**AC:**

**Item No.**

# UNIVERSITY OF MUMBAI

# Bachelor of Engineering

**in**

# Computer Engineering

**Second Year with Effect from AY 2020-21**

**Third Year with Effect from AY 2021-22**

**Final Year with Effect from AY 2022-23**

**(REV- 2019 'C' Scheme) from Academic Year 2019 – 20**

**Under**

# FACULTY OF SCIENCE & TECHNOLOGY

**(As per AICTE guidelines with effect from the academic year 2019–2020)**

**AC:**

**Item No.**

# UNIVERSITY OFMUMBAI

| Sr. No. | Heading | Particulars |
|---|---|---|
| 1 | Title of the Course | **Fourth Year Engineering ( Computer Engineering)** |
| 2 | Eligibility for Admission | **After Passing Second Year Engineering as per the Ordinance 0.6243** |
| 3 | Passing Marks | **40%** |
| 4 | Ordinances / Regulations ( if any) | **Ordinance 0.6243** |
| 5 | No. of Years / Semesters | **8 semesters** |
| 6 | Level | ~~P.G.~~ / **U.G.**/ ~~Diploma / Certificate~~ (Strike out which is not applicable) |
| 7 | Pattern | ~~Yearly~~ / **Semester** (Strike out which is not applicable ) |
| 8 | Status | ~~**New**~~/ Revised (Strike out which is not applicable ) |
| 9 | To be implemented from Academic Year | **With effect from Academic Year:2021-2022** |


Dr. S.K.Ukarande
Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

# Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology (in particular Engineering) of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty resolved that course objectives and course outcomes are to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. Choice based Credit and grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 13 weeks and remaining 2 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 170, wherein focus is not only on providing knowledge but also on building skills, attitude and self learning. Therefore in the present curriculum skill based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for Second Year of Engineering from the academic year 2021-22. Subsequently this will be carried forward for Third Year and Final Year Engineering in the academic years 2022-23, 2023-24, respectively.



Dr. S.K. Ukarande

Associate Dean

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Dean

Faculty of Science and Technology

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# Incorporation and Implementation of Online Contents fromNPTEL/ Swayam Platform

The curriculum revision is mainly focused on knowledge component, skill based activities and project based activities. Self learning opportunities are provided to learners. In the revision process this time in particular Revised syllabus of 'C' scheme wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme 'A' and 'B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum overall credits are reduced to 171, to provide opportunity of self learning to learner. Learners are now getting sufficient time for self learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD's/ Faculties of all the institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

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Associate Dean
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Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
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# Preface by Board of Studies in Computer Engineering

Dear Students and Teachers, we, the members of Board of Studies Computer Engineering, are very happy to present Third Year Computer Engineering syllabus effective from the Academic Year 2021-22 (REV-2019'C' Scheme). We are sure you will find this syllabus interesting, challenging, fulfill certain needs and expectations.

Computer Engineering is one of the most sought-after courses amongst engineering students. The syllabus needs revision in terms of preparing the student for the professional scenario relevant and suitable to cater the needs of industry in present day context. The syllabus focuses on providing a sound theoretical background as well as good practical exposure to students in the relevant areas. It is intended to provide a modern, industry-oriented education in Computer Engineering. It aims at producing trained professionals who can successfully acquainted with the demands of the industry worldwide. They obtain skills and experience in up-to-date the knowledge to analysis, design, implementation, validation, and documentation of computer software and systems.

The revised syllabus is finalized through a brain storming session attended by Heads of Departments or senior faculty from the Department of Computer Engineering of the affiliated Institutes of the Mumbai University. The syllabus falls in line with the objectives of affiliating University, AICTE, UGC, and various accreditation agencies by keeping an eye on the technological developments, innovations, and industry requirements.

The salient features of the revised syllabus are:

1. Reduction in credits to 170 is implemented to ensure that students have more time for extracurricular activities, innovations, and research.
2. The department Optional Courses will provide the relevant specialization within the branch to a student.
3. Introduction of Skill Based Lab and Mini Project to showcase their talent by doing innovative projects that strengthen their profile and increases the chance of employability.
4. Students are encouraged to take up part of course through MOOCs platform SWAYAM

We would like to place on record our gratefulness to the faculty, students, industry experts and stakeholders for having helped us in the formulation of this syllabus.



## Board of Studies in Computer Engineering

| | |
|---|---|
| Prof. Sunil Bhirud | : Chairman |
| Prof. SunitaPatil | : Member |
| Prof. LeenaRaga | : Member |
| Prof. Subhash Shinde | : Member |
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| Prof. Dayanand Ingle | : Member |
| Prof. Satish Ket | : Member |

**Program Structure for Fourth Year Computer Engineering**

**UNIVERSITY OF MUMBAI (With Effect** from 2022-2023)

## Semester VII

| Course Code | Course Name | Teaching Scheme (Contact Hours) | | Credits Assigned | | |
|---|---|---|---|---|---|---|
| | | Theory | Pract. Tut. | Theory | Pract. | Total |
| CSC701 | Machine Learning | 3 | -- | 3 | -- | 3 |
| CSC702 | Big Data Analytics | 3 | -- | 3 | | 3 |
| CSDC 701X | Department Level Optional Course-3 | 3 | -- | 3 | -- | 3 |
| CSDC 702X | Department Level Optional Course-4 | 3 | -- | 3 | -- | 3 |
| CSIO701 | Institute Level Optional Course-1 | 3 | -- | 3 | -- | 3 |
| CSL701 | Machine Learning Lab | -- | 2 | -- | 1 | 1 |
| CSL702 | Big Data Analytics Lab | -- | 2 | -- | 1 | 1 |
| CSDL 701X | Department Level Optional Course-3 Lab | -- | 2 | -- | 1 | 1 |
| CSDL 702X | Department Level Optional Course-4 Lab | -- | 2 | -- | 1 | 1 |
| CSP701 | Major Project 1 | -- | 6# | -- | 3 | 3 |
| **Total** | | **15** | **14** | **15** | **7** | **22** |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term Work | Pract. & oral | Total |
| | | Internal Assessment | | | End Sem Exam | Exam. Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| CSC701 | Machine Learning | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |
| CSC702 | Big Data Analysis | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |
| CSDC 701X | Department Level Optional Course-3 | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |
| CSDC 702X | Department Level Optional Course-4 | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |
| CSIO701 | Institute Level Optional Course-1 | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |
| CSL701 | Machine Learning Lab | -- | -- | -- | -- | -- | 25 | 25 | 50 |
| CSL702 | Big Data Analytics Lab | -- | -- | -- | -- | -- | 25 | 25 | 50 |
| CSDL 701X | Department Level Optional Course-3 Lab | | | | | | 25 | - | 25 |
| CSDL 702X | Department Level Optional Course-4 Lab | -- | -- | -- | -- | -- | 25 | - | 25 |
| CSP701 | Major Project 1 | -- | -- | -- | -- | -- | 50 | 25 | 75 |
| **Total** | | **--** | **--** | **100** | **400** | **--** | **150** | **75** | **725** |

**Program Structure for Fourth Year Computer Engineering**

**UNIVERSITY OF MUMBAI (With Effect** from 2022-2023)

## Semester VIII

| Course Code | Course Name | Teaching Scheme (Contact Hours) | | Credits Assigned | | |
|---|---|---|---|---|---|---|
| | | Theory | Pract. Tut. | Theory | Pract. | Total |
| CSC801 | Distributed Computing | 3 | -- | 3 | -- | 3 |
| CSDC 801X | Department Level Optional Course -5 | 3 | -- | 3 | -- | 3 |
| CSDC 802X | Department Level Optional Course -6 | 3 | -- | 3 | -- | 3 |
| CSIO801 | Institute Level Optional Course -2 | 3 | -- | 3 | -- | 3 |
| CSL801 | Distributed Computing Lab | -- | 2 | -- | 1 | 1 |
| CSDL 801X | Department Level Optional Course -5 Lab | -- | 2 | -- | 1 | 1 |
| CSDL 802X | Department Level Optional Course -6 Lab | -- | 2 | -- | 1 | 1 |
| CSP801 | Major Project 2 | -- | 12# | -- | 6 | 6 |
| **Total** | | **12** | **18** | **12** | **9** | **21** |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term Work | Pract & oral | Total |
| | | Internal Assessment | | | End Sem Exam | Exam Duration (in Hrs) | | | |
| | | Test 1 | Test 2 | Avg | | | | | |
| CSC801 | Distributed Computing | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |
| CSDC 801X | Department Level Optional Course -5 | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |
| CSDC 802X | Department Level Optional Course -6 | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |
| CSIO801 | Institute Level Optional Course -2 | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |
| CSL801 | Distributed Computing Lab | -- | -- | -- | -- | -- | 25 | 25 | 50 |
| CSDL 801X | Department Level Optional Course -5 Lab | -- | -- | -- | -- | -- | 25 | 25 | 50 |
| CSDL 802X | Department Level Optional Course -6 Lab | | | | | | 25 | 25 | 50 |
| CSP801 | Major Project 2 | -- | -- | -- | -- | -- | 100 | 50 | 150 |
| **Total** | | **--** | **--** | **80** | **320** | **--** | **175** | **125** | **700** |

**Major Project 1 and 2 :**

- Students can form groups with minimum 2 (Two) and not more than 4 (Four)
- Faculty Load : In Semester VII – ½ hour per week per project group
  In Semester VIII – 1 hour per week per project group

**Program Structure for Computer Engineering**

**UNIVERSITY OF MUMBAI (With Effect** from 2022-2023)

**Department and Institute Optional Courses and Labs**

| **Semester** | **Department/ Institute Optional Courses and Labs** | **Subject** |
|---|---|---|
| VII | Department Optional Course -3 | CSDC7011: Machine Vision<br>CSDC7012: Cyber Security<br>CSDC7013: Natural Language Processing |
| | Department Optional Lab -3 | CSDL7011: Machine Vision Lab<br>CSDL7012: Cyber Security Lab<br>CSDL7013: Natural Language Processing Lab |
| | Department Optional Course -4 | CSDC7021 : Augmented and Virtual Reality<br>CSDC7022 : Block Chain<br>CSDC7023 : Information Retrieval |
| | Department Optional Lab -4 | CSDL7021 : Augmented and Virtual Reality Lab<br>CSDL7022 : Block Chain Lab<br>CSDL7023 : Information Retrieval Lab |
| | Institute level Optional Courses-I | |

**Program Structure for Computer Engineering**

**UNIVERSITY OF MUMBAI (With Effect** from 2022-2023)

**Department and Institute Optional Courses and Labs**

| **Semester** | **Department/ Institute Optional Courses and Labs** | **Subject** |
|---|---|---|
| VIII | Department Optional Course -5 | CSDC8011 : Deep Learning<br>CSDC8012 : Digital Forensic<br>CSDC8013 : Applied Data Science |
| | Department Optional Lab -5 | CSDL8011 : Deep Learning Lab<br>CSDL8012 : Digital Forensic Lab<br>CSDL8013 : Applied Data Science Lab |
| | Department Optional Course -6 | CSDC8021 : Optimization in Machine Learning<br>CSDC8022: High Performance Computing<br>CSDC8023: Social Media Analytics |
| | Department Optional Lab -6 | CSDL8021 : Optimization in Machine Learning Lab<br>CSDL8022: High Performance Computing Lab<br>CSDL8023: Social Media Analytics Lab |
| | Institute level Optional Courses-II | |

| Course Code: | Course Title | Credit |
|---|---|---|
| CSC701 | Machine Learning | 3 |

| Prerequisite: Engineering Mathematics, Data Structures, Algorithms | |
|---|---|
| Course Objectives: | |
| 1 | To introduce the basic concepts and techniques of Machine Learning. |
| 2 | To acquire in depth understanding of various supervised and unsupervised algorithms |
| 3 | To be able to apply various ensemble techniques for combining ML models. |
| 4 | To demonstrate dimensionality reduction techniques. |
| Course Outcomes: | |
| 1 | To acquire fundamental knowledge of developing machine learning models. |
| 2 | To select, apply and evaluate an appropriate machine learning model for the given |
| 3 | To demonstrate ensemble techniques to combine predictions from different models. |
| 4 | To demonstrate the dimensionality reduction techniques. |

| Module | | Content | Hrs |
|---|---|---|---|
| 1 | | Introduction to Machine Learning | 04 |
| | 1.1 | Machine Learning, Types of Machine Learning, Issues in Machine Learning, Application of Machine Learning, Steps in developing a Machine Learning Application. | |
| | 1.2 | Training Error, Generalization error, Overfitting, Underfitting, Bias-Variance trade-off. | |
| 2 | | Learning with Regression and Trees | 09 |
| | 2.1 | Learning with Regression: Linear Regression, Multivariate Linear Regression, Logistic Regression. | |
| | 2.2 | Learning with Trees: Decision Trees, Constructing Decision Trees using Gini Index (Regression), Classification and Regression Trees (CART) | |
| | 2.3 | Performance Metrics: Confusion Matrix, [Kappa Statistics], Sensitivity, Specificity, Precision, Recall, F-measure, ROC curve | |
| 3 | | Ensemble Learning | 06 |
| | 3.1 | Understanding Ensembles, K-fold cross validation, Boosting, Stumping, XGBoost | |
| | 3.2 | Bagging, Subagging, Random Forest, Comparison with Boosting, Different ways to combine classifiers | |
| 4 | | Learning with Classification | 08 |
| | 4.1 | Support Vector Machine<br>Constrained Optimization, Optimal decision boundary, Margins and support vectors, SVM as constrained optimization problem, Quadratic | |

| | | | |
|---|---|---|---|
| | | Programming, SVM for linear and nonlinear classification, Basics of Kernel trick. | |
| | 4.2 | Support Vector Regression, Multiclass Classification | |
| 5 | | Learning with Clustering | 07 |
| | 5.1 | Introduction to clustering with overview of distance metrics and major clustering approaches. | |
| | 5.2 | Graph Based Clustering: Clustering with minimal spanning tree<br>Model based Clustering: Expectation Maximization Algorithm,<br>Density Based Clustering: DBSCAN | |
| 6 | | Dimensionality Reduction | 05 |
| | 6.1 | Dimensionality Reduction Techniques, Principal Component Analysis, Linear Discriminant Analysis, Singular Valued Decomposition. | |
| | | Total | 39 |

| | |
|---|---|
| Textbooks: | |
| 1 | Peter Harrington, “Machine Learning n Action”, DreamTech Press |
| 2 | Ethem Alpaydın, “Introduction to Machine Learning”, MIT Press |
| 3 | Tom M. Mitchell, “Machine Learning” McGraw Hill |
| 4 | Stephen Marsland, “Machine Learning An Algorithmic Perspective”, CRC Press |
| References: | |
| 1 | Han Kamber, ―Data Mining Concepts and Techniques‖, Morgan Kaufmann Publishers |
| 2 | Margaret. H. Dunham, ―Data Mining Introductory and Advanced Topics, Pearson Education |
| 3 | Kevin P. Murphy , Machine Learning ― A Probabilistic Perspective‖ |
| 4 | Samir Roy and Chakraborty, ―Introduction to soft computing‖, Pearson Edition. |
| 5 | Richard Duda, Peter Hart, David G. Stork, “Pattern Classification”, Second Edition, Wiley Publications. |
| Assessment: | |
| Internal Assessment: | |
| Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approximately 40% syllabus is completed and the second class test when an additional 40% syllabus is completed. Duration of each test shall be one hour. | |
| End Semester Theory Examination: | |
| 1 | Question paper will comprise a total of six questions. |
| 2 | All question carries equal marks |
| 3 | Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3) |

| | |
|---|---|
| 4 | Only Four questions need to be solved. |
| 5 | In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus. |

| Useful Digital Links | |
|---|---|
| 1 | Data sets for Machine Learning algorithms: https://www.kaggle.com/datasets |
| 2 | Machine Learning repository- https://archive.ics.uci.edu/ml/index.php |
| 3 | Machine Learning from Coursera |
| 4 | https://towardsdatascience.com/machine-learning/home |
| 5 | https://onlinecourses.nptel.ac.in/noc21_cs85/preview |

| Course Code | Course Name | Credit |
|---|---|---|
| CSC702 | Big Data Analysis | 03 |

| | |
|---|---|
| **Prerequisite: Database, Data mining.** | |
| **Course Objectives:** The course aims: | |
| 1 | To provide an overview of the big data platforms, its use cases and Hadoop ecosystem. |
| 2 | To introduce programming skills to build simple solutions using big data technologies such as MapReduce, Scripting for No SQL and R |
| 3 | To learn the fundamental techniques and principles in achieving big data analytics with scalability and streaming capability. |
| 4 | To enable students to have skills that will help them to solve complex real-world problems for decision support. |
| **Course Outcomes:** | |
| 1 | Understand the building blocks of Big Data Analytics. |
| 2 | Apply fundamental enabling techniques like Hadoop and MapReduce in solving real world problems. |
| 3 | Understand different NoSQL systems and how it handles big data. |
| 4 | Apply advanced techniques for emerging applications like stream analytics. |
| 5 | Achieve adequate perspectives of big data analytics in various applications like recommender systems, social media applications, etc. |
| 6 | Apply statistical computing techniques and graphics for analyzing big data. |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| **1** | | **Introduction to Big Data and Hadoop** | 2 |
| | 1.1 | Introduction to Big Data - Big Data characteristics and Types of Big Data | |
| | 1.2 | Traditional vs. Big Data business approach | |
| | 1.3 | Case Study of Big Data Solutions | |
| | 1.4 | Concept of Hadoop, Core Hadoop Components; Hadoop Ecosystem | |
| **2** | | **Hadoop HDFS and MapReduce** | 8 |
| | 2.1 | Distributed File Systems: Physical Organization of Compute Nodes, Large-Scale File-System Organization. | |
| | 2.2 | MapReduce: The Map Tasks, Grouping by Key, The Reduce Tasks, Combiners, Details of MapReduce Execution, Coping With Node Failures. | |
| | 2.3 | Algorithms Using MapReduce: Matrix-Vector Multiplication by MapReduce, Relational-Algebra Operations, Computing Selections by MapReduce, Computing Projections by MapReduce, Union ,Intersection, | |

