

Academic Programme Guide

Master of Engineering Computer Science and Engineering

*Based on Choice Based Credit System (CBCS)/Elective Course
System*

CHITKARA
UNIVERSITY



HIMACHAL PRADESH - NAAC Accredited

w.e.f.

Academic Year: 2018-19

Approved by the 21st Academic Council vide agenda item no. 21.6 dated 30-06-2018



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1. General Information

The M.E. Programme is a modular Programme consisting of 3 academic years. It consists of core courses, specialized courses and a dissertation project spanned across one entire academic year. The students seeking admission to the Programme are expected to have basic knowledge of Computer architecture, Computer network, Data base systems and software engineering. These courses constitute prerequisites for the M.E. (CSE) Programme. The courses offered in the Programme challenge the intellect of the students and enhance their knowledge. In addition to this the dissertation project let the students explore their research and development skills and to be a part of the various exciting research projects going on in the Department. This Programme offers a balanced emphasis on theoretical and practical knowledge in areas of software engineering, applications of computing, networks and more.

1.1 Programme Educational Objectives (PEOs)

PEO1: The post-graduating students can opt professional career in technical domain or pursue higher studies.

PEO2: The post-graduating students can solve social problems by designing/developing the products with the help of acquired knowledge.

PEO3: The post-graduating students would be able to have good communication skills, leadership quality, and ethical values.

PEO4: The post-graduating students would be capable to use the techniques, skills, and modern engineering tools.

1.2 Programme Outcomes (PO)

The Programme is designed to provide the knowledge and skills needed to become an effective manager in a variety of organizational settings. It is a broad based, career advancement degree, rather than technical training for a particular job within an organization. The broad goal of the Programme is to provide students with a foundation in content and supporting skills/competencies that will support their development as effective managers. The students shall be further groomed to work in a variety of organizational settings. The Programme Outcomes of CSE are summarized as below:

- PO1. Possess an ability to apply knowledge of Computer Science & Engineering.
- PO2. Possess an ability to design and conduct experiments, as well as to analyze and interpret data.

- PO3. Possess an ability to design a system, component or process to meet desired needs within realistic constraints such as economics, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
- PO4. Possess an ability to function on multidisciplinary teams.
- PO5. Possess an ability to identify, formulate and solve engineering problems
- PO6. Possess an understanding professional and ethical responsibility.
- PO7. Possess an ability to communicate effectively.
- PO8. Possess a capability to understand impact of engineering solutions in a global, economic, environmental, and societal context.
- PO9. Possess an ability to recognize the need for, and an ability to engage in life-long learning.
- PO10. Possess an ability to use the techniques, skills, and modern engineering tools necessary for engineering.

1.3 PEOs mission mapping

University Vision

To be a globally recognized organization promoting academic excellence through interdisciplinary applied research and to expand realms of knowledge through innovation.

University Mission

M1: To carry out the academic processes in accordance with global standards through active teacher-student-industry participation.

M2: To promote research, innovation and entrepreneurship in collaboration with industry, research laboratories and academic institutions of global repute.

M3: To inculcate high moral, ethical and professional values amongst our students, faculty & staff.

M4: To contribute in building skillful society.

In M.E. Computer Science Engineering Programme, the programme educational objectives (PEOs) are well-designed on the mission of providing the graduating students with knowledge and expertise required for professional practices in engineering and the necessary technical skills for working in corporate industries.

To enrich student's interpersonal skills, variety of extracurricular activities have been inculcated in the course curriculum in the form of national level technical and cultural festivals such as Algorithm and Hackathons respectively on yearly basis. A vital role is played by the department for overall grooming of the student through organizing industrial visits, workshops and technical quizzes/debates and project showcase competitions. The students are offered to participate or organize such events. These

value-added activities have been designed taking into account various Programme Objectives (POs) such as PO3, PO6, PO7, PO9, and PO10, and have been in accordance with all the mentioned Programme Educational Objectives (PEOs). By offering additional sports related activities, the overall purpose of service-learning is achieved with an emphasis on good health and well-being.

The programme also aims at achieving the sustainable development goals set up by the United Nations. PO3, PO7 and PO10 promote development for sustainable society, which depends on three aspects: Economic Forces, Public policy changes, Changes in Life-style. An engineer can contribute to sustainable development; as the role of technology in the transition to a sustainable society is a central one. Present day technologies include Machine learning, Digital image processing, cryptography and network security and advanced computer networks. The Programme of Computer Science Engineering is designed to build innovators, entrepreneurs, leaders and responsible citizens with the above-mentioned skills and knowledge that will help them contribute to achieving the UN 2030 agenda.

PEOs and POs are designed and oriented to meet the mission of university. The PEOs ensure that the graduating students are well equipped with technical knowledge, command over communication skills, leadership qualities, and accomplishment of life-long learning to apply for solving the relevant engineering problems in community at local, national and international level, thereby helping establish a balanced social and professional environment. Thus, the objective of the programme is to produce high quality analytic and creative minded computer engineers to transform the society into knowledgeable, and sustainable society.

1.4 Programme Constitution

- The courses offered in first year are 4 core subjects and 2 elective subjects.
- In the second year there are 2 core subjects and 3 elective subjects. Also, Publishing Research (PR)' and 'Intellectual Property Rights (IPR)' will be taught in 2nd and 3rd semester to avail the knowledge of writing research paper and patent filing at the initial stage of their ME programme.
- Subject "Research Methodology" is introduced in the 3rd semester so that students can learn analysis tools in the initial stage of research work.
- The course "Preliminary Thesis work and Thesis work will be done by the students in the year 3 along with the Research paper communicated/accepted/published in Scopus indexed conference/journal. This research paper will be based on the research objectives.

- We follow outcome-based education and programme outcomes are mapped with course outcomes. For details see the appendix A of mapping report.

1.5 Placement Opportunities

The course of M.E. in Computer Science offers wide job prospects in I.T and software firms. There are various private as well as government sector jobs available for post graduates in CSE.

2. Eligibility for Admission

The students seeking admission in M.E. CSE Programme should have minimum 60% marks or minimum 6.0 CGPA on the scale of 10 in their B.E. / B.Tech. [Electronics/Electrical/CSE/IT] or MSc [CS]/MSc [IT] or MCA. The admission is based on criteria set by university statutory body.

3. Programme Duration

The duration of the ME Programme is three years - divided into 6 semesters. Maximum duration of the Programme is N+2 years where “N” stands for minimum or normal duration prescribed for completion of the Programme. Thus, the maximum duration for completion of M.E. Programme is 5 years. In exceptional circumstances, further extensions of one year may be granted on the recommendation of concerned statutory body of the university.

4. Pedagogical Aspects

The structural layout of the Programme and its courses requires that each course be divided in lecture, tutorial and practical sessions. Duration of each session as given in the column against the course in the course scheme is one hour.

Lecture sessions: Lectures are delivered by traditional - chalk board method, supplemented by modern Information Communication technology (ICT) methods. The students are encouraged to ask questions and involve in group discussion to the extent allowed by the teacher. In some subjects where case-study based methodology is adopted, the lectures are supplemented by discussions on case studies.

