (http://www.tcs.com/news_events/press_releases/Pages/TCS- Inaugurates-Japan-centric-Delivery-Center-Pune.aspx)

# Acknowledgement

## Task Force at Curriculum Design

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