| | | | |
|---|---|---|---|
| | | and Difference by MapReduce | |
| | 2.4 | Hadoop Limitations | |
| **3** | | **NoSQL** | 10 |
| | 3.1 | Introduction to NoSQL, NoSQL Business Drivers | |
| | 3.2 | NoSQL Data Architecture Patterns: Key-value stores, Graph stores, Column family (Bigtable)stores, Document stores, Variations of NoSQL architectural patterns, NoSQL Case Study | |
| | 3.3 | NoSQL solution for big data, Understanding the types of big data problems; Analyzing big data with a shared-nothing architecture; Choosing distribution models: master-slave versus peer-to-peer; NoSQL systems to handle big data problems. | |
| **4** | | **Mining Data Streams** | 11 |
| | 4.1 | The Stream Data Model: A Data-Stream-Management System, Examples of Stream Sources, Stream Queries, Issues in Stream Processing. | |
| | 4.2 | Sampling Data techniques in a Stream | |
| | 4.3 | Filtering Streams: Bloom Filter with Analysis. | |
| | 4.4 | Counting Distinct Elements in a Stream,Count-Distinct Problem, Flajolet-Martin Algorithm, Combining Estimates, Space Requirements | |
| | 4.5 | Counting Ones in a Window: The Cost of Exact Counts,The Datar-Gionis-Indyk-Motwani Algorithm, Query Answering in theDGIM Algorithm, Decaying Windows. | |
| **5** | | **Real-Time Big Data Models** | 4 |
| | 5.1 | A Model for Recommendation Systems, Content-Based Recommendations, Collaborative Filtering | |
| | 5.2 | Case Study: Product Recommendation | |
| | 5.3 | Social Networks as Graphs, Clustering of Social-Network Graphs, Direct Discovery of Communities in a social graph | |
| **6** | | **Data Analytics with R** | 4 |
| | 6.1 | Exploring Basic features of R, Exploring RGUI, Exploring RStudio, Handling Basic Expressions in R, Variables in R, Working with Vectors, Storing and Calculating Values in R, Creating and using Objects, Interacting with users, Handling data in R workspace, Executing Scripts, Creating Plots, Accessing help and documentation in R | |
| | 6.2 | Reading datasets and Exporting data from R, Manipulating and Processing Data in R, Using functions instead of script, built-in functions in R | |
| | 6.3 | Data Visualization: Types, Applications | |



| **Textbooks:** | |
|---|---|
| 1 | Cre Anand Rajaraman and Jeff Ullman ―Mining of Massive Datasets‖, Cambridge UniversityPress |
| 2 | Alex Holmes ―Hadoop in Practice‖, Manning Press, Dreamtech Press. |
| 3 | Dan Mcary and Ann Kelly ―Making Sense of NoSQL‖ – A guide for managers and the rest of us, Manning Press. |
| 4 | DT Editorial Services, “Big Data Black Book”, Dreamtech Press |

| | |
|---|---|
| 5 | EMC Education Services,"Data Science and Big Data Analytics",Wiley |

**References:**

| | |
|---|---|
| 1 | Bill Franks , —Taming The Big Data Tidal Wave: Finding Opportunities In HugeData StreamsWithAdvancedAnalytics|,Wiley |
| 2 | Chuck Lam, —Hadoop inAction|, Dreamtech Press |
| 3 | Jared Dean, —Big Data, Data Mining, and Machine Learning: Value Creation for Business Leaders and Practitioners|,Wiley India Private Limited, 2014. |
| 4 | Jiawei Han and Micheline Kamber, —Data Mining: Concepts and Techniques|, Morgan Kaufmann Publishers, 3rd ed, 2010. |
| 5 | Lior Rokach and Oded Maimon, —Data Mining and Knowledge Discovery Handbook|, Springer, 2nd edition,2010. |
| 6 | Ronen Feldman and James Sanger, —The Text Mining Handbook: Advanced Approaches in Analyzing Unstructured Data|, Cambridge University Press, 2006. |
| 7 | Vojislav Kecman, —Learning and Soft Computing|, MITPress, 2010. |

**Assessment:**

**Internal Assessment:**

Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional40% syllabus is completed. Duration of each test shall be one hour.

**End Semester Theory Examination:**

| | |
|---|---|
| 1 | Question paper will consist of 6 questions, each carrying 20 marks. |
| 2 | The students need to solve a total of 4 questions. |
| 3 | Question No.1 will be compulsory and based on the entire syllabus. |
| 4 | Remaining question (Q.2 to Q.6) will be selected from all the modules. |

**Useful Links**

| | |
|---|---|
| 1 | https://nptel.ac.in/courses/106104189 |
| 2 | https://www.coursera.org/specializations/big-data#courses |
| 3 | https://www.digimat.in/nptel/courses/video/106106169/L01.html |
| 4 | https://www.coursera.org/learn/nosql-databases#syllabus |
| 5 | https://www.coursera.org/learn/basic-recommender-systems#syllabus |

| Course Code | Course Name | Credit |
|---|---|---|
| CSDC7011 | Machine Vision | 03 |

| Pre-requisite: Computer Graphics | |
|---|---|
| **Course Objectives:** The course aims: | |
| 1 | To understand the need and significance Machine Vision |
| 2 | To explore basics of image processing |
| 3 | To explore the components of Machine Vision System |
| 4 | To develop application using machine Vision |
| 5 | To study transformation, interpolation, filters. |
| **Course Outcomes:** Learners will be able to | |
| 1 | Elaborate the components of Machine Vision Application |
| 2 | Perform image ,video preprocessing operations |
| 3 | Explain various transformations, interpolation. |
| 4 | Elaborate motion tracking in video. |
| 5 | Analyze and Implement appropriate filtering techniques for a given problem. |
| 6 | Develop applications based on machine vision.. |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| **1** | | **Introduction to Machine Vision** | 4 |
| | | Computer and Human Vision Systems., The Human Eye, Computer versus Human Vision Systems, Evolution of Computer Vision, Computer/Machine Vision and Image Processing, Applications of Computer Vision | |
| **2** | | **Digital Image Fundamentals** | 8 |
| | | Digital Image, Monochrome and Color Images, Image Brightness and Contrast., 2D, 3D, and 4D Images, Digital Image Representation , Digital Image File Formats, Fundamental Image Operations, Points, Edges, and Vertices , Point Operations , Thresholding ,Brightness, Geometric Transformations , Spatial Transformation , Affine Transformation, Image Interpolation ,Nearest-Neighbor Interpolation ,Bilinear Interpolation , Bi-cubic Interpolation ,Fundamental Steps in Digital Image Processing. | |
| **3** | | **Machine Vision and System Components** | 8 |

| | | | |
|---|---|---|---|
| | | Machine Vision System, Machine Vision Camera: CCD and CMOS Image Sensors, TDI Sensor, Camera Type - Area Scan Cameras, Line Scan Cameras, Smart Cameras, Camera Lens-Resolution, Contrast and Sharpness, Lenses and their parameters: Types of Lenses, Lens Mounts, Lens Selection Examples-Field of View Much larger than Camera sensor size or Smaller or close to Camera Sensor size, Machine Vision Lighting: Lighting: Light Sources in Machine Vision, Illumination Techniques-Backlighting, Front Lighting, Diffused Lighting, Oblique Lighting, Dark Field Lighting, Infrared and Ultraviolet Light, Filters, Machine Vision Software, Machine Vision Automation, Integration of Machine Vision Components | |
| **4** | | **Digital Image Processing for Machine Vision Applications** | 10 |
| | | Preprocessing., Image Filtering, Normalized Box Filter Gaussian Filter Bilateral Filter, Comparison of Filter Techniques, Sub sampling/Scaling Histogram, Image Segmentation, Threshold-Based Segmentation Edge-Based Segmentation First-Order Derivative Edge Detection. Second-Order Derivative Operators, Comparison of Edge Detection Techniques, Region-Based Segmentation Region Growing Methods, Region Split and Merge Method, Morphological Image Processing: Dilation, Erosion, Opening, Closing, Hit-or-Miss transformation, Object Recognition. Template Matching. Blob Analysis | |
| **5** | | **Motion Analysis** | **4** |
| | | Differential motion Analysis, Optical Flow, Analysis based on correspondence of interest points, Detection of specific motion Patterns, Video Tracking | |
| **6** | | **Emerging Trends in Machine Vision** | **5** |
| | 6.1 | History of Industrial Revolution(s), Machine Vision and Industry 4.0, Emerging Vision Trends in Manufacturing, 3D Imaging, Emerging Vision Trends in Manufacturing, | |
| | 6.2 | Applications in Machine/ Computer Vision: Face detection, face recognition, eigen faces, car on roads | |



**Textbooks:**


| | |
|---|---|
| 1. | Sheila Anand and L.Priya , “A Guide for Machine Vision in Quality Control”, Taylor & Francis Inc, Imprint CRC Press Inc, Dec 2019 |
| 2. | Rafael C. Gonzalez and Richard E. Woods, “Digital Image Processing”, Pearson |
| 3. | Carsten Stegar, Markus Ulrich, and Christian Wiedemann , “Machine Vision Algorithms and Applications”,Second completely Revised and Enlarged Edition |

| | |
|---|---|
| 4. | Milan Sonka, Vaclav Hlavac, Roger Boyle, “Image Processing Analysis and Machine Vision”, Second Edition, Cengage Learning. |

**References:**

| | |
|---|---|
| 1. | Chiranji Lal Chowdhary, Mamoun Alazab, Ankit Chaudhary, SaqibHakak and Thippa Reddy Gadekallu ,”Computer Vision and Recognition Systems Using Machine and Deep Learning Approaches, Fundamentals, technologies and applications” , IET COMPUTING SERIES 42 |
| 2 | Joe Minichino Joseph Howse ,”Learning OpenCV 3 Computer Vision with Python”, Second Edition, Packt Publishing Ltd. |
| 3. | Alexander Hornberg,, “ Handbook of Machine and Computer Vision The Guide for Developers and Users, |

**Assessment:**

**Internal Assessment:**

Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional40% syllabus is completed. Duration of each test shall be one hour.

**End Semester Theory Examination:**

| | |
|---|---|
| 1 | Question paper will consist of 6 questions, each carrying 20 marks. |
| 2 | The students need to solve a total of 4 questions. |
| 3 | Question No.1 will be compulsory and based on the entire syllabus. |
| 4 | Remaining question (Q.2 to Q.6) will be selected from all the modules. |

**Useful Links**

| | |
|---|---|
| 1 | https://nptel.ac.in/courses/108103174 |
| 2 | https://www.coursera.org/learn/introduction-computer-vision-watson-opencv |
| 3 | https://www.udacity.com/course/introduction-to-computer-vision--ud810 |
| 4 | https://onlinecourses.nptel.ac.in/noc21_ee23/preview |

| Course Code | Course Title | Credit |
|---|---|---|
| CSDC7012 | Cyber Security | 3 |

| | | | |
|---|---|---|---|
| **Prerequisite: Computer Networks, Databases** | | | |
| **Course Objectives:** | | | |
| 1 | To understand the need for Cyber Security Awareness. | | |
| 2 | To understand the Flow and Methodology of an attack | | |
| 3 | To learn and explore various Static and Web vulnerability analysis tools | | |
| 4 | To understand the various IPR, Privacy and Security compliances | | |
| **Course Outcomes:** | | | |
| 1 | Understand the need of Cyber Security and awareness of existing law infrastructure | | |
| 2 | Illustrate the various tools and techniques used by attackers to launch their attacks | | |
| 3 | Appraise various mechanisms of conducting system vulnerability analysis | | |
| 4 | Discuss various web application vulnerability scanning techniques | | |
| 5 | Identify the various network defense methodologies | | |
| 6 | Describe the various Privacy and standard compliances | | |
| **Module** | | **Content** | **Hrs** |
| **1** | | **Introduction to Cyber Crime and Attack Psychology** | **7** |
| | 1.1<br><br><br><br>1.2 | **Cyber Crime:** Need for Cyber Security, Cybercrime definition, Types of Cybercrime. Classifications of cybercrime, Hackers, Crackers and cyber criminals Indian IT ACT 2008 and its amendments.<br><br>**Attack Psychology:** How cyber criminals plan the attacks, Social Engineering, Cyber stalking, Cyber café and Cybercrimes, Botnets, Attack vector, Attacks on Mobile. | |
| **2** | | **Threat and Vulnerability Landscape** | **7** |
| | | Goals of Security, Vulnerability vs Threat, What is Privacy, Anonymity and pseudonymity, The Vulnerability Landscape, Threat Modeling and risk Assessment, The Zero Trust model, Spyware, Adware, Scareware , Browser Hijacking, Phishing vs Vishing vs SMShing, Doxing and Spamming,Social Engineering attack. | |
| **3** | | **System Vulnerability Scanning and Network Reconnaissance** | **7** |

| | | | |
|---|---|---|---|
| | | Password Cracking, Key loggers and Spywares, Virus and Worms, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Overflow, Phishing, Identity Theft (ID Theft),network information gathering, vulnerability scanning, Open Port Identification, Banner Grabbing Techniques, Vulnerability probing. | |
| **4** | | **Web Application Security** | **8** |
| | | OWASP, Web Security Considerations, Management, Cookies, SSL, HTTPS, SSH, Privacy on Web, Web Browser Attacks, Account Harvesting, Web Bugs, Clickjacking, Cross-Site Request Forgery, Session Hijacking and Management, Phishing and Pharming Techniques, Web Service Security, OAuth 2.0 | |
| **5** | | **Network Security and Defense Tools** | **6** |
| | | Network security: Cyber Hygine, Firewalls vs Packet Filters, Stateless vs Statefull Firewalls, Intrusion Detection System and its types, Honeypots, Demilitarized Zones, Network Address Translation (NAT), Port Forwarding. Virtual Private Networks, Email Security(GPG Encryption), Registry Settings for Mobile Devices | |
| **6** | | **Information Security Privacy and Standard Compliances** | **4** |
| | | HIPPA, FISMA, PCI DSS, GDPR, Intellectual Property Aspect of Cyber Law, Creative Commons Library, Data Protection Laws in India. | |

**Textbooks:**

| | |
|---|---|
| 1 | William Stallings, Computer Security Principles and Practice, , Sixth Edition, Pearson Education |
| 2 | Charles P. Pfleeger Security in Computing, , Fifth Edition, Pearson Education |
| 3 | The Complete Cyber Security Course -Volume 1- Nathan House |
| 4 | Eric Cole, Network Security Bible, Second Edition, Wiley |

**References:**

| | |
|---|---|
| 1 | Nina Godbole, Sunit Belapure, Cyber Security, Wiley India, New Delhi |
| 2 | The Information technology Act, 2000; Bare Act- Professional Book Publishers, |
| 3 | Michael Gregg, “Build your own Security Lab”, Wiley India |
| 4 | Dieter Gollman, “Computer Security”, Third Edition, Wiley |

**Digital References:**

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|---|
| Virtual Penetration Testing Labs- https://pentesterlab.com |
| OWASP- https://owasp.org/ |
| DVWA- https://dvwa.co.uk |
| FISMA - https://csrc.nist.gov/projects/risk-management/fisma-background |
| PCI DS https://www.itgovernance.eu/blog/en/a-guide-to-the-4-pci-dss-compliance-levels |

**Assessment:**

**Internal Assessment:**

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.