5. Programme Structure

Semester-1				
S.No	Course Code	Course Title	L-T-P	Credits
1	CS902	Data Warehouse & Mining	4-0-0	4
2	CS903	Cryptography & Network Security	4-0-0	4
3	CS906	Advanced Data Structures	3-0-0	3
4	CS907	Advanced Data Structures Lab	0-0-2	1

		Total Credits		12
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Semester-2				
S.No	Course Code	Course Title	L-T-P	Credits
1	CS921	Advanced Computer Networks	3-0-0	3
2	CS922	Advanced Computer Networks Lab	0-0-2	1
3	RS991	Intellectual Property Rights and Publishing Research (I)	1-0-0	1
4		Elective I	4-0-0	4
5		Elective II	4-0-0	4
		Total Credits		13

Semester-3				
S.No	Course Code	Course Title	L-T-P	Credits
1	CS913	Advanced Operating Systems	4-0-0	4
2	RS992	Intellectual Property Rights and Publishing Research (II)	1-0-0	1
3	RS993	Research Methodology	3-0-0	3
4		Elective III	4-0-0	4
		Total Credits		12

Semester-4				
S.No	Course Code	Course Title	L-T-P	Credits
1	CS908	Advanced Database Management Systems	3-0-0	3
2	CS909	Advanced Database Management Systems Lab	0-0-2	1
3		Elective IV	4-0-0	4
4		Elective V	4-0-0	4
		Total Credits		12

Semester-5				
S.No	Course Code	Course Title	L-T-P	Credits
1	RS994	Preliminary Thesis Work	0-0-8	8
		Total Credits		8

Semester-6				
S.No	Course Code	Course Title	L-T-P	Credits
1	RS995	Thesis	15	15
		Total Credits		15

Total Credits = 72

Programme Electives				
S.No	Course Code	Course Title	L-T-P	Credits
Elective I				
1	CS 951	Programming in C#	4-0-0	4
2	CS 952	Programming in Python	4-0-0	4
3	CS 953	Programming in R	4-0-0	4
Elective II				
1	CS 954	Advanced Programming in Java	4-0-0	4
2	CS 955	Virtual Private Network	4-0-0	4
Elective III				
1	CS 956	Bioinformatics	4-0-0	4
2	CS 957	Software testing & Quality Assurance	4-0-0	4
3	CS 958	S/W Project Management	4-0-0	4
4	CS 959	Cloud Computing & Virtualization	4-0-0	4
Elective IV				
1	CS 960	Natural Language Processing	4-0-0	4
2	CS 961	Pattern Recognition	4-0-0	4
3	CS 962	Next Generation Wireless & Sensor Networks	4-0-0	4
4	CS 963	Big Data Analytics	4-0-0	4
Elective V				
1	CS 964	Soft Computing	4-0-0	4
2	CS 965	Communication Network and Protocols	4-0-0	4
3	EC909	Digital Image Processing	3-0-0	3
4	EC910	Digital Image Processing Lab	0-0-2	1

6. Assessment and Evaluation

The evaluation will be continuous and the weightage of various components are as given in tables specified for each type of course.

For Theory Courses	
Evaluation Component	Weightage (%)
Quizzes /Assignments/ Presentation/Class Test/ Open Book Test/ Case Study	20
Sessional Tests (STs)	20
End Term Examination	60
Total	100

Evaluation components for Theory Courses

There is only one Sessional Tests (STs) for all theory papers, and considered in final evaluation. The policy on the evaluation component – ‘Quizzes / Tutorials / Assignments’ is decided by the course coordinator and HOD and is announced separately for each course. The End Term examination for practical courses includes conduct of experiment and an oral examination (viva voce).

For Lab Courses	
Evaluation Component	Weightage (%)
Lab Performance / File work	40
Internal Viva – Voce	20
End Term	40
Total	100

Evaluation Components for Practical Courses

7. Rules for Attendance

Students are expected to be regular in attending the classes. 75% attendance (of all held sessions – lectures, tutorials, lab) is compulsory in a course in order to be eligible for appearing in end term comprehensive examination. 10% concession in this mandatory requirement is possible only in extreme circumstances and at the sole discretion of the Vice Chancellor. 5% concession is possible only in case of extreme circumstances and at the sole discretion of the Head of the Department. Students are encouraged for participating in co-curricular activities conducted by prestigious institutions at national/International level. Such students would be eligible for grant of special Duty Leaves (limited by a cap decided by the Vice Chancellor) to make up for the attendance, in case any class work is missed during this period. This privilege extended to the students will not be termed as right and is limited to just the attendance benefit.

8. Grading System

The list of letter and non-letter grades, their applicability and connotation are given below:

% Marks Range of Total	Grade	Qualitative Meaning	Grade Point
80 – 100	O	Outstanding	10
70 – 79	A+	Excellent	9

60 – 69	A	Very Good	8
55 – 59	B+	Good	7
50 – 54	B	Above Average	6
45 – 49	C	Average	5
40 – 44	P	Pass	4
0 – 39	F	Fail	0
	I	Incomplete	0

If a student obtains grade P or above, he is declared pass in that subject. The grade F is equivalent to being fail in that subject, in the latter case, the student has to reappear in the end term examination of that subject, whenever its exam is conducted again with the regular examination, after payment of appropriate examination fee.

If the student is detained from appearing in the end term examination because of shortage of attendance in the regular semester or is absent in the end term exam, his grade in that subject is 'I', till he/she appears again in the end term examination and obtains a new grade.

The grade I (Incomplete) may be awarded in the following conditions:

- (i) Where a case of unfair means is pending, a 'Grade I' is awarded till the case is finalized.
- (ii) Where a case of indiscipline is pending, a 'Grade I' is awarded till the case is finalized.
- (iii) In cases of unfair means and indiscipline where the results for a particular examination are declared can be declared as null and void.
- (iv) In cases, where the student does not complete his course work because of some reason viz, shortage of attendance / is absent in the end term examination.

In case the grades are not received by the University as per the time schedule the, the Head of department may make a specific authorization for the Course coordinator to report GA (Grade Awaited). The head of department will also simultaneously advise Dean Examination about the estimated time by which the grades will be received. Whenever the report GA appears in the grade sheet, permission for further registration of such a student will be decided by Head of the Department.

The Cumulative Grade Point Average (CGPA) denotes the overall performance of a student in all courses in which he is awarded letter grades. It is the weighted average of the grade points of all the letter grades received by the student from the time of his entry into the University.

Calculation of CGPA

The CGPA (calculated on a 10-point scale) would be used to describe the overall performance of a student (from the semester of admission till the point of reckoning) in all courses for which LETTER GRADES will be awarded. SGPA will indicate the performance of student for any particular semester. Formulas for calculation of SGPA and CGPA have been provided as below:

$$SGPA_i = \frac{\sum_{j=1}^n C_{ij} G_j}{\sum_{j=1}^n C_{ij}} \quad CGPA = \frac{\sum_{i=1}^N \left(SGPA_i * \sum_{j=1}^n C_{ij} \right)}{\sum_{i=1}^N \left(\sum_{j=1}^n C_{ij} \right)}$$

Where n = number of subjects in the semester; N = number of semesters; $SGPA_i$ = SGPA for the i th semester; C_{ij} = number of credits for the j th course in i th semester; and G_j = Grade point corresponding to the grade obtained in the j th course.

Example to Understand the Calculation of SGPA

Suppose a student is registered in four courses ‘W’, ‘X’, ‘Y’ and ‘Z’ in a particular semester as mentioned below in the Column - I of the table. Column - II in the table below depicts the number of credits, which those courses carried. At the end of the semester, student was awarded with the grades as mentioned in Column – III in the table given below. Column – IV indicates the corresponding grade weight. Column – V and Column – VI indicate essentially the Credit value and Grade Points for every course completed by a student in that particular semester.