**End Semester Theory Examination:**

| | |
|---|---|
| 1 | Question paper will comprise of total six questions. |
| 2 | All question carries equal marks |
| 3 | Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3) |
| 4 | Only Four question need to be solved. |
| 5 | In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus. |

| Course Code | Course Name | Credit |
|---|---|---|
| CSDC7013 | Natural Language Processing | 03 |

| | |
|---|---|
| **Pre-requisite:** Theory of Computer Science, System Programming &Compiler Construction | |
| **Course Objectives:** The course aims | |
| 1 | To define natural language processing and to learn various stages of natural language processing. |
| 2 | To describe basic concepts and algorithmic description of the main language levels: Morphology, Syntax, Semantics, and Pragmatics &Discourse analysis. |
| 3 | To design and implement various language models and POS tagging techniques. |
| 4 | To design and learn NLP applications such as Information Extraction, Question answering. |
| 5 | To design and implement applications based on natural language processing. |

| | |
|---|---|
| **Course Outcomes:**Students will be able | |
| 1 | To describe the field of natural language processing. |
| 2 | To design language model for word level analysis for text processing. |
| 3 | To design various POS tagging techniques and parsers. |
| 4 | To design, implement and test algorithms for semantic and pragmatic analysis. |
| 5 | To formulate the discourse segmentation and anaphora resolution. |
| 6 | To apply NLP techniques to design real world NLP applications. |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| **1** | 1.1 | **Introduction to NLP** | 3 |
| | | Origin & History of NLP; Language, Knowledge and Grammar in language processing; Stages in NLP;Ambiguities and its types in English and Indian Regional Llanguages; Challenges of NLP;Applications of NLP | |
| | 1.2 | **Self-Learning topics:** Variety types of tools for regional languages pre-processing and other functionalities | |
| **2** | 2.1 | **Word Level Analysis** | 9 |
| | | Basic Terms: Tokenization, Stemming, Lemmatization; Survey of English Morphology, Inflectional Morphology, Derivational Morphology; Regular expression with types;<br><br>Morphological Models: Dictionary lookup, finite state morphology; Morphological parsing with FST (Finite State Transducer);Lexicon free FST Porter Stemmer algorithm; Grams and its variation: Bigram, Trigram; Simple (Unsmoothed) N-grams;<br><br>N-gram Sensitivity to the Training Corpus; Unknown Words: Open | |

| | | | |
|---|---|---|---|
| | | versus closed vocabulary tasks; Evaluating N-grams: Perplexity; Smoothing: Laplace Smoothing, Good-Turing Discounting; | |
| | 2.2 | **Self-Learning topics:** Noisy channel models, various edit distance, Advance Issues in Language Modelling | |
| **3** | 3.1 | **Syntax analysis** | 10 |
| | | Part-Of-Speech tagging(POS); Tag set for English (Upenn Treebank); Difficulties /Challenges in POS tagging; Rule-based, Stochastic and Transformation-based tagging; Generative Model: Hidden Markov Model (HMM Viterbi) for POS tagging;<br><br>Issues in HMM POS tagging; Discriminative Model: Maximum Entropy model, Conditional random Field (CRF);Parsers: Top down and Bottom up; Modelling constituency; Bottom Up Parser: CYK, PCFG (Probabilistic Context Free Grammar), Shift Reduce Parser; Top Down Parser: Early Parser, Predictive Parser | |
| | 3.2 | **Self-Learning topics:** Evaluating parsers, Parsers based language modelling, Regional languages POS tree banks | |
| **4** | 4.1 | **Semantic Analysis** | 7 |
| | | Introduction, meaning representation; Lexical Semantics; Corpus study; Study of Various language dictionaries like WorldNet, Babelnet; Relations among lexemes & their senses –Homonymy, Polysemy, Synonymy, Hyponymy; Semantic Ambiguity;<br>Word Sense Disambiguation (WSD); Knowledge based approach( Lesk's Algorithm), Supervised (Naïve Bayes, Decision List),Introduction to Semi-supervised method (Yarowsky) Unsupervised (Hyperlex) | |
| | 4.2 | **Self-Learning topics:** Dictionaries for regional languages, Distributional Semantics, Topic Models | |
| **5** | 5.1 | **Pragmatic & Discourse Processing** | 5 |
| | | Discourse: Reference Resolution, Reference Phenomena, Syntactic & Semantic constraint on coherence; Anaphora Resolution using Hobbs and Cantering Algorithm | |
| | 5.2 | **Self-Learning topics:** Discourse segmentation, Conference resolution | |
| **6** | 6.1 | **Applications of NLP** | 5 |
| | | Case studies on (preferable in regional language):Machine translation; Text Summarization; Sentiment analysis; Information retrieval; Question Answering system | |
| | 6.2 | **Self-Learning topics:** Applications based on Deep Neural Network with NLP such as LSTM network, Recurrent Neural network etc. | |



| **Textbooks:** | |
|---|---|
| 1 | Daniel Jurafsky, James H. and Martin, Speech and Language Processing, Second Edition, Prentice Hall, 2008. |
| 2 | Christopher D.Manning and HinrichSchutze, Foundations of Statistical Natural Language Processing, MIT Press, 1999. |
| **References:** | |
| 1 | Siddiqui and Tiwary U.S., Natural Language Processing and Information Retrieval, Oxford University Press, 2008. |
| 2 | Daniel M Bikel and ImedZitouni — Multilingual natural language processing applications: |

| | |
|---|---|
| | from theory to practice, IBM Press, 2013. |
| 3 | Alexander Clark, Chris Fox, Shalom Lappin — The Handbook of Computational Linguistics and Natural Language Processing, John Wiley and Sons, 2012. |
| 4 | Nitin Indurkhya and Fred J. Damerau, —Handbook of Natural Language Processing, Second Edition, Chapman and Hall/CRC Press, 2010. |
| 5 | Niel J le Roux and SugnetLubbe, A step by step tutorial: An introduction into R application and programming. |
| 6 | Steven Bird, Ewan Klein and Edward Loper, Natural language processing with Python: analyzing text with the natural language toolkit, O'Reilly Media, 2009. |


| **Digital References :** | |
|---|---|
| 1 | http://www.cse.iitb.ac.in/~cs626-449 |
| 2 | http://cse24-iiith.virtual-labs.ac.in/# |
| 3. | https://nptel.ac.in/courses/106105158 |

| **Assessment:** | |
|---|---|
| **Internal Assessment:** | |
| Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour. | |
| **End Semester Theory Examination:** | |
| 1 | Question paper will consist of 6 questions, each carrying 20 marks. |
| 2 | The students need to solve a total of 4 questions. |
| 3 | Question No.1 will be compulsory and based on the entire syllabus. |
| 4 | Remaining question (Q.2 to Q.6) will be selected from all the modules. |

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| Course Code | Course Name | Credit |
|---|---|---|
| CSDC7021 | Virtual and Augmented Reality | 04 |

| | |
|---|---|
| **Prerequisite: Computer Graphics** | |
| **Course Objectives:** The course aims: | |
| 1 | To understand the need and significance of Virtual Reality. |
| 2 | To explore the concepts of Virtual reality and develop 3D virtual environments. |
| 3 | To understand the technical and engineering aspects of virtual reality systems. |
| 4 | To analyze various techniques for applying virtual reality. |
| 5 | To provide a foundation to the fast growing field of AR and make the students aware of the various AR devices. |
| **Course Outcomes: Learners will be able to** | |
| 1: | Describe how VR systems work and list the applications of VR |
| 2: | Elaborate geometric presentationof the virtual world and its operations. |
| 3: | Explain the concepts of motion and tracking in VR systems. |
| 4: | Design and implementation of the hardware that enables VR systems tobe built. |
| 5: | Describe how AR systems work and analyze the hardware requirement of AR |
| 6: | Analyze and understand the working of various state of the art AR devices. |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| 1 | | **Introduction to Virtual Reality** | 5 |
| | | What is virtual reality? ,The beginnings of VR , VR paradigms , Collaboration, Virtual reality systems, Representation ,User interaction | |
| 2 | | **The Geometry of Virtual Worlds** | 6 |
| | | Geometric Models, Changing Position and Orientation, Axis-Angle Representations of Rotation, Viewing Transformations, Chaining the Transformations | |
| 3 | | **Motion in Real and Virtual Worlds** | 6 |
| | | Velocities and Accelerations , The Vestibular System , Physics in the Virtual World , Mismatched Motion and Vection | |
| 4 | | **Applying Virtual Reality** | 7 |
| | | Virtual reality: the medium, Form and genre, What makes an application a good candidate for VR, Promising application fields, Demonstrated benefits of virtual reality , More recent trends in virtual reality application development, A framework for VR application development | |
| 5 | | **Augmented Reality** | 8 |
| | | Terminology, Simple augmented reality, Augmented reality as an emerging technology, Augmented reality applications, Marker detection, Marker pose, Marker types and identification: Template markers, 2D bar-code markers, Imperceptible markers: Image markers, Infrared markers, Miniature markers, Discussion on marker use, General marker detection application | |
| 6 | | **AR Development & Applications** | |

| | | | |
|---|---|---|---|
| | | User interfaces, Avoiding physical contacts , Practical experiences with head-mounted displays , Authoring and dynamic content ,AR applications and future visions, How to design an AR application ,Technology adoption and acceptance , Where to use augmented reality | |

| **Textbooks:** | |
|---|---|
| 1 | Virtual Reality, Steven M. LaValle, Cambridge University Press, 2016 |
| 2 | Understanding Virtual Reality: Interface, Application and Design, William R Sherman and Alan B Craig, (The Morgan Kaufmann Series in Computer Graphics)". Morgan Kaufmann Publishers, San Francisco, CA, 2002 |
| 3 | Developing Virtual Reality Applications: Foundations of Effective Design, Alan B Craig,William R Sherman and Jeffrey D Will, Morgan Kaufmann, 2009. |
| 4 | Theory and applications of marker-based augmented reality SanniSiltanen |
| **References:** | |
| 1 | AR Game Development‖, 1st Edition,Allan Fowler, A press Publications, 2018, ISBN 978-1484236178 |
| 2 | Augmented Reality: Principles & Practice by Schmalstieg / Hollerer, Pearson Education India;<br>First edition (12 October 2016),ISBN-10: 9332578494 |
| 3 | Learning Virtual Reality, Tony Parisi,O'Reilly Media, Inc., 2015, ISBN- 9781491922835 |

| **Digital Useful Links** | |
|---|---|
| 1 | https://freevideolectures.com/course/3693/virtual-reality |
| 2 | https://www.vrlabacademy.com/ |
| 3 | https://arvr.google.com/ar/ |
| 4 | https://konterball.com/ |

| **Assessment:** |
|---|
| **Internal Assessment:** |
| Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional40% syllabus is completed. Duration of each test shall be one hour. |
| **End Semester Theory Examination:** |

| | |
|---|---|
| 1 | Question paper will consist of 6 questions, each carrying 20 marks. |
| 2 | The students need to solve a total of 4 questions. |
| 3 | Question No.1 will be compulsory and based on the entire syllabus. |
| 4 | Remaining question (Q.2 to Q.6) will be selected from all the modules. |

| Course Code: | Course Title | Credit |
|---|---|---|
| CSDC7022 | Blockchain | 3 |

| Prerequisite: Cryptography and System Security | |
|---|---|
| **Course Objectives:** | |
| 1 | Understand blockchain platforms and its terminologies. |
| 2 | Understand the use of cryptography required for blockchain. |
| 3 | Understand smart contracts, wallets, and consensus protocols. |
| 4 | Design and develop blockchain applications |
| **Course Outcomes:** | |
| 1 | Explain blockchain concepts. |
| 2 | Apply cryptographic hash required for blockchain. |
| 3 | Apply the concepts of smart contracts for an application. |
| 4 | Design a public blockchain using Ethereum. |
| 5 | Design a private blockchain using Hyperledger. |
| 6 | Use different types of tools for blockchain applications. |

| Module | | Content | Hrs |
|---|---|---|---|
| **1** | | **Introduction to Blockchain** | **6** |
| | 1.1 | What is a blockchain, Origin of blockchain (cryptographically secure hash functions), Foundation of blockchain: Merkle trees | |
| | 1.2 | Components of blockchain, Block in blockchain, Types: Public, Private, and Consortium, Consensus Protocol, Limitations and Challenges of blockchain | |
| **2** | | **Cryptocurrency** | **6** |
| | 2.1 | Cryptocurrency: Bitcoin, Altcoin, and Tokens (Utility and Security), Cryptocurrency wallets: Hot and cold wallets, Cryptocurrency usage, Transactions in Blockchain, UTXO and double spending problem | |
| | 2.2 | Bitcoin blockchain: Consensus in Bitcoin, Proof-of-Work (PoW), Proof-of-Burn (PoB), Proof-of-Stake (PoS), and Proof-of-Elapsed Time (PoET), Life of a miner, Mining difficulty, Mining pool and its methods | |
| **3** | | **Programming for Blockchain** | **8** |
| | 3.1 | Introduction to Smart Contracts, Types of Smart Contracts, Structure of a Smart Contract, Smart Contract Approaches, Limitations of Smart Contracts | |
| | 3.2 | Introduction to Programming: Solidity Programming – Basics, functions, Visibility and Activity Qualifiers, Address and Address Payable, Bytes and Enums, Arrays-Fixed and Dynamic Arrays, Special Arrays-Bytes and strings, Struct, Mapping, Inheritance, Error handling | |
| | 3.3 | Case Study – Voting Contract App, Preparing for smart contract development | |

| | | | |
|---|---|---|---|
| **4** | | **Public Blockchain** | **8** |
| | | Introduction to Public Blockchain, Ethereum and its Components, Mining in Ethereum, Ethereum Virtual Machine (EVM), Transaction, Accounts, Architecture and Workflow, Comparison between Bitcoin and Ethereum | |
| | | Types of test-networks used in Ethereum, Transferring Ethers using Metamask, Mist Wallet, Ethereum frameworks, Case study of Ganache for Ethereum blockchain. Exploring etherscan.io and ether block structure | |
| **5** | | **Private Blockchain** | **8** |
| | 5.1 | Introduction, Key characteristics, Need of Private Blockchain, Smart Contract in a Private Environment, State Machine Replication, Consensus Algorithms for Private Blockchain - PAXOS and RAFT, Byzantine Faults: Byzantine Fault Tolerant (BFT) and Practical BFT | |
| | 5.2 | Introduction to Hyperledger, Tools and Frameworks, Hyperledger Fabric, Comparison between Hyperledger Fabric & Other Technologies | |
| | 5.3 | Hyperledger Fabric Architecture, Components of Hyperledger Fabric: MSP, Chain Codes, Transaction Flow, Working of Hyperledger Fabric, Creating Hyperledger Network, Case Study of Supply Chain Management using Hyperledger | |
| **6** | | **Tools and Applications of Blockchain** | **3** |
| | | Corda, Ripple, Quorum and other Emerging Blockchain Platforms, Blockchain in DeFi: Case Study on any of the Blockchain Platforms. | |

**Textbooks:**


| | |
|---|---|
| 1 | Blockchain Technology, Chandramouli Subramanian, Asha A. George, Abhillash K. A and Meena Karthikeyen, Universities Press. |
| 2 | Mastering Ethereum, Building Smart Contract and Dapps, Andreas M. Antonopoulos Dr. Gavin Wood, O'reilly. |
| 3 | Imran Bashir, Mastering Blockchain: A deep dive into distributed ledgers, consensus protocols, smart contracts, DApps, cryptocurrencies, Ethereum, and more, 3rd Edition, Packt Publishing |


**References:**


| | |
|---|---|
| 1 | Blockchain for Beginners, Yathish R and Tejaswini N, SPD |
| 2 | Blockchain Basics, A non Technical Introduction in 25 Steps, Daniel Drescher, Apress. |
| 3 | Blockchain with Hyperledger Fabric,Luc Desrosiers, Nitin Gaur, Salman A. Baset, Venkatraman Ramakrishna, Packt Publishing |


**Assessment:**

**Internal Assessment:**

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.

**End Semester Theory Examination:**

| | |
|---|---|
| 1 | Question paper will comprise a total of six questions. |
| 2 | All question carries equal marks |
| 3 | Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3) |
| 4 | Only Four question need to be solved. |
| 5 | In question paper weightage of each module will be proportional to the number of respective lecture hours as mention in the syllabus. |

| **Digital Useful Links** | |
|---|---|
| 1 | Blockchain By Example, Bellaj Badr, Richard Horrocks, Xun (Brian) Wu, November 2018, Implement decentralized blockchain applications to build scalable Dapps. |
| 2 | Blockchain for Business, https://www.ibm.com/downloads/cas/3EGWKGX7. |
| 3 | https://www.hyperledger.org/use/fabric |
| 4 | NPTEL: https://onlinecourses.nptel.ac.in/noc19_cs63/preview |

| Course Code | Course Name | Credit |
|---|---|---|
| CSDC7023 | Information Retrieval | 03 |

| | |
|---|---|
| **Prerequisite: Data structures and algorithms** | |
| **Course Objectives: The course aims students :** | |
| 1 | To learn the fundamentals of Information Retrieval |
| 2 | To analyze various Information retrieval modeling techniques |
| 3 | To understand query processing and its applications |
| 4 | To explore the various indexing and scoring techniques |
| 5 | To assess the various evaluation methods |
| 6 | To analyze various information retrieval for real world application |
| **Course Outcomes: Learner will be able to: -** | |
| 1 | Define and describe the basic concepts of the Information retrieval system. |
| 2 | Design the various modeling techniques for information retrieval systems. |
| 3 | Understand the query structure and various query operations |
| 4 | Analyzing the indexing and scoring operation in information retrieval systems |
| 5 | Perform the evaluation of information retrieval systems |
| 6 | Analyze various information retrieval for real world application |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| **1** | | **Introduction to Information Retrieval** | 4 |
| | 1.1 | Introduction to Information Retrieval, Basic Concepts, Information Versus Data, Trends and research issues in information retrieval. | |
| | 1.2 | The retrieval process, Information retrieval in the library, web and digital libraries. | |
| **2** | | **Modeling in Information Retrieval** | 8 |
| | 2.1 | Taxonomy of Information Retrieval models, Classic Information Retrieval, Alternate set: Theoretical model, Alternative Algebraic models, Alternative Probabilistic models | |
| | 2.2 | Structured text Retrieval models, Models for browsing | |
| **3** | | **Query and Operations in Information Retrieval** | 8 |
| | 3.1 | Query structures, Keyboard based querying, Pattern matching, Structured queries | |
| | 3.2 | User relevance feedback, Automatic local analysis, Automatic global analysis | |
| **4** | | **Indexing and Scoring in Information Systems** | 8 |
| | 4.1 | Introduction, Inverted Files, Other Indices for Text, Boolean queries and Introduction to Sequential searching | |

| | | | |
|---|---|---|---|
| | 4.2 | Scoring, term weighting and the vector space model, Parametric and zone indexes, Weighted zone scoring, Learning weights, The optimal weight, Term frequency and weighting, Inverse document frequency, Tf-idf weighting.<br>The vector space model for scoring, Queries as vectors, Computing vector scores, Efficient scoring and ranking, Inexact top K document retrieval | |
| **5** | | **Evaluation of Information Retrieval Systems** | 6 |
| | 5.1 | Information retrieval system evaluation, Standard test collections, Evaluation of unranked retrieval sets, Evaluation of ranked retrieval results, Assessing and justifying the concept of relevance | |
| | 5.2 | System quality and user utility, System issues, Refining a deployed system | |
| **6.** | | **Applications of Information Retrieval Systems** | 5 |
| | 6.1. | Introduction to Multimedia Information Retrieval | |
| | 6.2 | Introduction to Distributed Information Retrieval | |

| **Textbooks:** | |
|---|---|
| 1 | Modern information retrieval, Baeza-Yates, R. and Ribeiro-Neto, B., 1999. ACM press. |
| 2 | Introduction to Information Retrieval By Christopher D. Manning and PrabhakarRaghavan, Cambridge University Press |
| 3 | Information Storage & Retrieval By Robert Korfhage – John Wiley & Sons |
| **References:** | |
| 1 | Storage Network Management and Retrieval, VaishaliKhairnar |
| 2 | Introduction to Modern Information Retrieval. G.G. Chowdhury. NealSchuman |
| 3 | Natural Language Processing and Information Retrieval by Tanveer Siddiqui, U.S Tiwarey |

| **Useful Digital Links** | |
|---|---|
| 1 | https://web.stanford.edu/class/cs276/ |
| 2 | https://www.coursera.org/learn/text-retrieval |

| **Assessment:** | |
|---|---|
| **Internal Assessment:** | |
| Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour. | |
| **End Semester Theory Examination:** | |
| 1 | Question paper will consist of 6 questions, each carrying 20 marks. |
| 2 | The students need to solve a total of 4 questions. |
| 3 | Question No.1 will be compulsory and based on the entire syllabus. |
| 4 | Remaining question (Q.2 to Q.6) will be selected from all the modules. |

| Lab Code | Lab Name | Credit |
|---|---|---|
| CSL70011 | Machine Learning Lab | 1 |

| | |
|---|---|
| **Prerequisite:** Data Structures, Analysis of Algorithms | |
| **Lab Objectives:** | |
| 1 | To introduce the basic concepts and techniques of Machine Learning. |
| 2 | To acquire in depth understanding of various supervised and unsupervised algorithms |
| 3 | To be able to apply various ensemble techniques for combining ML models. |
| 4 | To demonstrate dimensionality reduction techniques. |

**Lab Outcomes:** At the end of the course, the students will be able to

| | |
|---|---|
| 1 | To implement an appropriate machine learning model for the given application. |
| 2 | To implement ensemble techniques to combine predictions from different models. |
| 3 | To implement the dimensionality reduction techniques. |

| **Suggested List of Experiments** | |
|---|---|
| **Sr. No.** | **Title of Experiment** |
| 1 | To implement Linear Regression. |
| 2 | To implement Logistic Regression. |
| 3 | To implement Ensemble learning (bagging/boosting) |
| 4 | To implement multivariate Linear Regression. |
| 5 | To implement SVM |
| 6 | To implement PCA/SVD/LDA |
| 7 | To implement Graph Based Clustering |
| 8 | To implement DB Scan |
| 9 | To implement CART |
| 10 | To implement LDA |
| | |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 6 experiments. |
| 2 | Journal must include one mini project/case study on any machine learning application. |
| 3 | The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing marks in term work. |
| 4 | Total 25 Marks (Experiments & Assignments: 15-marks, Attendance: 05-marks, mini project: 05-marks) |

**Oral & Practical exam.**

| | |
|---|---|
| | Based on the entire syllabus **CSC7011** Machine Learning **and CSL7011**: Machine Learning Lab |

| Lab Code | Lab Name | Credit |
|---|---|---|
| CSL7012 | Big Data Analytics Lab | 1 |

| | |
|---|---|
| **Prerequisite**: C Programming Language. | |
| **Lab Objectives:** Students will be able to | |
| 1 | Solve Big Data problems using Map Reduce Technique and apply to various algorithms. |
| 2 | Identify various types of NoSQL databases and execute NOSQL commands |
| 3 | Understand implementation of various analytic techniques using Hive/PIG/R/Tableau, etc. |
| 4 | Apply streaming analytics to real time applications. |
| **Lab Outcomes:** | |
| 1 | To interpret business models and scientific computing paradigms, and apply software tools for big data analytics. |
| 2 | To implement algorithms that uses Map Reduce to apply on structured and unstructured data |
| 3 | To perform hands-on NoSql databases such as Cassandra, HadoopHbase, MongoDB, etc. |
| 4 | To implement various data streams algorithms. |
| 5 | To develop and analyze the social network graphs with data visualization techniques. |

| **Suggested List of Experiments**<br>**(Select a case study and perform the experiments 1 to 8.)**.<br>Star (*) marked experiments are compulsory. | |
|---|---|
| **Sr. No.** | **Name of the Experiment** |
| 1* | Hadoop HDFS Practical:<br>-HDFS Basics, Hadoop Ecosystem Tools Overview.<br>-Installing Hadoop.<br>-Copying File to Hadoop.<br>-Copy from Hadoop File system and deleting file.<br>-Moving and displaying files in HDFS.<br>-Programming exercises on Hadoop |
| 2 | Use of Sqoop tool to transfer data between Hadoop and relational database servers.<br>a. Sqoop - Installation.<br>b. To execute basic commands of Hadoop eco system componentSqoop. |
| 3* | To install and configure MongoDB/ Cassandra/ HBase/ Hypertable to execute NoSQL commands |
| 4 | Experiment on Hadoop Map-Reduce:<br>-Write a program to implement a word count program using MapReduce. |
| 5 | Experiment on Hadoop Map-Reduce:<br>-Implementing simple algorithms in Map-Reduce: Matrix multiplication, Aggregates, Joins, Sorting, Searching, etc |
| 6 | Create HIVE Database and Descriptive analytics-basic statistics. |
| 7* | Data Stream Algorithms (any one):<br>- Implementing DGIM algorithm using any Programming Language<br>- Implement Bloom Filter using any programming language<br>Implement Flajolet Martin algorithm using any programming language |
| 8 | Social Network Analysis using R (for example: Community Detection Algorithm) |
| 9 | Data Visualization using Hive/PIG/R/Tableau/. |
| 10 | Exploratory Data Analysis using Spark/ Pyspark. |

| | |
|---|---|
| 11* | Mini Project: One real life large data application to be implemented (Use standard Datasets available on the web).<br>- Streaming data analysis – use flume for data capture, HIVE/PYSpark for analysis of twitter data, chat data, weblog analysis etc.<br>- Recommendation System (for example: Health Care System, Stock Market Prediction, Movie Recommendation, etc.)<br>SpatioTemporal DataAnalytics |

| **Useful Links:** | |
|---|---|
| 1 | https://www.coursera.org/learn/hadoop#syllabus |
| 2 | https://www.coursera.org/learn/introduction-mongodb#syllabus |
| 3 | https://www.coursera.org/learn/data-visualization-tableau?specialization=data-visualization#syllabus |
| 4 | https://www.coursera.org/learn/introduction-to-big-data-with-spark-hadoop#syllabus |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 8 experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignment: 05-marks) |
| **Oral & Practical exam** | |
| | Based on the entire syllabus of and CSC702 : Big Data Analytics and CSL702 Big Data Analytics Lab |

| Lab Code | Lab Name | Credit |
|---|---|---|
| **CSDL7011** | **Machine Vision Lab** | **1** |

| **Prerequisite: Computer Graphics, Image Processing, Python** | |
|---|---|
| **Lab Objectives:** | |
| 1 | To perform basic image processing operations |
| 2 | To explore different preprocessing technique |
| 3 | To develop application related to Machine vision |
| 4 | To detect and recognize objects |
| **Lab Outcomes:** | |
| 1 | Students will be able to read image and video file, perform different processing |
| 2 | Students will be able to do edge detection ,depth estimation |
| 3 | Students will be able to choose appropriate algo for segmentation |
| 4 | Students will be able to implement object detection technique |

| **Suggested Experiments:** Students are required to complete at least 8 experiments. | |
|---|---|
| **Sr.No.** | **Name of the Experiment** |
| 1 | **Handling Files, Cameras, and GUIs**<br>Basic I/O scripts ,Reading/writing an image file ,Converting between an image and raw bytes ,Accessing image data with numpy.array ,Reading/writing a video file ,Capturing camera frames,<br>Displaying images in a window, Displaying camera frames in a window |
| 2 | **Processing Images** with OpenCV 3<br>Converting between different color spaces,<br>The Fourier Transform, High pass filter, Low pass filter, |
| 3 | **Edge detection** with Canny,<br>Contour detection,<br>Contours – bounding box, minimum area rectangle, and minimum enclosing circle ,Contours – convex contours and the Douglas-Peucker algorithm<br>,Line and circle detection |
| 4 | **Depth Estimation**<br>Capturing frames from a depth camera<br>Creating a mask from a disparity map<br>Masking a copy operation<br>Depth estimation with a normal camera |
| 5 | **Object segmentation** using the Watershed and GrabCut algorithms<br>Example of foreground detection with GrabCut<br>Image segmentation with the Watershed algorithm |
| 6 | **Detecting and Recognizing Faces**<br>Conceptualizing Haar cascades<br>Getting Haar cascade data<br>Using OpenCV to perform face detection<br>Performing face detection on a still image |
| 7 | **Performing face detection on video**<br>Performing face recognition<br>Generating the data for face recognition<br>Recognizing faces<br>Preparing the training data<br>Loading the data and recognizing faces |

| | |
|---|---|
| | Performing an Eigenfaces recognition |
| 8 | **Retrieving Images and Searching**<br>Using Image Descriptors ,<br>Feature detection algorithms,<br>Defining features<br>Detecting features – corners<br>Feature extraction and description using DoG and SIFT<br>Anatomy of a keypoint |
| 9 | **Detecting and Recognizing Objects**<br>Object detection and recognition techniques<br>HOG descriptors<br>The scale issue<br>The location issue<br>Non-maximum (or non-maxima) suppression<br>Support vector machines<br>People detection |
| 10 | **Creating and training an object detector**<br>Bag-of-words<br>BOW in computer vision<br>Detecting cars in a scene |

| **Reference &Useful Links:** | |
|---|---|
| 1 | Learning OpenCV 3 Computer Vision with Python Second Edition, by Joe Minichino Joseph Howse Published by Packt Publishing Ltd. |
| 2 | http://iitk.ac.in/ee/computer-vision-lab |
| 3 | https://nptel.ac.in/courses/108103174 |
| 4 | https://docs.opencv.org/3.4/d9/df8/tutorial_root.html |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 8 experiments. |
| 2 | Journal must include at least 2 assignments. |
| 3 | The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work. |
| 4 | Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks) |

| Lab Code | Lab Name | Credit |
|---|---|---|
| CSDL7012 | Cyber Security Lab | 1 |

| | |
|---|---|
| **Prerequisite:** Computer Network | |
| **Lab Objectives:** | |
| 1 | To study and implement the flow and methodology of an attack |
| 2 | To explore various static and web vulnerability analysis tools |
| 3 | To study and implement the various Privacy and Security compliances |
| **Lab Outcomes:** At the end of the course, the students will be able to | |
| 1 | Demonstrate the concept of various Privacy and standard compliances |
| 2 | Apply various tools for conducting system vulnerability analysis |
| 3 | Understand the various web application vulnerability scanning techniques |
| 4 | Apply the various network defense techniques |
| 5 | Demonstrate the concept of various techniques used by attackers to launch their attacks |

| **Suggested List of Experiments** | |
|---|---|
| **Sr. No.** | **Title of Experiment** |
| 1 | Study and implement phishing using website cloning.<br>**Recommended Tool:** HTTrack Website Copier. |
| 2 | Static Code Analysis using open source tools.<br>**Recommended Tool:** Flawfinder Python Distribution |
| 3 | Web Application Vulnerability Scanning and Auditing using open source tools.<br>**Recommended Tools:** Nikto / Wapiti / Burpsuite (Kali Linux/ Windows) |
| 4 | Study and exploit database flaws and vulnerabilities using SQL Injection Attack.<br>**Recommended Tool:** SQLMap (Kali Linux / Windows) |
| 5 | Study and Implement Packet Sniffing using Open Source Tools.<br>**Recommended Tools:** Wireshark, TCP Dump |
| 6 | Study and implement Session Hijacking / Man in the Middle (MiTM) attack in a controlled virtual environment.<br>**Recommended Tools:** Ettercap / Bettercap |
| 7 | Penetration Testing and Vulnerability Exploitation<br>**Recommended Tool:** Metasploit (Kali Linux) |
| 8 | Study and Implement Cross Site Request Forgery in a controlled virtual environment.<br>**Recommended Tool:** Damn Vulnerable Web App (DVWA) Web Server |
| 9 | Exploring Authentication, Authorization and Access Control (AAA) .<br>**Recommended Tool:** Cisco Packet Tracer Student Edition, TACACS |
| 10 | Study and Implement Firewalls using IP tables.<br>**Recommended Tool:** Kali Linux, IPTables, Oraclebox/VmWare |
| 11 | Study and Implement a Network Intrusion Detection System (NIDS)<br>**Recommended Tool:** Kali Linux, SNORT, Oraclebox/VmWare |
| 12 | Study and Implement a Host Based Intrusion Detection System (HIDS)<br>**Recommended Tool:** Kali Linux, OSSEC, Oraclebox/VmWare |
| 13 | Study and Implement Email Security using PGP Encryption<br>**Recommended Tool:** GnuPG (Open Source Implementation of PGP) |

| | |
|---|---|
| 14 | Study and Explore Malware/Keylogger Detection<br>**Recommended Tool:** netstat, TCPView |
| 15 | Study and Explore the Creative Commons Library |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 10 experiments. |
| 2 | Journal must include at least 2 assignments on content of theory and practical of "Cyber Security" |
| 3 | The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work. |
| 4 | Total 25 Marks (Experiments: 15-marks, Attendance Theory& Practical: 05-marks, Assignments: 05-marks) |

| Lab Code | Lab Name | Credit |
|---|---|---|
| CSDL7013 | **Natural Language processing Lab** | **1** |

| **Prerequisite: Java/Python** | |
|---|---|
| **Lab Objectives:** The course aims | |
| 1 | To understand the key concepts of NLP. |
| 2 | To learn various phases of NLP. |
| 3 | To design and implement various language models and POS tagging techniques. |
| 4 | To understand various NLP Algorithms |
| 5 | To learn NLP applications such as Information Extraction, Sentiment Analysis, Question answering, Machine translation etc. |
| 6 | To design and implement applications based on natural language processing |
| **Lab Outcomes:**Learners will be able | |
| 1 | Apply various text processing techniques. |
| 2 | Design language model for word level analysis. |
| 3 | Model linguistic phenomena with formal grammar. |
| 4 | Design, implement and analyze NLP algorithms. |
| 5 | To apply NLP techniques to design real world NLP applications such as machine translation, sentiment analysis, text summarization, information extraction, Question Answering system etc. |
| 6 | Implement proper experimental methodology for training and evaluating empirical NLP systems. |

| **Suggested List of Experiments**<br>**(Select a case study and perform the experiments 1 to 8.)**. | |
|---|---|
| Star (*) marked experiments are compulsory. | |
| **Sr. No.** | **Name of the Experiment** |
| 1 | Study various applications of NLP and Formulate the Problem Statement for Mini Project based on chosen real world NLP applications:<br>[Machine Translation, Text Categorization, Text summarization, chat Bot, Plagarism, Spelling & Grammar checkers, Sentiment / opinion analysis, Question answering, Personal Assistant, Tutoring Systems, etc.] |
| 2 | Apply various text preprocessing techniques for any given text : Tokenization and Filtration & Script Validation. |
| 3 | Apply various other text preprocessing techniques for any given text : Stop Word Removal, Lemmatization / Stemming. |
| 4 | Perform morphological analysis and word generation for any given text. |
| 5 | Implement N-Gram model for the given text input. |
| 6 | Study the different POS taggers and Perform POS tagging on the given text. |
| 7 | Perform Chunking for the given text input. |
| 8 | Implement Named Entity Recognizer for the given text input. |

| | |
|---|---|
| 9 | Implement Text Similarity Recognizer for the chosen text documents. |
| 10 | Exploratory data analysis of a given text (Word Cloud) |
| 11 | Mini Project Report: For any one chosen real world NLP application. |
| 13 | Implementation and Presentation of Mini Project |
| 14 | Study various applications of NLP and Formulate the Problem Statement for Mini Project based on chosen real world NLP applications:<br>[Machine Translation, Text Categorization, Text summarization, chat Bot, Plagarism, Spelling & Grammar checkers, Sentiment / opinion analysis, Question answering, Personal Assistant, Tutoring Systems, etc.] |