Number of Credits and Courses

Courses in which student registered (Col. I)	Credits (Col. II)	Letter Grade (Col. III)	Grade Value (Col. IV)	Credit Value (Col. V)	Grade Points (Col. VI)
Course W	3	B-	6	3 x 6	18
Course X	3	A-	8	3 x 8	24
Course Y	3	A+	10	3 x 10	30
Course Z	2	A+	10	2 x 10	20
Total	11			Total	92

Thus, the total SGPA of the student would be =

$$SGPA = \frac{\text{Total grade pts.}}{\text{Total no. of credits}} = \frac{92}{11} = 8.36$$

Suppose the GPA of the student in two successive terms is 7.0 and 8.0 with respective course credits being 12 and 11, then the

$$CGPA = \frac{7 \times 12 + 8 \times 11}{12 + 11} = \frac{84 + 88}{23} = 7.48$$

9. Promotion and Registration

Any Bonafide student, who appears for the examination conducted by the University, shall be promoted to the next higher semester and shall carry forward all course(s) / subject(s) in which he/she is declared fail. The student shall have to pass all papers within stipulated maximum duration to qualify for the award of degree.

All students are eligible to register for next semester irrespective of number of backlogs unless if:

- 1) He / She has dues outstanding to the University, hostel, or any recognized authority or body of the University.
- 2) His / Her grade sheet in his immediately preceding term is withheld.
- 3) He / She has been specifically debarred or asked to stay away from that term.

Late registration may be granted in case a student fails to register on the stipulated date. Student failing to register on the specified day of registration will be allowed to register only after permission from Head of the Department and after paying the stipulated late fee. Any student who has not registered will not be allowed to attend classes. The registration of the student may be cancelled, if at the later stage, it is found that the student is not eligible for registration due to following reasons:

- a) If the registration of a student in a course is not found to be in accordance with the regulations, his/her registration in that course will be cancelled and the grade obtained, if any, will be rejected.
- b) The registration of a student in a course or complete set of courses in a term can be cancelled by the concerned authority when he is found guilty in cases of unfair means, breach of discipline, etc. or when he/she persistently and deliberately does not pay his dues.
- c) Absence for a period of four or more weeks at a stretch during a term shall result in automatic cancellation of the registration of a student from all the courses in that term.

10. Migration/Credit Transfer Policy

The following procedures will be followed for credit transfer for student under migration, studied in other Universities in India and Abroad:

“The credits earned by the student from the other universities in India or abroad shall be transferred as such. The Degree shall only be awarded to candidate subject to the condition that student earned the minimum no. of credit defined by Academic Regulation/APG of the Programme run by the Chitkara University.”

In case a student undergoes international exchange programme or internship for 1 semester/ 1 year, then the courses, credits and grades earned by the student in abroad during that period should be reflected on the grade card issued by the Chitkara University. The courses will be marked as (*) on the grade card/transcript. The description of the (*)

will be “credits and grades as adopted university/institute name.... during international exchange programme.

11. Eligibility to Award of Degree

In addition to conditions given in section 8 of Academic Regulations, a CGPA of 5.5 and minimum credit of 72 is required to receive degree in any of the Engineering Programs. A student is deemed to have become eligible for the degree if, in addition to satisfying the above requirements he has:

- (a) Satisfied all rules of evaluation.
- (b) No case of indiscipline or unfair means is pending against him.

However, in case of a student having outstanding dues against him to be paid to the University, Hostel or any other recognized organ of the University, his degree will be withheld until the said dues are cleared.

Under extreme exceptional circumstances where gross violation of graduation is detected at a later stage the Academic Council may recommend to the Governing Body the recall of a degree already awarded.

12. Programme Overview

Programme Name: Master of Engineering-Fellowship in Computer Science and Engineering

Duration: 3 years (Normal)

This postgraduate programme in Computer Science Engineering prepares students for the ever-expanding computer engineering fields. The students take in all 17 courses of which 9 are core courses and 5 are elective courses and 3 are industry-oriented subjects. The programme prepares students on basic and advanced subjects of computer engineering and also builds necessary engineering skills in areas of Computer architecture, Computer network, Data base systems and software engineering. The students get an overview of basic and advanced programming concepts and also learn them to apply in real life applications. Training the students with help of a 100 % application oriented and project-based learning approach remains the key strength of the programme.

Details of courses

Semester I

Course Code	Course Name	L-T-P	Credits
CS902	Data Warehouse & Mining	4-0-0	4

Course Learning Outcomes (CLO):

- CLO1: Understand the functionality of the various data mining and data warehousing components.
- CLO2: Appreciate the strengths and limitations of various data mining and data warehousing models
- CLO3: To acquire knowledge about data pre-processing, quality, manage, manipulate, clean and analyse data and to make them skilled for the implementation.
- CLO4: To acquire knowledge about modelling and design of data warehouses.
- CLO5: To implement various data clustering and classification approaches.

***The mapping of CO /PO attainment/Graduate Attributes are at Annexure-A**

Course Outline

Relational Databases: Integrity Constraints revisited, Extended ER diagram, Relational Algebra & Calculus, Functional, Multivalued and Join Dependency, Normal Forms, Rules about functional dependencies. Query Processing and Optimization: Valuation of Relational Operations, Transformation of Relational Expressions, Indexing and Query Optimization, Limitations of Relational Data Model Objected Oriented and Object Relational Databases: Modelling Complex Data Semantics, Specialization, Generalization, Aggregation and Association, Objects, Object Identity, Equality and Object Reference, Architecture of Object Oriented and Object Relational Databases Parallel and Distributed Databases: Distributed Data Storage-Fragmentation & Replication, Location and Fragment Transparency Distributed Query Processing and Optimization, Distributed Transaction Modeling and concurrency Control, Distributed Deadlock, Commit Protocols. Advanced Transaction Processing: Nested and Multilevel Transactions, Compensating Transactions, Weak Levels of Consistency, Transaction Work Flows and Transaction Processing Monitors. Active Database and Real Time Databases: Triggers in SQL, Multimedia Databases: Modeling and Storage of Image and Multimedia Data, Data Structures –R-tree, k-d tree, Quad trees, Content Based Retrieval, Geographic Information Systems (GIS) WEB Database: Accessing Databases through WEB, WEB Servers, XML Databases, Commercial Systems. Data Warehousing: Data Warehousing Architecture, Multidimensional Data Model, Update Propagation OLAP Queries. Data Mining: Knowledge Representation Using Rules, Association and Classification Rules, Sequential Patterns, Algorithms for Rule Discovery Case Study: Oracle Xi

Data warehouse – Difference between Operational DBs and Data warehouses – Multidimensional Data Model – Data warehouse Architecture – Data warehouse Implementation – OLAP Techniques Concepts & Disadvantages, Data Mining, Introduction Data Mining – Knowledge Discovery from Databases(KDD) Process – Data Processing for Data Mining – Data Cleaning, Integration, Transformation, Reduction – Data Mining Primitives – Data Mining Query Language.

Basics of Machine Learning and Artificial Intelligence - Introduction to the standard normal distribution and normal distribution, Introduction to business moments, Artificial Intelligence.

Recommended Books

- Elmasri, R., Navathe, S. B., Elmasri, R., & Navathe, S. B. (2000). Fundamentals of Database Systems. Addison-Wesley/publisher.
- Garcia-Molina, H. (2008). Database systems: the complete book. Pearson Education India.
- Ramakrishnan, R., Gehrke, J., & Gehrke, J. (2003). Database management systems (Vol. 3). New York: McGraw-Hill.
- Date, C. J. (1975). An introduction to database systems. Pearson Education India.
- Singh, S. K. (2009). Database systems: Concepts, design and applications. Pearson Education India.
- Silberschatz, A., Korth, H. F., & Sudarshan, S. (2002). Database system concepts (Vol. 5). New York: McGraw-Hill.
- Maier, D. (1983). The theory of relational databases (Vol. 11). Rockville: Computer science press.
- Ullman, J. D. (1983). Principles of database systems. Galgotia publications.