| **Term Work:** | |
|---|---|
| 1 | Study various applications of NLP and Formulate the Problem Statement for Mini Project based on chosen real world NLP applications:<br>[Machine Translation, Text Categorization, Text summarization, chat Bot, Plagarism, Spelling & Grammar checkers, Sentiment / opinion analysis, Question answering, Personal Assistant, Tutoring Systems, etc.] |
| 2 | Apply various text preprocessing techniques for any given text: Tokenization and Filtration & Script Validation. |
| 3 | Apply various other text preprocessing techniques for any given text: Stop Word Removal, Lemmatization / Stemming. |

| Lab Code | Lab Name | Credit |
|---|---|---|
| **CSDL7021** | **Augmented and Virtual Reality Lab** | **1** |

| | |
|---|---|
| **Prerequisite:** Computer Graphics, Image Processing, Python | |
| **Lab Objectives:** | |
| 1 | To perform installation of Unity |
| 2 | To explore working of VR Gadget |
| 3 | To develop scene VR application |
| 4 | To track objects in virtual environment |
| **Lab Outcomes:** Learners will be able to | |
| 1 | Setup VR development environment |
| 2 | Use HTC Vive/ Google Cardboard/ Google Daydream and Samsung gear VR. |
| 3 | Develop VR scene and place object |
| 4 | Work with Augmented Faces features. |

| **Suggested Experiments:** Students are required to complete at least 6 experiments. | |
|---|---|
| | |
| **Sr. No.** | **Name of the Experiment** |
| 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:<br>i. a cube, plane and sphere, apply transformations on the 3 game objects.<br>ii. add a video and audio source |
| 4 | Develop a scene in Unity that includes a cube, plane and sphere. Create a new material and texture separately for three Game objects. Change the colour, material and texture of each Game object separately in the scene. Write a C# program in visual studio to change the colour and material/texture of the game objects dynamically on button click. |
| 5 | 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. |
| 6 | 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 . |
| 7 | Place a three-dimensional ARCore pawn on detected AR plane surfaces |
| 8 | Using the Augmented Faces feature in your own apps**.** |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 6 experiments. |
| 2 | Journal must include at least 2 assignments. |
| 3 | The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work. |
| 4 | Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks) |

| Lab Code | Lab Name | Credit |
|---|---|---|
| **CSDL7022** | **Blockchain Lab** | **1** |

| | |
|---|---|
| **Prerequisite:** Cryptography and Network Security | |
| **Lab Objectives:** | |
| 1 | To explore Blockchain concepts. |
| 2 | To implement public and private Blockchain. |
| 3 | To create applications using Blockchain. |
| **Lab Outcomes:** At the end of the course, the students will be able to | |
| 1 | Creating Cryptographic hash using merkle tree. |
| 2 | Design Smart Contract using Solidity. |
| 3 | Implementing ethereum blockchain using Geth. |
| 4 | Demonstrate the concept of blockchain in real world application. |

| **Suggested List of Experiments** | |
|---|---|
| **Sr. No.** | **Title of Experiment** |
| 1 | Cryptography in Blockchain, Merkle root tree hash |
| 2 | Creating Smart Contract using Solidity and Remix IDE. |
| 3 | Creating Transactions using Solidity and Remix IDE |
| 4 | Embedding wallet and transaction using Solidity |
| 5 | Blockchain platform ethereum using Geth. |
| 6 | Blockchain platform Ganache. |
| 7 | Case Study on Hyperledger |
| 8 | Case Study on Other Blockchain platforms. |
| 9 | Creating a blockchain Application |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 8 experiments and one mini project. |
| 2 | Journal must include at least 2 assignments on content of theory and practical of "Blockchain Lab" |
| 3 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 4 | Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks) |

| Lab Code | Lab Name | Credit |
|---|---|---|
| CSDL7023 | Information Retrieval Lab | 1 |

| Prerequisite: Java, Python | |
|---|---|
| **Lab Objectives:** | |
| 1 | To understand the formation of queries. |
| 2 | To implement the various modeling techniques for IR. |
| 3 | To execute query expansion techniques. |
| 4 | To evaluate Information retrieval systems. |
| **Lab Outcomes: Students will be able :-** | |
| 1 | To frame queries for information retrieval |
| 2 | To implement modeling techniques |
| 3 | To perform query expansion techniques |
| 4 | To demonstrate evaluation techniques for IR |

**Suggested Experiments:** Students are required to perform any **5 experiments** from the suggested list along with **a case study** (* indicates compulsory experiment)

| Sr. No. | Name of the Experiment |
|---|---|
| 1 | To understand the query structure and execute various structured queries |
| 2 | To implement any IR modeling technique |
| 3 | To implement Pattern matching method used for IR |
| 4 | To execute query expansion technique (Local/Global) |
| 5 | To design inverted indices for any information retrieval model |
| 6 | To implement tf-id weighting |
| 7 | To evaluate the system/application under study |
| 8* | To understand the Case Study and generate a report for the same |

| Term Work: | |
|---|---|
| 1 | Term work should consist of **5 experiments and 1 case study** |
| 2 | Journal must include **at least 2 assignments**. |
| 3 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 4 | Total: **25 Marks (Experiments: 10-marks, Case study - 5 marks Attendance Theory & Practical: 05-marks, Assignments: 05-marks)** |

| Course Code | Course Name | Credit |
|---|---|---|
| **CSP701** | **Major Project 1** | **03** |

| **Course Objectives:** | |
|---|---|
| The project work facilitates the students to develop and prove Technical, Professional and Ethical skills and knowledge gained during graduation program by applying them from problem identification, analyzing the problem and designing solutions. | |
| **Course Outcomes:** Learner will able | |
| 1 | To develop the understanding of the problem domain through extensive review of literature. |
| 2 | To Identify and analyze the problem in detail to define its scope with problem specific data. |
| 3 | To know various techniques to be implemented for the selected problem and related technical skills through feasibility analysis. |
| 4 | To design solutions for real-time problems that will positively impact society and environment.. |
| 5 | To develop clarity of presentation based on communication, teamwork and leadership skills. |
| 6 | To inculcate professional and ethical behavior. |



**Guidelines:**

1. **Project Topic Selection and Allocation:**

- Project topic selection Process to be defined and followed:
  - Project orientation can be given at the end of sixth semester.
  - Students should be informed about the domain and domain experts whose guidance can be taken before selecting projects.
  - Student's should be recommended to refer papers from reputed conferences/ journals like IEEE, Elsevier, ACM etc. which are not more than 3 years old for review of literature.
  - Students can certainly take ideas from anywhere, but be sure that they should evolve them in the unique way to suit their project requirements. Students can be informed to refer Digital India portal, SIH portal or any other hackathon portal for problem selection.

- Topics can be finalized with respect to following criterion:
  - **Topic Selection**: The topics selected should be novel in nature (Product based, Application based or Research based) or should work towards removing the lacuna in currently existing systems.
  - **Technology Used:** Use of latest technology or modern tools can be encouraged**.**
  - Students should not repeat work done previously (work done in the last three years).

- Project work must be carried out by the group of at least 2 students and maximum 4.
- The project work can be undertaken in a research institute or organization/Industry/any business establishment. (out-house projects)
- The project proposal presentations can be scheduled according to the domains and should be judged by faculty who are expert in the domain.
- Head of department and senior staff along with project coordinators will take decision regarding final selection of projects.
- Guide allocation should be done and students have to submit weekly progress report to the internal guide.
- Internal guide has to keep track of the progress of the project and also has to maintain attendance report. This progress report can be used for awarding term work marks.
- In case of industry/ out-house projects, visit by internal guide will be preferred and external members can be called during the presentation at various levels

2. **Project Report Format:**

At the end of semester, each group needs to prepare a project report as per the guidelines issued by the University of Mumbai.

A project report should preferably contain at least following details:

- Abstract
- Introduction
- Literature Survey/ Existing system
- Limitation Existing system or research gap
- Problem Statement and Objective
- Proposed System
    - Analysis/Framework/ Algorithm
    - Design details
    - Methodology (your approach to solve the problem) Proposed System
- Experimental Set up
    - Details of Database or details about input to systems or selected data
    - Performance Evaluation Parameters (for Validation)
    - Software and Hardware Set up
- Implementation Plan for Next Semester
    - Timeline Chart for Term1 and Term-II (Project Management tools can be used.)
- References

**Desirable**

Students can be asked to undergo some Certification course (for the technical skill set that will be useful and applicable for projects.)

**3. Term Work:**

Distribution of marks for term work shall be done based on following:

- Weekly Log Report
- Project Work Contribution
- Project Report (Spiral Bound) (both side print)
- Term End Presentation (Internal)

The final certification and acceptance of TW ensures the satisfactory performance on the above aspects.

**4. Oral and Practical:**

Oral and Practical examination (Final Project Evaluation) of Project 1 should be conducted by Internal and External examiners approved by University of Mumbai at the end of the semester.

**Suggested quality evaluation parameters are as follows:**

- Quality of problem selected
- Clarity of problem definition and feasibility of problem solution
- Relevance to the specialization / industrial trends
- Originality
- Clarity of objective and scope
- Quality of analysis and design
- Quality of written and oral presentation
- Individual as well as team work

| Course Code: | Course Title | Credit |
|---|---|---|
| CSC801 | Distributed Computing | 3 |

| | |
|---|---|
| **Prerequisite:** Computer Networks and Operating Systems. | |
| **Course Objectives:** | |
| 1 | To provide students with contemporary knowledge in distributed systems. |
| 2 | To explore the various methods used for communication in distributed systems. |
| 3 | To provide skills to measure the performance of distributed synchronization algorithms. |
| 4 | To provide knowledge of resource management, and process management including process migration. |
| 5 | To learn issues involved in replication, consistency, and file management. |
| 6 | To equip students with skills to analyze and design distributed applications. |
| **Course Outcomes: At the end of the course students will be able to** | |
| 1 | Demonstrate the knowledge of basic elements and concepts related to distributed system technologies. |
| 2 | Illustrate the middleware technologies that support distributed applications such as RPC, RMI and Object-based middleware. |
| 3 | Analyze the various techniques used for clock synchronization, mutual exclusion and deadlock. |
| 4 | Demonstrate the concepts of Resource and Process management. |
| 5 | Demonstrate the concepts of Consistency, Replication Management and fault Tolerance. |
| 6 | Apply the knowledge of Distributed File systems in building large-scale distributed applications. |

| Module | Content | Hrs |
|---|---|---|
| **1** | **Introduction to Distributed Systems** | **4** |
| 1.1 | Characterization of Distributed Systems: Issues, Goals, Types of distributed systems, Grid and Cluster computing Models, Hardware and Software Concepts: NOS, DOS. | |
| 1.2 | Middleware: Models of middleware, Services offered by middleware. | |
| **2** | **Communication** | **4** |
| 2.1 | Interprocess communication (IPC): Remote Procedure Call (RPC), Remote Method Invocation (RMI). | |
| 2.2 | Message-Oriented Communication, Stream Oriented Communication, Group Communication. | |
| **3** | **Synchronization** | **10** |
| 3.1 | Clock Synchronization: Physical clock, Logical Clocks, Election Algorithms | |
| 3.2 | Distributed Mutual Exclusion, Requirements of Mutual Exclusion Algorithms and Performance measures.<br>Non- token Based Algorithms: Lamport, Ricart–Agrawala‘s and Maekawa‘s Algorithms; Token-based Algorithms: Suzuki-Kasami‘s Broadcast Algorithms and Raymond‘s Tree-based Algorithm; and Comparative Performance Analysis. | |

| | | |
|---|---|---|
| 3.3 | Deadlock: Introduction, Deadlock Detection: Centralized approach, Chandy - Misra_Hass Algorithm. | |
| **4** | **Resource and Process Management** | **7** |
| 4.1 | Desirable Features of Global Scheduling algorithm, Task assignment approach, Load balancing approach and load sharing approach. | |
| 4.2 | Introduction to Process Management, Process Migration, Code Migration. | |
| **5** | **Replication, Consistency and Fault Tolerance** | |
| 5.1 | Distributed Shared Memory: Architecture, design issues. | 8 |
| 5.2 | Introduction to replication and consistency, Data-Centric and Client-Centric Consistency Models, Replica Management. | |
| 5.3 | Fault Tolerance: Introduction, Process resilience, Recovery. | |
| **6** | **Distributed File Systems** | **6** |
| 6.1 | Introduction and features of DFS, File models, File Accessing models, File-Caching Schemes, File Replication, Case Study: Network File System (NFS). | |
| 6.2 | Designing Distributed Systems: Google Case Study. | |

| **Textbooks:** | |
|---|---|
| 1 | Andrew S. Tanenbaum and Maarten Van Steen, Distributed Systems: Principles and Paradigms, 2nd edition, Pearson Education. |
| 2 | Mukesh Singhal, Niranjan G. Shivaratri, "Advanced concepts in operating systems: Distributed, Database and multiprocessor operating systems", MC Graw Hill education. |
| 3 | Pradeep K.Sinha, "Distributed Operating System-Concepts and design", PHI. |
| **References:** | |
| 1 | M. L. Liu, ―Distributed Computing Principles and Applications‖, Pearson Addison Wesley, 2004 |
| 2 | George Coulouris, Jean Dollimore, Tim Kindberg, "Distributed Systems: Concepts and Design", 4th Edition, Pearson Education, 2005. |

| **Useful Links** | |
|---|---|
| 1 | https://nptel.ac.in/courses/106106107 |
| 2 | https://nptel.ac.in/courses/106106168 |
| 3 | http://csis.pace.edu/~marchese/CS865/Lectures/Chap7/Chapter7fin.htm |
| 4 | https://nptel.ac.in/courses/106104182 |

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|---|---|
| **<u>Assessment</u>:** | |
| **Internal Assessment:** | |
| Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and the second-class test when an additional 40% syllabus is completed. The duration of each test shall be one hour. | |
| **End Semester Theory Examination:** | |
| 1 | The question paper will comprise a total of six questions. |
| 2 | All question carries equal marks |
| 3 | Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3) |
| 4 | Only four questions need to be solved. |
| 5 | In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus. |

| Course Code: | Course Title | Credit |
|---|---|---|
| CSDC8011 | Deep Learning | 3 |

| | |
|---|---|
| **Prerequisite: Basic mathematics and Statistical concepts, Linear algebra, Machine Learning** | |
| **Course Objectives:** | |
| 1 | To learn the fundamentals of Neural Network. |
| 2 | To gain an in-depth understanding of training Deep Neural Networks. |
| 3 | To acquire knowledge of advanced concepts of Convolution Neural Networks, Autoencoders and Recurrent Neural Networks. |
| 4 | Students should be familiar with the recent trends in Deep Learning. |
| **Course Outcomes:** | |
| 1 | Gain basic knowledge of Neural Networks. |
| 2 | Acquire in depth understanding of training Deep Neural Networks. |
| 3 | Design appropriate DNN model for supervised, unsupervised and sequence learning applications. |
| 4 | Gain familiarity with recent trends and applications of Deep Learning. |

| Module | | Content | 39Hrs |
|---|---|---|---|
| **1** | | **Fundamentals of Neural Network** | **4** |
| | 1.1 | Biological neuron, Mc-Culloch Pitts Neuron, Perceptron, Perceptron Learning, Delta learning, Multilayer Perceptron: Linearly separable, linearly non-separable classes | |
| | 1.2 | Deep Networks: Fundamentals, Brief History, Three Classes of Deep Learning Basic Terminologies of Deep Learning | |
| **2** | | **Training, Optimization and Regularization of Deep Neural Network** | **10** |
| | 2.1 | **Training Feedforward DNN**<br>Multi Layered Feed Forward Neural Network, Learning Factors, Activation functions: Tanh, Logistic, Linear, Softmax, ReLU, Leaky ReLU, Loss functions: Squared Error loss, Cross Entropy, Choosing output function and loss function | |
| | 2.2 | **Optimization**<br>Learning with backpropagation, Learning Parameters: Gradient Descent (GD), Stochastic and Mini Batch GD, Momentum Based GD, Nesterov Accelerated GD, AdaGrad, Adam, RMSProp | |
| | 2.3 | **Regularization**<br>Overview of Overfitting, Types of biases, Bias Variance Tradeoff<br>Regularization Methods: L1, L2 regularization, Parameter sharing, Dropout, Weight Decay, Batch normalization, Early stopping, Data Augmentation, Adding noise to input and output | |
| **3** | | **Autoencoders: Unsupervised Learning** | **6** |
| | 3.1 | Introduction, Linear Autoencoder, Undercomplete Autoencoder, Overcomplete Autoencoders, Regularization in Autoencoders | |

| | | | |
|---|---|---|---|
| | 3.2 | Denoising Autoencoders, Sparse Autoencoders, Contractive Autoencoders | |
| | 3.3 | Application of Autoencoders: Image Compression | |
| **4** | | **Convolutional Neural Networks (CNN): Supervised Learning** | **7** |
| | 4.1 | Convolution operation, Padding, Stride, Relation between input, output and filter size, CNN architecture: Convolution layer, Pooling Layer, Weight Sharing in CNN, Fully Connected NN vs CNN, Variants of basic Convolution function | |
| | 4.2 | Modern Deep Learning Architectures:<br>LeNET: Architecture, AlexNET: Architecture | |
| **5** | | **Recurrent Neural Networks (RNN)** | **8** |
| | 5.1 | Sequence Learning Problem, Unfolding Computational graphs, Recurrent Neural Network, Bidirectional RNN, Backpropagation Through Time (BTT), Vanishing and Exploding Gradients, Truncated BTT | |
| | 5.2 | Long Short Term Memory: Selective Read, Selective write, Selective Forget, Gated Recurrent Unit | |
| **6** | | **Recent Trends and Applications** | **4** |
| | 6.1 | Generative Adversarial Network (GAN): Architecture | |
| | 6.2 | Applications: Image Generation, DeepFake | |

| **Textbooks:** | |
|---|---|
| 1 | Ian Goodfellow, Yoshua Bengio, Aaron Courville. “Deep Learning”, MIT Press Ltd, 2016 |
| 2 | Li Deng and Dong Yu, “Deep Learning Methods and Applications”, Publishers Inc. |
| 3 | Satish Kumar "Neural Networks A Classroom Approach" Tata McGraw-Hill. |
| 4 | JM Zurada “Introduction to Artificial Neural Systems”, Jaico Publishing House |
| 5 | M. J. Kochenderfer, Tim A. Wheeler. “Algorithms for Optimization”, MIt Press. |
| **References:** | |
| 1 | Buduma, N. and Locascio, N., “Fundamentals of deep learning: Designing next-generation machine intelligence algorithms" 2017. O'Reilly Media, Inc.". |
| 2 | François Chollet. “Deep learning with Python “(Vol. 361). 2018 New York: Manning. |
| 3 | Douwe Osinga. “Deep Learning Cookbook”, O’REILLY, SPD Publishers, Delhi. |
| 4 | Simon Haykin, Neural Network- A Comprehensive Foundation- Prentice Hall International, Inc |
| 5 | S.N.Sivanandam and S.N.Deepa, Principles of soft computing-Wiley India |

| **Assessment:** | |
|---|---|
| **Internal Assessment:** | |
| The assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour. | |
| **End Semester Theory Examination:** | |
| 1 | Question paper will comprise a total of six questions. |
| 2 | All questions carry equal marks. |
| 3 | Question 1 and question 6 will have questions from all modules. Remaining 4 questions will be based on the remaining 4 modules. |
| 4 | Only four questions need to be solved. |

| | |
|---|---|
| 5 | In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus. |

| **Useful Links** | |
|---|---|
| 1 | https://nptel.ac. https://deeplearning.cs.cmu.edu/S21/index.html |
| 2 | http://www.cse.iitm.ac.in/~miteshk/CS6910.html |
| 3 | https://nptel.ac.in/courses/106/106/106106184/ |
| 4 | https://www.deeplearningbook.org/ |

| Course Code: | Course Title | Credit |
|---|---|---|
| CSDC8012 | Digital Forensics | 3 |

| | |
|---|---|
| **Prerequisite:** Computer Network, Cryptography and System Security | |
| **Course Objectives:** | |
| 1 | To discuss the need and process of digital forensics and Incident Response Methodology. |
| 2 | To explore the procedures for identification, preservation, and acquisition of digital evidence. |
| 3 | To explore techniques and tools used in digital forensics for Operating system and malware investigation . |
| 4 | To explore techniques and tools used for Mobile forensics and browser, email forensics |
| **Course Outcomes:** | |
| 1 | Discuss the phases of Digital Forensics and methodology to handle the computer security incident. |
| 2 | Describe the process of collection, analysis and recovery of the digital evidence. |
| 3 | Explore various tools to analyze malwares and acquired images of RAM/hard drive. |
| 4 | Acquire adequate perspectives of digital forensic investigation in mobile devices |
| 5 | Analyze the source and content authentication of emails and browsers. |
| 6 | Produce unambiguous investigation reports which offer valid conclusions. |

| Module | | Content | Hrs |
|---|---|---|---|
| **1** | | **Introduction to Digital Forensics** | **6** |
| | 1.1 | Digital ForensicsDefination, Digital Forensics Goals, Digital Forensics Categories - Computer Forensics, Mobile Forensics, Network Forensics, Database Forensics | |
| | 1.2 | Introduction to Incident - Computer Security Incident, Goals of Incident Response, CSIRT, Incident Response Methodology, Phase after detection of an incident | |
| **2** | | **Digital Evidence, Forensics Duplication and Digital Evidence Acquisition** | **9** |
| | 2.1 | Digital evidence, Types of Digital Evidence, Challenges in acquiring Digital evidence, Admissibility of evidence, Challenges in evidence handling, Chain of Custody | |
| | 2.2 | Digital Forensics Examination Process - Seizure, Acquisition, Analysis, Reporting. Necessity of forensic duplication, Forensic image formats, Forensic duplication techniques,. | |
| | 2.3 | Acquiring Digital Evidence - Forensic Image File Format, Acquiring Volatile Memory (Live Acquisition), Acquiring Nonvolatile Memory (Static Acquisition), Hard Drive Imaging Risks and Challenges, Network Acquisition | |
| **3** | | **Forensics Investigation** | **4** |
| | 3.1 | Analyzing Hard Drive Forensic Images, Analyzing RAM Forensic Image, Investigating Routers | |
| | 3.2 | Malware Analysis - Malware, Viruses, Worms, Essential skills and tools for Malware Analysis, List of Malware Analysis Tools and | |

| | | | |
|---|---|---|---|
| | | Techniques | |
| **4** | | **Windows and Unix Forensics Investigation** | **8** |
| | 4.1 | Investigating Windows Systems - File Recovery, Windows Recycle Bin Forensics, Data Carving, Windows Registry Analysis, USB Device Forensics, File Format Identification, Windows Features Forensics Analysis, Windows 10 Forensics, Cortana Forensics | |
| | 4.2 | Investigating Unix Systems - Reviewing Pertinent Logs, Performing Keyword Searches, Reviewing Relevant Files, Identifying Unauthorized User Accounts or Groups, Identifying Rogue Processes, Checking for Unauthorized Access Points, Analyzing Trust Relationships | |
| **5** | | **Mobile Forensics** | **8** |
| | 5.1 | Android Forensics, Mobile Device Forensic Investigation - Storage location, Acquisition methods, Data Analysis | |
| | 5.2 | GPS forensics - GPS Evidentiary data, GPS Exchange Format (GPX), GPX Files, Extraction of Waypoints and TrackPoints, Display the Tracks on a Map. | |
| | 5.3 | SIM Cards Forensics - The Subscriber Identification Module (SIM), SIM Architecture, Security, Evidence Extraction. | |
| **6** | | **Browser, Email Forensic & Forensic Investigation Reporting** | **4** |
| | 6.1 | Web Browser Forensics, Google chrome, Other web browser investigation<br>Email forensics - Sender Policy Framework (SPF), Domain Key Identified Mail (DKIM), Domain based Message Authentication Reporting and Confirmation (DMARC) | |
| | 6.2 | Investigative Report Template, Layout of an Investigative Report, Guidelines for Writing a Report | |

| **Textbooks:** | |
|---|---|
| 1 | Kevin Mandia, Chris Prosise, "Incident Response and computer forensics", Tata McGrawHill, 2006 |
| 2 | Digital Forensics Basics A Practical Guide Using Windows OS — Nihad A. Hassan, APress Publication, 2019 |
| 3 | Xiaodong Lin, "Introductory Computer Forensics: A Hands-on Practical Approach", Springer Nature, 2018 |

| **Suggested MOOC Course Links** | |
|---|---|
| 1 | Course on "Ethical Hacking"<br>https://nptel.ac.in/courses/106/105/106105217/ |
| 2 | Course on "Digital Forensics"<br>https://onlinecourses.swayam2.ac.in/cec20_lb06/preview |
| 3 | Course on Cyber Incident Response<br>https://www.coursera.org/learn/incident-response |
| 4 | Course on "Penetration Testing, Incident Responses and Forensics"<br>https://www.coursera.org/learn/ibm-penetration-testing-incident-response-forensics |

**Assessment:**

**Internal Assessment:**

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.

**End Semester Theory Examination:**

| | |
|---|---|
| 1 | Question paper will comprise a total of six questions. |
| 2 | All question carries equal marks |
| 3 | Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3) |
| 4 | Only Four questions need to be solved. |
| 5 | In question paper weightage of each module will be proportional to the number of respective lecture hours as mention in the syllabus. |

| Course Code | Course Name | Credit |
|---|---|---|
| CSDC8013 | Applied Data Science | 03 |

| | |
|---|---|
| **Prerequisite:** Machine Learning, Data Structures & Algorithms | |
| **Course Objectives:** | |
| 1 | To introduce students to the basic concepts of data science. |
| 2 | To acquire an in-depth understanding of data exploration and data visualization. |
| 3 | To be familiar with various anomaly detection techniques. |
| 4 | To understand the data science techniques for different applications. |
| **Course Outcomes:** | |
| 1 | To gain fundamental knowledge of the data science process. |
| 2 | To apply data exploration and visualization techniques. |
| 3 | To apply anomaly detection techniques. |
| 4 | To gain an in-depth understanding of time-series forecasting. |
| 5 | Apply different methodologies and evaluation strategies. |
| 6 | To apply data science techniques to real world applications. |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| **1** | | **Introduction to Data Science** | 2 |
| | 1.1 | Introduction to Data Science, Data Science Process | |
| | 1.2 | Motivation to use Data Science Techniques: Volume, Dimensions and Complexity, Data Science Tasks and Examples | |
| | 1.3 | Overview of Data Preparation, Modeling, Difference between data science and data analytics | |
| **2** | | **Data Exploration** | 8 |
| | 2.1 | Types of data, Properties of data<br>**Descriptive Statistics:**<br>Univariate Exploration: Measure of Central Tendency, Measure of Spread, Symmetry, Skewness: Karl Pearson Coefficient of skewness, Bowley's Coefficient, Kurtosis<br>Multivariate Exploration: Central Data Point, Correlation, Different forms of correlation, Karl Pearson Correlation Coefficient for bivariate distribution | |

| | | | |
|---|---|---|---|
| | 2.2 | **Inferential Statistics:**<br><br>Overview of Various forms of distributions: Normal, Poisson, Test Hypothesis, Central limit theorem, Confidence Interval, Z-test, t-test, Type-I, Type-II Errors, ANOVA | |
| **3** | | **Methodology and Data Visualization** | **06** |
| | 3.1 | **Methodology:** Overview of model building, Cross Validation, K-fold cross validation, leave-1 out, Bootstrapping | |
| | 3.2 | **Data Visualization**<br>Univariate Visualization: Histogram, Quartile, Distribution Chart<br>Multivariate Visualization: Scatter Plot, Scatter Matrix, Bubble chart, Density Chart<br>Roadmap for Data Exploration | |
| | 3.3 | **Self-Learning Topics:** Visualizing high dimensional data: Parallel chart, Deviation chart, Andrews Curves. | |
| **4** | | **Anomaly Detection** | **06** |
| | 4.1 | Outliers, Causes of Outliers, Anomaly detection techniques, Outlier Detection using Statistics | |
| | 4.2 | Outlier Detection using Distance based method, Outlier detection using density-based methods, SMOTE | |
| **5** | | **Time Series Forecasting** | 4 |
| | 5.1 | Taxonomy of Time Series Forecasting methods, Time Series Decomposition | |
| | 5.2 | Smoothening Methods: Average method, Moving Average smoothing, Time series analysis using linear regression, ARIMA Model, Performance Evaluation: Mean Absolute Error, Root Mean Square Error, Mean Absolute Percentage Error, Mean Absolute Scaled Error | |
| | 5.3 | **Self-Learning Topics:** Evaluation parameters for Classification, regression and clustering. | |
| **6** | | **Applications of Data Science** | 4 |
| | | Predictive Modeling: House price prediction, Fraud Detection<br>Clustering: Customer Segmentation<br><br>Time series forecasting: Weather Forecasting<br><br>Recommendation engines: Product recommendation | |



| **Textbooks:** | |
|---|---|
| 1 | Vijay Kotu, Bala Deshpande. “Data Science Concepts and Practice”, Elsevier, M.K. Publishers. |
| 2 | Steven Skiena, “Data Science Design Manual”, Springer International Publishing AG |
| 3 | Samir Madhavan. “Mastering Python for Data Science”, PACKT Publishing |
| 4 | Dr. P. N. Arora, Sumeet Arora, S. Arora, Ameet Arora, “Comprehensive Statistical Methods”, S.Chand Publications, New Delhi. |

| References: | |
|---|---|
| 1 | Jake VanderPlas. “Python Data Science Handbook”, O’reilly Publications. |
| 2 | Francesco Ricci, LiorRokach, BrachaShapira, Paul B. Kantor, “Recommender Systems Handbook”, Springer. |
| 3 | S.C. Gupta, V. K. Kapoor “Fundamentals of Mathematical Statistics”, S. Chand and Sons, New Delhi. |
| 4 | B. L. Agrawal. “Basic Statistics”, New Age Publications, Delhi. |

| Useful Links | |
|---|---|
| 1 | https://onlinecourses.nptel.ac.in/noc22_cs32/preview |
| 2 | https://onlinecourses.nptel.ac.in/noc21_cs69/preview |

| Assessment: | |
|---|---|
| **Internal Assessment:** | |
| Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional40% syllabus is completed. Duration of each test shall be one hour. | |
| **End Semester Theory Examination:** | |
| 1 | Question paper will comprise a total of six questions. |
| 2 | All questions carry equal marks. |
| 3 | Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3). |
| 4 | Only Four questions need to be solved. |

| Course Code: | Course Title | Credit |
|---|---|---|
| CSDC8021 | Optimization in Machine Learning | 3 |

| Prerequisite: Engineering Mathematics, Algorithms and data structures |
|---|
| **Course Objectives:** |
| 1. Understand, analyze and apply existing derivative based optimization algorithms |
| 2. Analyze and apply stochastic methods in optimization |
| 3. Analyze convex optimization for machine learning problems |
| 4. Understand real life problems and apply evolutionary methods to optimize them |
| **Course Outcomes:** |
| 1. To understand foundational optimization ideas including gradient descent, stochastic gradient methods |
| 2. To apply convex optimization algorithm |
| 3. To analyze and demonstrate several population methods in Evolutionary Computation |
| 4.Toapply advanced evolutionary algorithms such as particle swarm and ant colony optimization |

| Module | | Content | Hrs |
|---|---|---|---|
| **1** | | **Introduction and Background to Optimization Theory** | **4** |
| | 1.1 | Basic Ingredients of Optimization Problems, Optimization Problem Classifications, Optima Types, Optimization Method Classes, Overview of Unconstrained and Constrained Optimization, Basics of convex optimization | |
| **2** | | **Derivative based Optimization** | **10** |
| | 2.1<br>2.2<br>2.3 | The Basics of Optimization (univariate, bivariate and multivariate optimization), Convex Objective Functions<br>First-Order optimization Methods : Gradient Descent, Conjugate Gradient, Momentum, Nesterov Momentum, Adagrad, RMSProp, learning rate optimization<br>Second order optimization: Newton method | |
| **3** | | **Stochastic Methods** | **6** |
| | | Noisy Descent, Mesh Adaptive Direct Search, Cross-Entropy Method, Natural Evolution Strategies, Covariance Matrix Adaptation | |
| **4** | | **Convex Optimization** | **6** |
| | | Optimization problems, Convex optimization, Linear optimization problems, Quadratic optimization problems, | |

| | | | |
|---|---|---|---|
| | | Geometric programming, Overview of Generalized inequality constraints and Vector optimization | |
| **5** | | **Evolutionary Methods** | **8** |
| | 5.1<br><br><br><br><br><br><br>5.2 | Introduction to Evolutionary Computation: Generic Evolutionary Algorithm, Representation: The Chromosome, Initial Population, Fitness Function, Selection: Selective Pressure, Random Selection, Proportional Selection,Tournament Selection, Rank-Based Selection, Elitism and Evolutionary Computation versus Classical Optimization, Stopping conditions<br>Canonical Genetic Algorithm, Binary Representations of Crossover and Mutation: Binary Representations, Control Parameters | |
| **6** | | **Advance Evolutionary Methods** | **5** |
| | 6.1 | Basic Particle Swarm Optimization, Global Best PSO, Local Best PSO, g-best versus l-best PSO, Velocity Components, Geometric Illustration, Algorithm Aspects, Social Network Structures | |
| | 6.2 | Ant Colony Optimization Meta-Heuristic, Foraging Behavior of Ants, Stigmergy and Artificial Pheromone, Simple Ant Colony Optimization, Ant System, Ant Colony System | |

| **Textbooks:** | |
|---|---|
| 1 | Mykel J. Kochenderfer, Tim A.Wheeler, Algorithms for Optimization, MIT Press (2019) |
| 2 | Andries P Engelbrecht, Computational Intelligence-An Introduction, Second-Edition, Wiley publication |
| 3 | Charu C. Aggarwal, Linear Algebra and Optimization for Machine Learning, , Springer ,2020. |
| **References:** | |
| 1 | SuvritSra, Sebastian Nowozin, Stephen J. Wright, Optimization for Machine Learning, The MIT Press |
| 2 | Xin-She Yang Middlesex ,Optimization techniques and applications with examples, Wiley |
| 3 | A.E. Eiben, J. E. Smith, Introduction to Evolutionary Computing, Springer |

| **Useful Links** | |
|---|---|
| 1 | **Convex optimization (NPTEL)** |
| 2 | **Constrained and Unconstrained optimization (NPTEL)** |
| 3 | **Machine-learning-model-performance (Coursera)** |
| 4 | **Deep-neural-network optimization (Coursera)** |