Course Code	Course Name	L-T-P	Credits
CS903	Cryptography & Network Security	4-0-0	4

Course Learning Outcomes (CLO):

- CLO1: Skilled to identify common network security vulnerabilities/attacks.
- CLO2: Explain the foundations of Cryptography and network security
- CLO3: Critically evaluate the risks and threats to networked computers.
- CLO4: Demonstrate detailed knowledge of the role of encryption to protect data. analyse security issues arising from the use of certain types of technologies.
- CLO5: Identify the appropriate procedures required to secure networks.

***The mapping of CO /PO attainment/Graduate Attributes are at Annexure-A**

Course Outline

Introduction to Security: Security Attacks – Types of attacks, Vulnerabilities. Access Control – Authentication and Authorization. Basics of Cryptography: Classical Encryption Techniques – Symmetric and Asymmetric cryptography. Substitution Techniques – Mono alphabetic ciphers, Polyalphabetic ciphers. Transposition Techniques: Block Ciphers and Stream Ciphers. Data Encryption Standard (DES), Strength of DES and Triple DES. AES, Overview of Block cipher modes of operation. Public-Key Cryptography: Principles of Public-Key Cryptosystems – The RSA Algorithm, Security of RSA. Key Management: Digital Certificates, PKI. Diffie-Hellman Key Exchange. Cryptographic Hash: Applications of cryptographic Hash Function, Properties of Hash Function. Hash Algorithms—MD5, Secure Hash Algorithm (SHA). MAC Algorithms—HMAC. Digital Signatures and authentication protocols – DSS – El Gamal. Web Security: Kerberos and Secure Socket Layer. Electronic Commerce Security: Electronic Payment System, Secure electronic transaction (SET), Ecash (Digi cash). Electronics mail security: PGP

PRIVACY (PGP), S/MIME. Intruders and Viruses: Networks intrusion detection system (NIDS) and its role in Perimeter defense, Intrusion prevention systems (IPS) and its limitations, Viruses.

Recommended Books

- Menezes, B. L. (2012). Network Security and Cryptography. Wadsworth Publishing Company Incorporated.
- Maier, D. (1983). The theory of relational databases (Vol. 11). Rockville: Computer science press.

Course Code	Course Name	L-T-P	Credits
CS906	Advanced Data Structures	3-0-0	3

Course Learning Outcomes (CLO):

- CLO1: Learn the various data structures used.
CLO2: Students are skilled to understand the data visualization.

***The mapping of CO /PO attainment/Graduate Attributes are at Annexure-A**

Course Outline

Introduction to Data Structures: Basic Terminology, Classification of data structures, operations on data structures, Abstract Data Types, Time and Space Complexity, Asymptotic Notations. Linear Data Structures: Array, Linked List, Stack and Queue. Trees: Introduction to trees, Binary Trees, Binary Search Trees, AVL Trees, Red-Black Trees, B Trees and B+ Trees. Heaps: Heaps, Binary Heaps, Binomial Heaps, Fibonacci Heaps, Comparison of Binary, Binomial, and Fibonacci Heaps, Applications of Heaps. Graphs: Graph Terminology, Directed Graphs, Bi-connected Components, Representation of Graphs, Graph Traversal Algorithms. Advance Topics in Data Structures: Introduction to Searching, Interpolation Search, Jump Search, Introduction to Sorting, Merge Sort, Quick Sort, Radix Sort, Heap Sort, Hashing and Collision, Memory Management in Data Structures.

Recommended Books:

- Lipschutz, S., & Lipson, M. L. (1986). Schaum's,“. Outline of Theory and Problems of Data Structures,” McGraw: Hill Book Company.
- Langsam, Y., Augenstein, M., & Tenenbaum, A. M. (1996). Data Structures using C and C++ (Vol. 2). New Jersey: Prentice Hall.
- Salaria, R. S. (2004). Data Structures & Algorithms Using C++. KHANNA PUBLISHING HOUSE.
- Thareja, R. (2011). Data structures using C. Oxford University Press, Inc..
- Horowitz, E., Sahni, S., & Anderson-Freed, S. (1976). Fundamentals of data structures (Vol. 20). Potomac, MD: Computer science press.
- Corman, T. H., Leiserson, C. E., Rivet, R. L., & Stein, C. (2009). Introduction to Algorithms, 3rd-edition. Google Scholar Google Scholar Digital Library Digital Library.

Course Code	Course Name	L-T-P	Credits
CS907	Advanced Data Structures Lab	0-0-2	1

Course Learning Outcomes (CLO):

- CLO1: Learn the installation of software.
CLO2: Skilled to write loops, functions and pass arguments.

***The mapping of CO /PO attainment/Graduate Attributes are at Annexure-A**

Course Outline

Array, Array Traversing, Array Insertion, Array Deletion, Linked List Implementation, Creation, Insertion, Deletion and Traversal, Stack, Insertion and Deletion in stack using array, Insertion and Deletion in stack using linked list, Queue, Insertion and Deletion in queue using array, Insertion and Deletion in queue using linked list, Polish Notations, Infix to postfix, Infix to prefix, Evaluation of postfix, Sorting and Searching in an Array, Insertion Sort, Selection Sort, Linear Search, Binary Search, Multiple Stack Implementation, Multiple Queue Implementation, An Invigilator was giving duty in an examination hall and the roll no list was fixed and students are sitting. Suddenly, one student came in the class by 10 minutes late and invigilator has to allow to sit the student according to his roll no. All the students are giving exam, one student started cheating and invigilator taken his sheet and tell him to leave the class. Implement the problem. Manager of an organization wants to search the data of an employee from the database who take maximum leaves. In order to deduct the salary of that employee, manager searched the data according to the employee id from the list and get the data of that employee. Predict the output.

Recommended Books:

- Lipschutz, S., & Lipson, M. L. (1986). Schaum's,“. Outline of Theory and Problems of Data Structures,” McGraw: Hill Book Company.
- Langsam, Y., Augenstein, M., & Tenenbaum, A. M. (1996). Data Structures using C and C++ (Vol. 2). New Jersey: Prentice Hall.
- Salaria, R. S. (2004). Data Structures & Algorithms Using C++. KHANNA PUBLISHING HOUSE.
- Thareja, R. (2011). Data structures using C. Oxford University Press, Inc..
- Horowitz, E., Sahni, S., & Anderson-Freed, S. (1976). Fundamentals of data structures (Vol. 20). Potomac, MD: Computer science press.
- Corman, T. H., Leiserson, C. E., Rivet, R. L., & Stein, C. (2009). Introduction to Algorithms, 3rd-edition. Google Scholar Google Scholar Digital Library Digital Library.

Semester II

Course Code	Course Name	L-T-P	Credits
CS921	Advanced Computer Networks	3-0-0	3

Course Learning Outcomes (CLO):

- CLO1: Understand the main abstract concepts related to the layered communication architecture
- CLO2: Analyze and implement some of the most advanced routing and congestion control algorithms. Evaluate the performances of computer networks (through mathematical modeling and simulation).
- CLO3: Understand basics and principles of new generation of computer networking infrastructure (VoIP, SIP, RTP).
- CLO4: Practice Networking Simulating skills as employed in Industry for Planning and Design (CISCO Packet Tracer).

***The mapping of CO /PO attainment/Graduate Attributes are at Annexure-A**

Course Outline

Reference Models Introduction, Seven-Layer ISO-OSI architecture of networking, Concepts of Layer Protocols and Layer interface, TCP model with TCP/IP protocol stack, Comparison of ISO-OSI and TCP models, Topologies, mode of transfer, Guided Transmission Media, Wireless Transmission, Ethernet cabling standards (Cat-1, Cat-2, Cat-3, Cat-4, Cat-5, Cat-5e, Cat-6a), T-568A Straight-Through Ethernet Cable, T-568B Straight-Through Ethernet Cable.

Error- Detection and Error-Correction numerical techniques (CRC, Hamming Code, Parity Bit, checksum), Elementary data link protocols -simplest, stop-and-wait protocol, sliding window protocols- 1-bit sliding window protocol, go back-n, selective repeat. Channel allocation, Multiple access protocols: random access (Aloha, Pure Aloha, slotted Aloha).IP protocol (IPv4 and IPv6), IP addresses (Classful and Classless), CIDR, Subnets, Supernetting VLSM, Routing algorithms (Static and Dynamic): Basic commands of Routers: hostname, password, Show Run, Show IP int brief, Assigning IP addresses to interfaces, Configuration of Static Routing, Configuration of Dynamic Routing: RIP V1 and RIP V2, Design and configuration of OSPF (Open Shortest Path First) in single area. Design and configuration of EIGRP Routing. WWW(world wide web), DNS(Domain Name System)- generic domain, country domain, inverse domain, SNMP(Simple Network Management Protocol), Cryptography-(Cryptographic Techniques, Computer-based Symmetric and Asymmetric Key Cryptographic Algorithms, Public Key Infrastructure (PKI), Internet Security Protocols, Network Security.), Firewalls, Digital Signature, Design and configuration of ACL: Standard and Extended, Design and Configuration of NAT (Network Address Translation): Static, Dynamic, PAT, Design and configuration of VPN Virtual private networks, Switching configuration concepts, Design and configuration of VLAN (Virtual Local Area Networks).

Recommended Books:

- Forouzan, A. B. (2007). Data communications & networking (sie). Tata McGraw-Hill Education.
- Stallings, W. (2007). Data and computer communications. Pearson Education India.

Course Code	Course Name	L-T-P	Credits
CS922	Advanced Computer Networks lab	0-0-2	1

Course Learning Outcomes (CLO):

- CLO1: To understand the captured data by using the relevant tools and focus on the involvement of layered approach in data transmission.
- CLO2: To enhance the analytical skills of the students to understand and simulate the working of TCP/IP reference model.

***The mapping of CO /PO attainment/Graduate Attributes are at Annexure-A**

Course Outline

Introduction of Cables, Network Devices: Hub, Switches, Router.

To design and perform IP addressing in network.

To design and implement peer to peer connectivity and share resources.

To design and implement a computer network demonstrating Star Topology.

Basic commands of Routers: hostname, password, Show Run, Show IP int brief, Assigning IP addresses to interfaces.

To design and simulate Static Routing.

To design and simulate Dynamic Routing: RIP V1 and RIP V2.

To design and simulate routing with OSPF (Open Shortest Path First) in single area.

To design and simulate EIGRP Routing.

To create and implement ACL: Standard and Extended.

To design and implement NAT (Network Address Translation): Static, Dynamic, PAT.

Recommended Books:

- CCNA Study Guide by Sybex Publication
- CCNA Preparation Guide by Cisco Press

Course Code	Course Name	L-T-P	Credits
RS991	Intellectual Property Rights and Publishing Research (I)	1-0-0	1

Course Learning Outcomes (CLO):

- CLO1: Understand the basics and need of IPRs.
- CLO2: Fill the invention disclosure form for patenting of an idea.
- CLO3: Conduct the prior art to decide the patentability of the idea.
- CLO4: Skilled to draft provisional/complete specifications of the patent application.
- CLO5: Understand the challenges of the country in cause of promoting high quality research.
- CLO6: Better appreciate the meaning of some basic terminologies related to general parameters used for gauging the research outcome.
- CLO7: Use the Nature Master Class solution to their advantage, which will further help

them in writing better quality research papers.

***The mapping of CO /PO attainment/Graduate Attributes are at Annexure-A**

Course Outline

Introduction - Intellectual Property, Intellectual Property Rights, Categories of Intellectual Property, Rights protected under Intellectual Property, IPR as Instruments of Development, History of IPR in India, History of Copyright Law in India, History of Patent Law in India, History of Trademark Law in India Overview of Laws related to Intellectual Property Rights in India. Copyright – Introduction of Copyright, Copyright law in India Classes of works for which copyright protection is available, Ownership of Copyright, Assignment of copyright, Transmission of copyright by testamentary disposition, Relinquish copyright, Term of copyright, Rights of Broadcasting Organization and of Performers, Intellectual Property Rights (IPR) of Computer Software, Procedure of registration under copyright in India. Patent - Introduction to Patent, meaning of ‘Invention’ under Patent Law, What is not an ‘Invention’? Patent system in India: what can be patented and what cannot be patented, Hierarchy of officers and jurisdiction of patent offices. Different types of patent applications, Precautions while patenting, Publication and Examination, Granting of patent, term and date of patent, Renewal and restoration, Rights of a Patentee, Compulsory license under Paris convention, Compulsory license under TRIPS, Patent Agent - Eligibility and criteria, Patent Infringement & penalties, E-filing of a patent in India. Trademark-What is Trademark? Features types and functions of a trademark, Trademarks law of India, Who can apply for a trademark, How to file a trademark application for registration, Procedure for series registration and collective marks, Renewal of trademark, Offences and Penalties, Procedure of e-filing. Designs - What is Design, Design law in India, Need for Registration of design, Exclusion from scope of design, Requirement for registration of Design, Who can apply, Procedure for submission of application of registration, Cancellation, Piracy, Administration. Geographical Indications of Goods: What is a Geographical Indication? Laws relating to Geographical Indication of Goods Registration of Geographical Indication, Procedure for Filing application for registration of Geographical Indication, Infringement of Geographical Indication. Semiconductor Integrated Circuits Design: Semiconductor Integrated Circuits Layout-Design (SICLD) Act, 2000Criteria for registration of Chip Layout Design, Duration, Person entitled to protection of Layout-Designs, Steps for registration of a layout-design, Documents to be submitted along with application, Prohibition from registration, Penalties. Biological Diversity Biodiversity Act, 2002, Access to Biological Diversity, Exclusion under Biological Diversity Act, Penalty, National Biodiversity Authority. Protection of Plant Varieties and Farmer Rights Protection of Plant Varieties and Farmers' Right Act, 2001, Duration of protection of a registered plant variety, Registration of Plants, Application for registration, Criteria for registration of new variety, Prerequisites for filing an application form for registration of plant variety, Guidelines for submission of applications for Registration of Plant Varieties, Plant Authority (PPV&FR Authority). Undisclosed information- Introduction to Undisclosed Information. The agreement of trade related aspects of intellectual property rights (TRIPS). World intellectual property organization (WIPO) mission of WIPO, core tasks of WIPO, how WIPO works, WIPO goals. Intellectual property treaties - Paris convention for the protection of industrial property, Berne convention for the protection of literary and artistic works, the patent cooperation treaty (PCT), patent law treaty (PLT). Commercialization of intellectual property rights - commercialization of intellectual property rights by licensing, valuation of IPR, concept of IP valuation, methods of valuation.

Recommended Books:

- Ramakrishna, B., & HS, A. K. (2017). Fundamentals of intellectual property rights: for students, industrialist and patent lawyers. Notion Press.
- Prasad, B. (1996). Concurrent engineering fundamentals (Vol. 1). NJ: Prentice Hall PTR.
- Kompal Bansal and Parikshit Bansal, “Fundamentals of IPR for Engineers”, B.S. Publications.
- Cyber Law. Texts & Cases, South-Western’s Special Topics Collections
- Prabhuddha Ganguly, “Intellectual Property Rights”, Tata Mc Graw Hill, New Delhi
- Irish, V. (2005). Intellectual property rights for engineers (Vol. 22). IET.
- www.ipindia.nic.in - Intellectual Property Office, India
- www.patentoffice.nic.in – Patent office, India
- http://copyright.gov.in/ - Copyright Office, India
- ipr.icegate.gov.in – Automated Recordation & Targeting for IPR Protection
- www.icegate.gov.in-E- Commerce portal of Central Board of Excise and Customs
- www.ipab.tn.nic.in- Intellectual Property Appellate Board, India

Course Code	Course Name	L-T-P	Credits
EC909	Digital Image Processing	3-0-0	3

Course Learning Outcomes (CLO):

- CLO1: Understand fundamental steps of digital image processing.
- CLO2: Examine various types of images, intensity transformations and spatial filtering.
- CLO3: Understand, implement and compare various image enhancement techniques.
- CLO4: Skilled to implement and compare various image compression techniques.
- CLO5: Apply image processing algorithms in practical applications.