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|---|---|
| **Assessment:** | |
| **Internal Assessment:** | |
| Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour. | |
| **End Semester Theory Examination:** | |
| 1 | Question paper will comprise a total of six questions. |
| 2 | All questions carry equal marks |
| 3 | Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3) |
| 4 | Only Four questions need to be solved. |
| 5 | In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus. |

| Course Code: | Course Title | Credit |
|---|---|---|
| CSDC8022 | High Performance Computing | 3 |

| | |
|---|---|
| **Prerequisite:** Computer Architecture, Operating System, Cloud Computing | |
| **Course Objectives:** The objective of the course is to | |
| 1 | Introduce the fundamental concepts of high-performance computing (HPC) architecture and parallel computing. |
| 2 | Provide foundations for developing, analyzing, and implementing parallel algorithms using parallelization paradigms like MPI, OpenMP, OpenCL, and CUDA. |
| 3 | Introduce range of activities associated with HPC in Cloud |
| **Course Outcomes: After learning the course, the students will be able to:** | |
| 1 | Understand parallel and pipeline processing approaches |
| 2 | Design a parallel algorithm to solve computational problems and identify issues in parallel programming. |
| 3 | Analyze the performance of parallel computing systems for clusters in terms of execution time, total parallel overhead, speedup. |
| 4 | Develop efficient and high-performance parallel algorithms using OpenMP and message passing paradigm |
| 5 | Develop high-performance parallel programming using OpenCL and CUDA framework |
| 6 | Perform the range of activities associated with High Performance Computing in Cloud Computing |

| Module | | Content | Hrs |
|---|---|---|---|
| **1** | | **Introduction to Parallel Computing** | **5** |
| | 1.1 | Parallelism (What, Why, Applications), Levels of parallelism(instruction, transaction, task, thread, memory, function) | |
| | 1.2 | **Classification Models:** Architectural Schemes(Flynn's, Shore's, Feng's, Handler's) | |
| | 1.3 | **Memory Access:** Distributed Memory, Shared Memory, Hybrid Distributed Shared Memory | |
| | 1.4 | **Parallel Architecture:** Pipeline Architecture: Arithmetic pipelines, Floating Point, Array Processor | |
| **2** | | **Parallel Programming Platform and Algorithm Design** | **11** |
| | 2.1 | **Parallel Programming Platform:** Physical Organization of Parallel Platforms, Communication Costs in Parallel Machines | |
| | 2.2 | **Algorithm Design:** Preliminaries, Decomposition Techniques, Characteristics of Tasks and Interactions, Mapping Techniques for Load Balancing, Methods for Containing Interaction Overheads, Parallel Algorithm Models. | |
| **3** | | **Performance Measures** | **3** |
| | | **Performance Measures:** Speedup, execution time, efficiency, cost, scalability, Effect of granularity on performance, Scalability of Parallel Systems, Amdahl's Law, Gustavson's Law, Performance Bottlenecks, The Karp Flatt Metric. | |
| **4** | | **HPC Programming: OpenMP and MPI** | **10** |

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|---|---|---|---|
| | | **HPC Programming: OpenMP** | |
| | 4.1 | Introduction: Threads, Share memory Architecture, Multi-core processors and Hyperthreading, Fork and join model. | |
| | 4.2 | OpenMP directives: #pragma omp parallel, Hello world with openMP, #pragma omp for, #pragma omp for schedule.Serial vs Parallel PI program. | |
| | 4.3 | Synchronisation: Introduction, Private vs Shared variables. Critical section, #pragma omp critical, #pragma omp atomic, #pragma omp barrier, #pragma omp reduction | |
| | | **HPC Programming: MPI** | |
| | 4.4 | Introduction: Processes, Multiprocessor programming model, Distributed system programming model, Inter-process communication using message passing: Asynchronous and Synchronous | |
| | 4.5 | MPI Programming: Hello world problem, mpi_initMPI_sendMPI_Recv, Synchronisation: MPI_Barrier | |
| | 4.6 | Hybrid (MPI + OpenMP) programming, Hardware requirement, Threads inside Processes, Hybrid Matrix multiplication | |
| | 4.7 | Message passing vs Share memory communication: Advantages and disadvantage | |
| **5** | | **Parallel programming using accelerators** | **4** |
| | | An Overview of GPGPUs, Introduction to CUDA, Introduction to Heterogeneous Computing using OpenCL, An Overview of OpenCL API, Heterogeneous Programming in OpenCL. | |
| **6** | | **High Performance Computing in the Cloud** | **4** |
| | | Virtualization and Containerization, Parallel Computing Frameworks, Scaling, HPC in the Cloud Use Cases. | |




| **Textbooks:** | |
|---|---|
| 1 | AnanthGrama, Anshul Gupta, George Karypis, Vipin Kumar “Introduction to Parallel Computing”, 2nd edition, Addison Wesley, 2003. |
| 2 | Shane Cook, Morgan Kaufmann “CUDA Programming: A Developer's Guide to Parallel Computing with GPUs”, 2012. |
| 3 | M. R. Bhujade “Parallel Computing”,2nd edition, New Age International Publishers, 2009. |
| 4 | Kai Hwang, Naresh Jotwani, “Advanced Computer Architecture: Parallelism, Scalability, Programmability” McGraw Hill, Second Edition, 2010. |
| 5 | Georg Hager, Gerhard Wellein, Chapman “Introduction to High Performance Computing for Scientists and Engineers” Hall/CRC Computational Science Series, 2011. |

**References:**

| | |
|---|---|
| 1 | Michael J. Quinn “Parallel Programming in C with MPI and OpenMPI” by, McGraw Hill Education, 2008. |
| 2 | Kai Hwang ,Zhiwei, “Scalable Parallel Computing: Technology, Architecture, Programming”, McGraw-Hill Education, 1998. |
| 3 | Laurence T. Yang, Minyi Guo, “High-Performance Computing: Paradigm and Infrastructure”, by, Wiley, 2006. |

| Useful Links | |
|---|---|
| 1 | https://nptel.ac.in/courses/112105293 |
| 2 | https://archive.nptel.ac.in/courses/128/106/128106014/ |

| **Assessment:** | |
|---|---|
| **Internal Assessment:** | |
| Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed. Duration of each test shall be one hour. | |
| **End Semester Theory Examination:** | |
| 1 | Question paper will comprise of total six questions. |
| 2 | All question carries equal marks |
| 3 | Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3) |
| 4 | Only four questions need to be solved. |
| 5 | In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus. |

| Course Code | Course Name | Credit |
|---|---|---|
| CSDC8023 | Social Media Analytics | 03 |

| | |
|---|---|
| **Prerequisite:** Graph Theory, Data Mining, Python/R programming | |
| **Course Objectives:** The course aims: | |
| 1 | Familiarize the learners with the concept of social media. |
| 2 | Familiarize the learners with the concept of social media analytics and understand its significance. |
| 3 | Enable the learners to develop skills required for analyzing the effectiveness of social media. |
| 4 | Familiarize the learners with different tools of social media analytics. |
| 5 | Familiarize the learner with different visualization techniques for Social media analytics. |
| 6 | Examine the ethical and legal implications of leveraging social media data. |
| **Course Outcomes:** | |
| 1 | Understand the concept of Social media |
| 2 | Understand the concept of social media Analytics and its significance. |
| 3 | Learners will be able to analyze the effectiveness of social media |
| 4 | Learners will be able to use different Social media analytics tools effectively and efficiently. |
| 5 | Learners will be able to use different effective Visualization techniques to represent social media analytics. |
| 6 | Acquire the fundamental perspectives and hands-on skills needed to work with social media data. |

| Module | Detailed Content | Hours |
|---|---|---|
| **1.** | **Social Media Analytics: An Overview** | |
| | Core Characteristics of Social Media, Types of Social Media, Social media landscape, Need for Social Media Analytics (SMA), SMA in small & large organizations.<br>Purpose of Social Media Analytics, Social Media vs. Traditional Business Analytics, Seven Layers of Social Media Analytics, Types of Social Media Analytics, Social Media Analytics Cycle, Challenges to Social Media Analytics, Social Media Analytics Tools | 6 |
| **2.** | **Social Network Structure, Measures & Visualization** | |
| | Basics of Social Network Structure - Nodes, Edges & Tie<br>Describing the Networks Measures - Degree Distribution, Density, Connectivity, Centralization, Tie Strength & Trust<br>Network Visualization - Graph Layout, Visualizing Network features, Scale Issues.<br>Social Media Network Analytics - Common Network Terms, Common Social Media Network Types, Types of Networks, Common Network Terminologies, Network Analytics Tools. | 6 |
| **3.** | **Social Media Text, Action & Hyperlink Analytics** | |
| | Social Media Text Analytics - Types of Social Media Text, Purpose of Text Analytics, Steps in Text Analytics, Social Media Text | 8 |

| | | |
|---|---|---|
| | Analysis Tools<br>Social Media Action Analytics - What Is Actions Analytics? Common Social Media Actions, Actions Analytics Tools<br>Social Media Hyperlink Analytics - Types of Hyperlinks, Types of Hyperlink Analytics, Hyperlink Analytics Tools | |
| **4.** | **Social Media Location & Search Engine Analytics** | |
| | Location Analytics - Sources of Location Data, Categories of Location Analytics, Location Analytics and Privacy Concerns, Location Analytics Tools<br>Search Engine Analytics - Types of Search Engines, Search Engine Analytics, Search Engine Analytics Tools | 6 |
| **5.** | **Social Information Filtering** | |
| | Social Information Filtering - Social Sharing and filtering , Automated Recommendation systems, Traditional Vs social Recommendation Systems<br>Understanding Social Media and Business Alignment, Social Media KPI, Formulating a Social Media Strategy, Managing Social Media Risks | 6 |
| **6.** | **Social Media Analytics Applications and Privacy** | |
| | Social media in public sector - Analyzing public sector social media, analyzing individual users, case study.<br>Business use of Social Media - Measuring success, Interaction and monitoring, case study.<br>Privacy - Privacy policies, data ownership and maintaining privacy online. | 7 |

| **Textbooks:** | |
|---|---|
| 1. | Seven Layers of Social Media Analytics_ Mining Business Insights from Social Media Text, Actions, Networks, Hyperlinks, Apps, Search Engine, and Location Data, Gohar F. Khan,(ISBN-10: 1507823207). |
| 2. | Analyzing the Social Web 1st Edition by Jennifer Golbeck |
| 3. | Mining the Social Web_ Analyzing Data from Facebook, Twitter, LinkedIn, and Other Social Media Sites, Matthew A Russell, O'Reilly |
| 4 | Charu Aggarwal (ed.), Social Network Data Analytics, Springer, 2011 |
| **References:** | |
| 1. | Social Media Analytics [2015], Techniques and Insights for Extracting Business Value Out of Social Media, Matthew Ganis, AvinashKohirkar, IBM Press |
| 2. | Social Media Analytics Strategy_ Using Data to Optimize Business Performance, Alex Gonçalves, APress Business Team |
| 3. | Social Media Data Mining and Analytics, Szabo, G., G. Polatkan, O. Boykin & A. Chalkiopoulus (2019), Wiley, ISBN 978-1-118-82485-6 |

| **Useful Links** | |
|---|---|
| 1 | https://cse.iitkgp.ac.in/~pawang/courses/SC16.html |
| 2 | https://onlinecourses.nptel.ac.in/noc20_cs78/preview |
| 3 | https://nptel.ac.in/courses/106106146 |
| 4 | https://7layersanalytics.com/ |

| | |
|---|---|
| **Assessment:** | |
| **Internal Assessment:** | |
| Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional40% syllabus is completed. Duration of each test shall be one hour. | |
| **End Semester Theory Examination:** | |
| 1 | Question paper will consist of 6 questions, each carrying 20 marks. |
| 2 | The students need to solve a total of 4 questions. |
| 3 | Question No.1 will be compulsory and based on the entire syllabus. |
| 4 | Remaining question (Q.2 to Q.6) will be selected from all the modules. |

| Lab Code | Lab Name | Credit |
|---|---|---|
| CSL801 | Distributed Computing Lab | 1 |

| | |
|---|---|
| **Prerequisite:** Computer Networks and Operating Systems. | |
| **Lab Objectives:** | |
| 1 | To understand basic underlying concepts of forming distributed systems. |
| 2 | To learn the concept of clock Synchronization |
| 3 | To learn Election Algorithm. |
| 4 | To explore mutual exclusion algorithms and deadlock handling in the distributed system |
| 5 | To study resource allocation and management. |
| 6 | To understand the Distributed File System |
| **Lab Outcomes:** At the end of the course, the students will be able to | |
| 1 | Develop test and debug usingMessage-Oriented Communication or RPC/RMI based client-server programs. |
| 2 | Implement techniques for clock synchronization. |
| 3 | Implement techniques for Election Algorithms. |
| 4 | Demonstrate mutual exclusion algorithms and deadlock handling. |
| 5 | Implement techniques of resource and process management. |
| 6 | Describe the concepts of distributed File Systems with some case studies. |

| **Suggested List of Experiments** | |
|---|---|
| **Sr. No.** | **Title of Experiment** |
| 1 | Inter-process communication |
| 2 | Client/Server using RPC/RMI |
| 3 | Group Communication |
| 4 | Clock Synchronization algorithms |
| 5 | Election Algorithm. |
| 6 | Mutual Exclusion Algorithm |
| 7 | Deadlock Management in Distributed System |
| 8 | Load Balancing |
| 9 | Distributed shared Memory |
| 10 | Distributed File System (AFS/CODA) |
| 11 | Case Study: CORBA |
| 12 | Case Study: Android Stack |

| | |
|---|---|
| **Term Work:** | |
| 1 | Term work should consist of 10 experiments. |
| 2 | Journal must include at least 2 assignments on content of theory and practical of CSC801 and CSL801(Distributed Computing) |
| 3 | The final certification and acceptance of term work ensure satisfactory performance of laboratory work and minimum passing marks in term work. |
| 4 | Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks) |
| **Oral and Practical exam** | |
| Based on the entire syllabus of CSC801: Distributed Computing and CSL801: Distributed Computing Lab | |

| Lab Code | Lab Name | Credit |
|---|---|---|
| CSDL8021 | Deep Learning Lab | 1 |

| | |
|---|---|
| **Prerequisite:** Python Programming, Engineering Mathematics | |
| **Lab Objectives:** | |
| 1 | To implement basic neural network models for simulating logic gates. |
| 2 | To implement various training algorithms for feedforward neural networks. |
| 3 | To design deep learning models for supervised, unsupervised and sequence learning. |
| **Lab Outcomes:** At the end of the course, the students will be able to | |
| 1 | Implement basic neural network models to learn logic functions. |
| 2 | Design and train feedforward neural networks using various learning algorithms. |
| 3 | Build and train deep learning models such as Autoencoders, CNNs, RNN, LSTM etc. |

| **Suggested List of Experiments** | |
|---|---|
| **1.** | **Based on Module 1 (Any two) using Virtual Lab** |
| | 1. Implement Mc-Culloch Pitts model for binary logic functions.<br>2. Implement Perceptron algorithm to simulate any logic gate.<br>3. Implement Multilayer Perceptron algorithm to simulate XOR gate.<br>4. To explore python libraries for deep learning e.g. Theano, TensorFlow etc. |
| **2** | **Module 2 (Any Two)** |
| | 5. Apply any of the following learning algorithms to learn the parameters of the supervised single layer feed forward neural network.<br>a. Stochastic Gradient Descent<br>b. Mini Batch Gradient Descent<br>c. Momentum GD<br>d. Nestorev GD<br>e. Adagrad GD<br>f. Adam Learning GD<br>6. Implement a backpropagation algorithm to train a DNN with at least 2 hidden layers.<br>7. Design and implement a fully connected deep neural network with at least 2 hidden layers for a classification application. Use appropriate Learning Algorithm, output function and loss function. |
| **4.** | **Module 3 (Any One)** |
| | 8. Design the architecture and implement the autoencoder model for Image Compression.<br>9. Design the architecture and implement the autoencoder model for Image denoising. |
| **5** | **Module 4 (Any One)** |
| | 10. Design and implement a CNN model for digit recognition application.<br>11. Design and implement a CNN model for image classification. |
| **6** | **Module 5 (Any One)** |

| | |
|---|---|
| | 12. Design and implement LSTM for Sentiment Analysis.<br>13. Design and implement GRU for classification on text data.<br>14. Design and implement RNN for classification of temporal data. |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 8 experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignment: 05-marks) |
| **Practical and Oral exam** | |
| | Based on the entire syllabus of CSDC8011: Deep Learning and CSDL8011: Deep Learning Lab |

| Lab Code | Lab Name | Credit |
|---|---|---|
| CSDL8022 | Digital Forensics Lab | 1 |