***The mapping of CO /PO attainment/Graduate Attributes are at Annexure-A**

Course Outline

Fundamentals of Image Processing: What is Digital Image Processing? Fundamental steps in Digital Image Processing, Application fields and Components of an image processing system. Digital Image Fundamentals: Elements of Visual Perception, Simple image formation model, Image Sampling and Quantization, Basic relationship between pixels, Linear and Non-Linear operations. Image Enhancement: Basic Gray level transformations, Histogram processing, Enhancement using Image subtraction and averaging. Basics of spatial and frequency domain filtering, Smoothing and sharpening filters. Homomorphic Filtering. Image Restoration: A Model of Image Degradation / restoration process. Algebraic approach to restoration: Inverse filtering, Minimum Mean Square Error (Wiener) Filtering. Image Restoration: A Model of Image Degradation / restoration process. Algebraic approach to restoration: Inverse filtering, Minimum Mean Square Error (Wiener) Filtering. Image Segmentation: Detection of Discontinuities, Point, Line and Edge detection, Edge linking and Boundary Detection, Thresholding, Region Based segmentation.: Basic geometric transformations: Introduction to Fourier Transform and DFT, FFT, Walsh-Hadamard Transform, Discrete Cosine Transform. Color Image Processing: Fundamentals, Color Models, Pseudo color Image Processing. Basics of full color image processing, Color

Transformations, Smoothing and Sharpening. Image Compression: Fundamentals, Lossless compression: Variable length coding, LZW coding, Bit plane coding, Lossless predictive coding, Lossy compression: Lossy Predictive Coding, Transform coding, Wavelet coding, Image & Video compression standards. Case Study: Morphological Image Processing: Dilation, erosion, Opening & Closing, Basic Morphological Algorithms.

Recommended Books:

- Gonzalez, R. C. (2009). Digital image processing. Pearson education India.
- Castleman, K. R. (1996). Digital image processing. Prentice Hall Press.
- Jain, A. K. (1989). Fundamentals of digital image processing. Prentice-Hall, Inc..
- Niblack, W. (1985). An introduction to digital image processing. Strandberg Publishing Company.

Course Code	Course Name	L-T-P	Credits
EC910	Digital Image Processing Lab	0-0-2	1

Course Learning Outcomes (CLO):

CLO1: Skilled to understand the installation of software.

CLO2: Practice the codes on software to gain better knowledge.

***The mapping of CO /PO attainment/Graduate Attributes are at Annexure-A**

Course Outline

To study fundamentals of image processing and write Programme to read and display different types of digital images.

To perform basic geometric transformations (2-D DFT, FFT etc.) on Digital Images.

To write Programme for zooming and shrinking of digital images and compare Nearest Neighbour interpolation, Bilinear interpolation and Bicubic interpolation methods of zooming.

To Perform enhancement in spatial domain on digital images and write programs for gray-level transformations, histogram processing and image averaging and subtraction.

To Perform Spatial Domain Enhancement using Filtration of digital images.

To Perform Frequency Domain Enhancement using Filtration of digital images.

To study and perform Image Restoration using Wiener Filters.

(i)To Perform erosion and dilation operation on the image

(ii)Use Morphological Closing to Fill Gaps in an Image and Morphologically Open Imagewith Disk-shaped Structuring Element

To perform detection of discontinuities: point, line and edges in a given image and study image Segmentation.

Recommended Books::

- Gonzalez, R. C. (2009). Digital image processing. Pearson education India.
- Castleman, K. R. (1996). Digital image processing. Prentice Hall Press.
- Jain, A. K. (1989). Fundamentals of digital image processing. Prentice-Hall, Inc.

- Niblack, W. (1985). An introduction to digital image processing. Strandberg Publishing Company.

Semester III

Course Code	Course Name	L-T-P	Credits
CS913	Advanced Operating Systems	4-0-0	4

Course Learning Outcomes (CLO):

- CLO1: Create Cloud and Docker using multiple operating systems simultaneously.
- CLO2: Detailed case study on Linux family.
- CLO3: Live experiments on concurrency, threads and deadlocks makes the students skilled.
- CLO4: To create your own operating system.

***The mapping of CO /PO attainment/Graduate Attributes are at Annexure-A**

Course Outline

Architecture, Goals & Structures of O.S, Basic functions, Interaction of O. S. & hardware architecture, System calls, Batch, multiprogramming. Multitasking, time sharing, parallel, distributed & real-time O.S. **Process Management** Process Concept, Process states, Process control, Threads, Uni-processor Scheduling: Types of scheduling: Pre-emptive, Non pre-emptive, Scheduling algorithms: FCFS, SJF, RR, Priority, Thread Scheduling, Real Time Scheduling. System calls like ps, fork, join, exec family, wait. **Concurrency control Concurrency:** Principles of Concurrency, Mutual Exclusion: S/W approaches, H/W Support, Semaphores, pipes, Message Passing, signals, Monitors, Classical Problems of **Synchronization:** Readers-Writers, Producer Consumer, and Dining Philosopher problem. **Deadlock:** Principles of deadlock, Deadlock Prevention, Deadlock Avoidance, Deadlock Detection, System calls like signal, kill. **Memory Management** Memory Management requirements, Memory partitioning: Fixed and Variable Partitioning, Memory Allocation: Allocation Strategies (First Fit, Best Fit, and Worst Fit), Fragmentation, Swapping, and Paging. Segmentation, paging **Virtual Memory:** Concepts, management of VM, Page Replacement Policies (FIFO, LRU, Optimal, Other Strategies), Thrashing. **I/O management & Disk scheduling:** I/O Devices, Organization of I/O functions, Operating System Design issues, I/O Buffering, Disk Scheduling (FCFS, SCAN, C-SCAN, SSTF), RAID, Disk Cache. **Inter Process Communication** Basic Concepts of Concurrency, Co-operating process, Advantage of Cooperating process, Bounded- Buffer -Shared-Memory Solution, Inter-process Communication (IPC), Basic Concepts of Inter-Process Communication and Synchronization. **Multi-Processor Based and Virtualization Concepts** Virtual machines; supporting multiple operating systems simultaneously on a single hardware platform; running one operating system on top of another. Reducing the software engineering effort of developing operating systems for new hardware architectures. True or pure virtualization. Para virtualization; optimizing performance of virtualization system; hypervisor call interface. **Advanced Operating System** Basics of Network Operating System, Server Operating System and Real Time Operating System.

Recommended Books:

- Silberschatz, A., Galvin, P. B., & Gagne, G. (2006). Operating system concepts. John

- Wiley & Sons.
- Stallings, W. (2006). Operating Systems 5th Edition. Pearson Education India.

Course Code	Course Name	L-T-P	Credits
CSL4635	Advanced Database Management Systems	4-0-0	4

Course Learning Outcomes:

Students will be able to:

- CLO.1: Understand and gain skills functionality of the various database systems.
- CLO.2: Practice the codes and study about the case studies.

Course Outline

Relational Databases: Integrity Constraints revisited, Extended ER diagram, Relational Algebra & Calculus, Functional, Multivalued and Join Dependency, Normal Forms, Rules about functional dependencies. Query Processing and Optimization: Valuation of Relational Operations, Transformation of Relational Expressions, Indexing and Query Optimization, Limitations of Relational Data Model.

Objected Oriented and Object Relational Databases: Modeling Complex Data Semantics, Specialization, Generalization, Aggregation and Association, Objects, Object Identity, Equality and Object Reference, Architecture of Object Oriented and Object Relational Databases Parallel and Distributed Databases: Distributed Data Storage-Fragmentation & Replication, Location and Fragment Transparency Distributed Query Processing and Optimization, Distributed Transaction Modeling and concurrency Control, Distributed Deadlock, Commit Protocols.

Advanced Transaction Processing: Nested and Multilevel Transactions, Compensating Transactions, Weak Levels of Consistency, Transaction Work Flows and Transaction Processing Monitors. Active Database and Real Time Databases: Triggers in SQL, Multimedia Databases: Modeling and Storage of Image and Multimedia Data, Data Structures –R-tree, k-d tree, Quad trees, Content Based Retrieval, Geographic Information Systems (GIS)

WEB Database: Accessing Databases through WEB, WEB Servers, XML Databases, Commercial Systems. Data Warehousing: Data Warehousing Architecture, Multidimensional Data Model, Update Propagation OLAP Queries. Data Mining: Knowledge Representation Using Rules, Association and Classification Rules, Sequential Patterns, Algorithms for Rule Discovery Case Study: Oracle Xi

Recommended Book(s):

- Elmars, Navathe, Somayajulu, Gupta, “Fundamentals of Database Systems”, 4th Edition, Pearson Education, 2007
- Garcia, Ullman, Widom, “Database Systems, The complete book”, Pearson Education, 2007
- R. Ramakrishnan, “Database Management Systems”, McGraw Hill International Editions, 1998
- Date, Kannan, Swaminathan, “An Introduction to Database Systems”, 8th Edition Pearson Education, 2007
- Singh S.K., “Database System Concepts, design and application”, Pearson Education, 2006.
- Silberschatz, Korth, Sudarshan, “Database System Concepts”, McGraw Hill, 6th Edition, 2006
- D. Maier, “The Theory of Relational Databases”, 1993, Computer Science Press, Rockville, Maryland
- Ullman, J. D., “Principals of database systems”, Galgotia publications, 1999
- Oracle Xi Reference Manual

Course Code	Course Name	L-T-P	Credits
RS992	Intellectual Property Rights and Publishing Research (II)	1-0-0	1

Course Learning Outcomes (CLO):

- CLO1: To make them skilled to understand the need of involving himself in cause of research.
- CLO2: To understand different aspects involved in a research article which make that a great paper.
- CLO3: To prepare a good summary of the literature survey carried out before starting to write a research paper himself.
- CLO4: To full-fledged research paper which can submitted to flagship journals and conferences.

***The mapping of CO /PO attainment/Graduate Attributes are at Annexure-A**

Course Outline

How to file a patent, Academic integrity policy of UGC. Plagiarism/ similarity index and other ethical issues| Different tools and norms. 7 minutes presentation by students in groups on a particular research problem existing in research area of interest. Patent filing process in India, PCT filing process. Research paper improvisation and primitive evaluation.

Recommended Books:

- Adukia, R. S. (2012). Handbook on Intellectual Property Rights in India.
- Resources available on Nature Master Class website. www.masterclasses.nature.com

- Cyber Law. Texts & Cases, South-Western's Special Topics Collections Prabhuddha Ganguly, "Intellectual Property Rights", Tata Mc Graw Hill, New Delhi

Course Code	Course Name	L-T-P	Credits
RS993	Research Methodology	3-0-0	3

Course Learning Outcomes (CLO):

CLO1: Start a carrier in research.

CLO2: Make them skilled and help in deciding about various tools and techniques which will help them in research for analysis, ethics, presentation and writing of research.

***The mapping of CO /PO attainment/Graduate Attributes are at Annexure-A**

Course Outline

Research: Meaning – Purpose- Types of research-significance of research. Collection of Data: Concept of Sample, Sample Size and Sampling Procedure, Various Types of Sampling Techniques. Determination and Selection of Sample Member, Types of Data- Secondary and Primary, Various Methods of Collection and Data, Preparation of Questionnaire and Schedule, Types of Questions, Sequencing of Questions, Check Questions, Length of Questionnaire, Precautions in Preparation of Questionnaire and Collection of Data. Analysis of Data-Coding, Editing and Tabulation of Data, Various Kinds of Charts and Diagrams Used in Data Analysis: Bar and Pie Diagrams and their Significance, Use of SPSS in Data Analysis, Application and Analysis of Variance (ANOVA). Measurement and Central Tendency, Measure of Dispersion and their Advantages. Report Preparation-Types and Layout of Research Report, Precautions in Preparing the Research Report. Bibliography and Annexure in the Report-Their Significance, Drawing Conclusions, Suggestions and Recommendations to the Concerned Persons. SPSS tool.

Recommended Books:

- Panneerselvam, R. (2014). Research methodology. PHI Learning Pvt. Ltd..
- Kothari, C. R. (2004). Research methodology: Methods and techniques. New Age International.

Semester IV

Course Code	Course Name	L-T-P	Credits
CS904	Machine Learning	3-0-0	3

Course Learning Outcomes (CLO):

CLO1: After Completing this course, the students will be skilled to analyze the data, identify the problems.

CLO2: The students will able to choose the relevant models and algorithms to turn available data into valuable and useful information.

CLO3: The students will able to apply different machine learning problems

CLO4: The students will be able to evaluate the performance of models.

CLO5: Expose students to new techniques and ideas that can be used to improve the effectiveness of current BI tools.

***The mapping of CO /PO attainment/Graduate Attributes are at Annexure-A**

Course Outline

Introduction: Mathematical Preliminaries: Eigen Value and Eigen Vectors, Probability and Bayes Theorem, Distributions of Data. Normalization Data acquisition, pre-processing, feature extraction and processing, feature ranking/selection, feature reduction, model learning, evaluation, deployment. Matrix algebra. **Supervised Learning:** Decision trees, Inductive bias, Classification, Regression, Perceptron, Tree learning algorithms. **Unsupervised learning:** Clustering, K-means algorithm, Univariate linear modeling function, Cost function and its minimization, Logistic regression, Softmax regression. **Neural Networks:** Artificial neurons, Gradients and back propagation, Gradient decent, Convolution neural networks: continuous convolution, discrete convolution, pooling. Recurrent neural networks. Deep neural networks. **Advanced topics:** Development of an application of machine learning; for example, Optical Character Recognition, Email spam identification, etc.

Recommended Books:

- Burkov, A. (2019). The hundred-page machine learning book (Vol. 1, p. 32). Quebec City, QC, Canada: Andriy Burkov.
- Bonaccorso, G. (2017). Machine learning algorithms. Packt Publishing Ltd.
- Bishop, C. M., & Nasrabadi, N. M. (2006). Pattern recognition and machine learning (Vol. 4, No. 4, p. 738). New York: springer.

Course Code	Course Name	L-T-P	Credits
CS905	Machine Learning Lab	0-0-2	1

Course Learning Outcomes (CLO):

- CLO1: Recognize the characteristics of machine learning that make it useful to real-world problems.
- CLO2: Characterize machine learning algorithms as supervised, semi-supervised, and unsupervised.
- CLO3: Effectively use of skills in different machine learning toolboxes.
- CLO4: Implement machine learning solutions to classification, regression, and clustering problems.
- CLO5: Understand how to perform evaluation of learning algorithms and model selection.