| Prerequisite: Computer Network, Cryptography and System Security | |
|---|---|
| **Lab Objectives:** | |
| 1 | To demonstrate the procedures for identification, preservation, and acquisition of digital evidence. |
| 2 | To demonstrate techniques and tools used in digital forensics for operating systems and malware investigation. |
| 3 | To demonstrate tools formobile forensics and browser, email forensics |
| 4 | To explore scenario based crime forensics investigations. |
| **Lab Outcomes:** At the end of the course, the students will be able to | |
| 1 | Explore various forensics tools and use them to acquire, duplicate and analyze data and recover deleted data. |
| 2 | Implement penetration testing using forensics tools. |
| 3 | Explore various forensics tools and use them to acquire and analyze live and static data. |
| 4 | Verification of source and content authentication of emails and browsers. |
| 5 | Demonstrate Timeline Report Analysis using forensics tools. |
| 6 | Discuss real time crime forensics investigations scenarios. |

| Suggested List of Experiments | |
|---|---|
| **Sr. No.** | **Title of Experiment** |
| 1 | Analysis of forensic images using open source tools.<br>● FTK Imager<br>● Autopsy |
| 2 | Explore forensics tools in kali linux for acquiring, analyzing and duplicating data.<br>● dd<br>● dcfldd |
| 3 | Performing penetration testing using Metasploit - kali Linux. |
| 4 | Performing RAM Forensic to analyze memory images to find traces of an attack.<br>● Capturing RAM Using the DumpIt Tool<br>● Volatility tool |
| 5 | Network forensics using Network Miner. |
| 6 | Windows Recycle Bin Forensics |
| 7 | Data Carving using open source tools<br>● Foremost<br>● Scalpel<br>● Jpegcarver |
| 8 | USB Device Forensics using<br>● USBDeview<br>● USB Detective |
| 9 | Web Browser Forensics using DB Browser for SQLite |
| 10 | Generate a Timeline Report Using Autopsy |
| 11 | Email Analysis |
| 12 | Case Study |

| | |
|---|---|
| **Term Work:** | |
| 1 | Term work should consist of 7 experiments covering all the modules and one case study. |
| 2 | Journal must include at least 2 assignments on content of theory and practical |
| 3 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 4 | Total 25 Marks (Experiments & Case Study : 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks) |
| **Oral & Practical exam** | |
| | Based on the entire syllabus of CSDC8012- Digital Forensics and CSDL8012- Digital Forensics Lab |

| Lab Code | Lab Name | Credit |
|---|---|---|
| CSL8023 | Applied Data Science Lab | 1 |

| | |
|---|---|
| **Prerequisite:** Engineering Mathematics, Machine Learning, Programming fundamentals | |
| **Lab Objectives:** | |
| 1 | To explore various stages in the data science lifecycle. |
| 2 | To understand data preparation, exploration and visualization techniques. |
| 3 | To model and evaluate different supervised/unsupervised learning techniques. |
| **Lab Outcomes:** At the end of the course, the students will be able to | |
| 1 | Apply various stages of the data science lifecycle for the selected case study. |
| 2 | Demonstrate data preparation, exploration and visualization techniques. |
| 3 | Implement and evaluate different supervised and unsupervised techniques. |

**Suggested List of Experiments**
**(Select a case study and perform the experiments 1 to 8.)**.

Star (*) marked experiments are compulsory.

**Name of the Experiment**

1. Explore the descriptive and inferential statistics on the given dataset.
2. Apply data cleaning techniques (e.g. Data Imputation).
3. Explore data visualization techniques.
4. Implement and explore performance evaluation metrics for Data Models (Supervised/Unsupervised Learning)
5. Use SMOTE technique to generate synthetic data.(to solve the problem of class imbalance)
6. Outlier detection using distance based/density based method.
7. Implement time series forecasting.

Illustrate data science lifecycle for selected case study. (Prepare case study document for the selected case study)

**Suggested Case Studies:**

1. Customer Segmentation
2. Fraud Detection
3. House Price prediction
4. Product Recommendation
5. Stock price prediction
6. Weather prediction

**Suggested Assignment List**

Assignments can be given on self learning topics or data deployment tools.

| | |
|---|---|
| **Term Work:** | |
| 1 | Term work should consist of 8 experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignment: 05-marks) |
| **Practical and Oral exam** | |
| | Based on the entire syllabus of CSDC 8013: Applied Data Science and CSDL 8013: Applied Data Science Lab |

| Lab Code | Lab Name | Credit |
|---|---|---|
| CSDL8021 | Optimization in Machine Learning | 1 |

| Prerequisite: Algorithms and data structures | |
|---|---|
| **Lab Objectives:** | |
| 1 | To apply derivative based optimization techniques |
| 2 | To understand evolutionary optimization to a given machine learning problem. |
| 3 | To apply advanced evolutionary optimization |
| 4 | To design and analyze optimization problems for real world applications |
| **Lab Outcomes:** At the end of the course, the students will be able to | |
| 1 | To implement derivative based optimization techniques |
| 2 | To implement evolutionary optimization |
| 3 | To implement advanced evolutionary optimization |
| 4 | To apply efficient optimization algorithm for real world applications |

| Suggested List of Experiments | |
|---|---|
| **Sr. No.** | **Title of Experiment** |
| 1 | To implement Gradient Descent algorithm |
| 2 | To implement the Stochastic Gradient Descent algorithm |
| 3 | To implement Newton method |
| 4 | To apply Genetic Algorithm for real world problem |
| 5 | To compare and implement different selection mechanism using genetic algorithm |
| 6 | To implement various mutation and crossover mechanisms |
| 7 | To implement Particles Swarm optimization |
| 8 | To implement Ant colony optimization |

| Term Work: | |
|---|---|
| 1 | Term work should consist of 6 experiments. |
| 2 | Journal must include at least 2 assignments on content of theory and practical of "**Optimization in Machine Learning**" |
| 3 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 4 | Total 25 Marks (Experiments and assignments: 15-marks, Attendance Theory & Practical: 05-marks, Case study /Mini project: 05-marks) |
| **Practical and Oral exam** | |
| | Based on the entire syllabus of CSDC8021: Optimization in Machine Learning and CSDL8021: Optimization in Machine Learning |

| Lab Code | Lab Name | Credit |
|---|---|---|
| CSDL8022 | **High Performance Computing Lab** | 1 |

| | |
|---|---|
| **Prerequisite:** C Programming | |
| **Lab Objectives:** The objective of the course is to: | |
| 1 | Enable students to build the logic to parallelize the programming task. |
| 2 | Give insight about performance of parallel computing systems. |
| 3 | Provide hands-on experience on parallel programming platforms/frameworks |
| **Lab Outcomes:** After learning the course, the students will be able to: | |
| 1 | Perform Linux based commands on remote machine |
| 2 | Compare the performance of sequential algorithms with parallel algorithm in terms of execution time, speedup and throughput. |
| 3 | Implement parallel program using OpenMP libraryand analyze its performance |
| 4 | Implement parallel program using MPIplatform and analyze its performance |
| 5 | Implement parallel program using OpenCL framework and analyze its performance |
| 6 | Implement parallel program using CUDA framework and analyze its performance |

| **Suggested Experiments:** Students are required to complete at least 8 experiments. | |
|---|---|
| Star (*) marked experiments are compulsory. | |
| **Sr. No.** | **Name of the Experiment** |
| 1* | To analyse the Linux based computer systems using following commands:<br>**a.** top , **b.**ps , **c.** kill, **d.** cat /proc/cpuinfo**e.**vmstat<br>**Hardware/Software Requirement:** Linux Operating System |
| 2* | To setup SSH passwordless logins for two or more Linux based machines and execute commands on a remote machine.<br>**Hardware/Software Requirement:** Linux Operating System,<br>Multi-core computer systems |
| 3* | Write a program in C to multiply two matrices of size 10000 x 10000 each and find it's execution-time using "time" command. Try to run this program on two or more machines having different configurations and compare execution-times obtained in each run. Comment on which factors affect the performance of the program.<br>**Hardware/Software Requirement:** Linux Operating System, gcc compiler,Multi-core computer systems |
| 4* | Write a "Hello World" program using OpenMP library also display number of threads created during execution.<br>**Hardware/Software Requirement:** Linux Operating System, gcc compiler,Dual core with HT or Quad-core or higher computer system. |
| 5* | Write a parallel program to calculate the value of PI/Area of Circle using OpenMP library.<br>**Hardware/Software Requirement:** Linux Operating System, gcc compiler,Dual core with HT or Quad-core or higher computer system. |
| 6* | Write a parallel program to multiply two matrices using openMP library and compare |

| | |
|---|---|
| | the execution time with its serial version. Also change the number of threads using omp_set_num_threads() function and analyse how thread count affects the execution time.<br>**Hardware/Software Requirement:** Linux Operating System, gcc compiler,Dual core with HT or Quad-core or higher computer system. |
| 7* | Install MPICH library and write a "Hello World" program for the same.<br>**Hardware/Software Requirement:** Linux Operating System, MPICH, Multi-processor systems or MPI Cluster. |
| 8* | Write a parallel program to multiply two matrices using MPI library and compare the execution-time with it's OpenMP and serial version.<br>**Hardware/Software Requirement:** Linux Operating System, MPICH, gcc, Multi-processor systems, or MPI Cluster. |
| 9* | Install MPICH on two and more machines and create a MPI cluster. Execute MPI programs on this cluster and check the performance.<br>**Hardware/Software Requirement:** Linux Operating System, MPICH, Multi-processor systems or MPI Cluster. |
| 10* | Implement a program to demonstrate balancing workload on MPI platform.<br>**Hardware/Software Requirement:** Linux Operating System, MPICH, Multi-processor systems or MPI Cluster. |
| 11 | Implement a parallel program to demonstrate the cube of N number within a set range using MPI/OpenMP/OpenCL/CUDA.<br>**Hardware/Software Requirement:** Linux Operating System, MPICH, Multi-processor systems or MPI Cluster.<br>A CUDA-capable GPU,A supported version of Microsoft Windows,A supported version of Microsoft Visual Studio, The NVIDIA CUDA Toolkit |
| 12 | Implement DFT computation of vector using OpenCL/CUDA/ Parallel Matlab<br>**Hardware/Software Requirement:** A CUDA-capable GPU,A supported version of Microsoft Windows,A supported version of Microsoft Visual Studio, The NVIDIA CUDA Toolkit |
| 13 | Implement Two Vector addition using OpenCL/CUDA/ Parallel Matlab<br>**Hardware/Software Requirement:** A CUDA-capable GPU, A supported version of Microsoft Windows,A supported version of Microsoft Visual Studio, The NVIDIA CUDA Toolkit |
| 14 | Implement even-odd/Bucket /Radix /Shell sort using OpenCL/CUDA/ Parallel Matlab<br>**Hardware/Software Requirement:** A CUDA-capable GPU, A supported version of Microsoft Windows,A supported version of Microsoft Visual Studio, The NVIDIA CUDA Toolkit |

| | |
|---|---|
| **Term Work:** | |
| 1 | Term work should consist of 8 experiments. |
| 2 | Journal must include at least 2 assignments. |
| 3 | The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work. |
| 4 | Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks) |
| **Practical and Oral Exam** | |
| | Based on the entire syllabus of CSDC8022 : High Performance Computing and CSDL8022 High Performance Computing Lab |

| Lab Code | Lab Name | Credit |
|---|---|---|
| **CSDL8023** | **Social Media Analytics Lab** | **1** |

| | |
|---|---|
| **Prerequisite**: Types of Graphs, Data Mining, Data Analytics | |
| **Lab Objectives:** | |
| 1 | To understand the fundamental concepts of social media networks. |
| 2 | To learn various social media analytics tools and evaluation matrices. |
| 3 | To collect and store social media data. |
| 4 | To analyze and visualize social media data |
| 5 | To design and develop social media analytics models. |
| 6 | To design and build a social media analytics application. |
| **Lab Outcomes: The students will be able to** | |
| 1 | Understand characteristics and types of social media networks. |
| 2 | Use social media analytics tools for business |
| 3 | Collect, monitor , store and track social media data |
| 4 | Analyze and visualize social media data from multiple platforms |
| 5 | Design and develop content and structure based social media analytics models. |
| 6. | Design and implement social media analytics applications for business. |

| **Suggested Experiments:** | |
|---|---|
| | |
| **Sr. No.** | **Name of the Experiment** |
| 1 | Study various -<br>i) Social Media platforms ( Facebook, twitter, YouTubeetc)<br>ii) Social Media analytics tools ( Facebook insights, google analytics net lyticetc)<br>iii) Social Media Analytics techniques and engagement metrics (page level, post level, member level)<br>iv) Applications of Social media analytics for business.<br>e.g. Google Analytics<br>https://marketingplatform.google.com/about/analytics/<br><br>https://netlytic.org/ |
| 2 | Data Collection-Select the social media platforms of your choice (Twitter, Facebook, LinkedIn, YouTube, Web blogs etc) ,connect to and capture social media data for business ( scraping, crawling, parsing). |
| 3 | Data Cleaning and Storage- Preprocess, filter and store social media data for business (Using Python, MongoDB, R, etc). |
| 4 | Exploratory Data Analysis and visualizationof Social Media Data for business. |
| 5 | Develop Content (text, emoticons, image, audio, video) based social media analytics model for business.<br>(e.g. Content Based Analysis :Topic , Issue ,Trend, sentiment/opinion analysis, audio, video, image analytics) |
| 6 | Develop Structure based social media analytics model for any business.<br>( e.g. Structure Based Models -community detection, influence analysis) |
| 7 | Develop a dashboard and reporting tool based on real time social media data. |

| | |
|---|---|
| 8 | Design the creative content for promotion of your business on social media platform. |
| 9 | Analyze competitor activities using social media data. |
| 10 | Develop social media text analytics models for improving existing product/ service by analyzing customer's reviews/comments. |

| **Reference Books:** | |
|---|---|
| **1** | Python Social Media Analytics: Analyze and visualize data from Twitter, YouTube, GitHub, and more Kindle Edition by Siddhartha Chatterjee , Michal Krystyanczuk |
| 2 | Learning Social Media Analytics with R,byRaghav Bali, Dipanjan Sarkar, Tushar Sharma. |
| 3 | Jennifer Golbeck, Analyzing the social web, Morgan Kaufmann, 2013 |
| 4 | Matthew A. Russell. Mining the Social Web: Data Mining Facebook, Twitter, Linkedin, Google+, Github, and More, 2nd Edition, O'Reilly Media, 2013 |
| 5 | Charu Aggarwal (ed.), Social Network Data Analytics, Springer, 2011 |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 10 experiments. |
| 2 | Journal must include at least 2 assignments. |
| 3 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 4 | **Total 25 Marks** (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks) |
| **Practical and Oral Exam** | |
| Based on the entire syllabus of CSDC8023: **Social Media Analytics** and CSDL80223: **Social Media Analytics Lab** | |

| Course Code | Course Name | Credit |
|---|---|---|
| CSP801 | Major Project 2 | 06 |

| Course Objectives:: | |
|---|---|
| The Project work facilitates the students to develop and prove Technical, Professional and Ethical skills and knowledge gained during graduation program by applying them from problem identification to successful completion of the project by implementing the solution. | |
| **Course Outcomes: Student will able to** | |
| 1 | Implement solutions for the selected problem by applying technical and professional skills. |
| 2 | Analyze impact of solutions in societal and environmental context for sustainable development. |
| 3 | Collaborate best practices along with effective use of modern tools. |
| 4 | Develop proficiency in oral and written communication with effective leadership and teamwork. |
| 5 | Nurture professional and ethical behavior. |
| 6 | Gain expertise that helps in building lifelong learning experience. |



**Guidelines:**

1. Internal guide has to keep track of the progress of the project and also has to maintain attendance report. This progress report can be used for awarding term work marks.

2. **Project Report Format:**

   At the end of semester, each group need to prepare a project report as per the guidelines issued by the University of Mumbai. Report should be submitted in hardcopy. Also, each group should submit softcopy of the report along with project documentation, implementation code, required utilities, software and user Manuals.

   A project report should preferably contain at least following details:

   - Abstract
   - Introduction
   - Literature Survey/ Existing system
   - Limitation Existing system or research gap
   - Problem Statement and Objective
   - Proposed System
     - Analysis/Framework/ Algorithm
     - Design details
     - Methodology (your approach to solve the problem) Proposed System
   - Experimental Set up

- Details of Database or details about input to systems or selected data
- Performance Evaluation Parameters (for Validation)
- Software and Hardware Set up

- Results and Discussion
- Conclusion and Future Work
- References
- Appendix – List of Publications or certificates

Desirable:

Students should be encouraged -

- to participate in various project competition.
- to write minimum one technical paper & publish in good journal.
- to participate in national / international conference.

**3. Term Work:**

Distribution of marks for term work shall be done based on following:

a. Weekly Log Report
b. Completeness of the project and Project Work Contribution
c. Project Report (Black Book) (both side print)
d. Term End Presentation (Internal)

The final certification and acceptance of TW ensures the satisfactory performance on the above aspects.

**4. Oral & Practical:**

Oral &Practical examination (Final Project Evaluation) of Project 2 should be conducted by Internal and External examiners approved by University of Mumbai at the end of the semester.

**Suggested quality evaluation parameters are as following:**

a. Relevance to the specialization / industrial trends
b. Modern tools used
c. Innovation
d. Quality of work and completeness of the project
e. Validation of results
f. Impact and business value
g. Quality of written and oral presentation
h. Individual as well as team work