***The mapping of CO /PO attainment/Graduate Attributes are at Annexure-A**

Course Outline

- a) Introduction and Installation to python and OpenCV.
 - b) Familiarization with different editors/environments.
- Loading of dataset and their feature extraction. For example, corner extraction using “Harris corner detection”.
- Introduction and implementation of linear regression on random data.
- Introduction and implementation of logistic regression on random data.
- Decision tree is a technique of supervised learning. Implement this algorithm using python-OpenCV.

Introduction and implementation of KNN on random data.

Write the python code to classify data to plot each data item as a point in n-dimensional space (where n is number of features you have) with the value of each feature being the value of a particular coordinate. (Support vector machine (SVM))

According to the data given below write the python code for the statement “*Players will pay if weather is sunny, is this statement is correct?*”. Use Naïve Byes classification method to solve the problem.

Weather	Play
Sunny	No
Overcast	Yes
Rainy	Yes
Sunny	Yes
Sunny	Yes
Overcast	Yes
Rainy	No
Rainy	No
Sunny	Yes
Rainy	Yes
Sunny	No
Overcast	Yes
Overcast	Yes
Rainy	No

An unsupervised procedure that follows a simple and easy way to classify a given data set through a certain number of clusters (assume k clusters). Data points inside a cluster are homogeneous and heterogeneous to peer groups. Struct a python code for above mentioned classifying technique.

Recommended Books:

- Mitchell, T. M. (2006). The discipline of machine learning (Vol. 9). Pittsburgh: Carnegie Mellon University, School of Computer Science, Machine Learning Department.
- Hart, P. E., Stork, D. G., & Duda, R. O. (2000). Pattern classification. Hoboken: Wiley.
- Jajuga, K., Sokolowski, A., & Bock, H. H. (Eds.). (2012). Classification, clustering, and data analysis: recent advances and applications.
- Duda, R. O., & Hart, P. E. (2006). Pattern classification. John Wiley & Sons.

Course Code	Course Name	L-T-P	Credits
CS 951	Programming in C#	4-0-0	4

Course Learning Outcomes (CLO):

- CLO.1 Implement the concept of object-oriented techniques and methodologies using c#
- CLO.2 Use Exception Handling concepts and skills for a Robust Application in c#.
- CLO.3 Demonstrate an understanding of c# Input and Output

CLO.4 Develop applications using multithreading concept of c#.

Course Outline

Understanding .NET: The C# Environment: The .Net Strategy, The Origins of .NET Technology, The .NET Framework, The Common Language Runtime, Framework Base Classes, User and Program Interfaces, Visual Studio .NET, .NET Languages, Benefits of the .NET Approach, C# and the .NET

Overview of C#: What is C#, Why C#, Evolution and Characteristics of C#, Applications of C#, How does C# Differ from C++ and Java, Introduction to C# Program, Namespaces, Adding Comments, Main Returning a Value, Using Aliases for Namespace Classes, Passing String Objects to Write Line Method, Command Line Arguments, Main with a Class, Providing Interactive Input, Using Mathematical Functions, Multiple Main Methods, Compile Time Errors, Program Structure, Program Coding Style

Literals, Variables and Data Types: Introduction to Literals, Variables, Data Types, Value Types, Reference Types, Declaration of Variables, Initialization of Variables , Default Values, Constant Variables, Scope of Variables, Boxing and Unboxing

Operators and Expressions: Arithmetic Operators, Relational Operators, Logical Operators, Assignment Operators, Increment and Decrement Operators, Conditional Operator, Bitwise Operators, Special Operators, Arithmetic Expressions, Evaluation of Expressions, Precedence of Arithmetic Operators, Type Conversions, Operator Precedence and Associativity, Mathematical Functions

Decision Making and Branching: Decision Making with if Statement , Simple if Statement , The if... else Statement , Nesting of if...else Statements , The else if Ladder , The Switch Statement , The ? : Operator , The while Statement ,The do Statement , The for Statement , The for each Statement , Jumps in Loops

Methods in C#: Declaring Methods , The Main Method , Invoking Methods, Nesting of Methods, Method Parameters , Pass by Value, Pass by Reference, The Output Parameters, Variable Argument Lists, Methods Overloading

Handling Arrays and Manipulating Strings: One-Dimensional Arrays , Creating an Array , Two-Dimensional Arrays , Variable-Size Arrays , The System. Array Class ,Array List Class, Creating Strings , String Methods , Inserting Strings , Comparing Strings , Finding Substrings , Mutable Strings , Arrays of Strings , Regular Expressions

Structures and Enumerations: Structures,Structs with Methods, Nested Structs, Differences between Classes and Structs, Enumerations, Enumerator Initialization , Enumerator Base Types , Enumerator Type Conversion

Classes and Objects: Basic Principles of OOP , Defining a Class , Adding Variables , Adding Methods , Member Access Modifiers , Creating Objects , Accessing Class Members , Constructors , Overloaded Constructors , Static Members , Static Constructors , Private Constructors , Copy Constructors , Destructors , Member Initialization , The this Reference , Nesting of Classes , Constant Members , Read-only Members , Properties , Indexers

Inheritance and Polymorphism

Classical Inheritance , Containment Inheritance , Defining a Subclass , Visibility Control , Defining Subclass Constructors , Multilevel Inheritance , Hierarchical Inheritance ,Overriding Methods , Hiding Methods , Abstract Classes , Abstract Methods, Sealed Classes: Preventing Inheritance , Sealed Methods , Polymorphism

Interfaces: Multiple Inheritance and Operator Overloading: Defining an Interface , Extending an Interface , Implementing Interfaces , Interfaces and Inheritance , Explicit Interface Implementation, Abstract Class and Interfaces, Overloadable Operators, Need for Operator Overloading, Defining Operator Overloading , Overloading Unary Operators ,Overloading Binary Operators , Overloading Comparison Operators

Delegates and Managing Console I/O Operations: Delegates , Delegate Declaration , Delegate Methods , Delegate Instantiation , Delegate Invocation , Using Delegates , Multicast Delegates , Events, The Console Class, Console Input, Console Output, Formatted Output, Numeric Formatting, Standard Numeric Format, Custom Numeric Format

Windows and Web-based Application Development on .NET: Understanding Microsoft Visual Studio, Creating and Running a Sample WinApp Windows Application, Creating and Running a SampleWinApp2 Windows Application, Web-based Application on .NET

Recommended Books:

- Liberty, J. (2003). Programming C. " O'Reilly Media, Inc."
- Nakov, S., & Kolev, V. (2013). Fundamentals of Computer Programming with C#: The Bulgarian C# Book. Faber Publishing.

Course Code	Course Name	L-T-P	Credits
CS 952	Programming in Python	4-0-0	4

Course Learning Outcomes (CLO):

- CLO.1 Run basic python programs.
- CLO.2 Use python skills in various fields of Data Science, Machine Learning and Artificial Intelligence.
- CLO.3 Logic building using looping and decision statements.
- CLO.4 Develop problem solving abilities using Python.
- CLO.5 Learn building packages and modules for reusability.
- CLO.6 Learn GUI development using Widgets in Python.

Course Outline

Introduction: Variables, expressions, and statements: Values and types, Variables, Variable names and keywords, Statements, Operators and operands, Expressions. Order of operations, Expressions, Order of operations, Modulus operator, String operations, Asking the user for input, Comments, Choosing mnemonic variable names.

Conditional execution: Boolean expressions, Logical operators, Conditional execution, Alternative execution, Chained conditionals, Nested conditionals, catching exceptions using try and except, Short-circuit evaluation of logical expressions.

Functions: Function calls, Built-in functions, Type conversion functions, Random numbers, Math functions, Adding new functions, Definitions and uses, Flow of execution, Parameters and arguments. Flow of execution, Parameters and arguments.

Iteration: Updating variables, while statement, Infinite loops, “Infinite loops” and break, Finishing iterations with continue, Definite loops using for, Loop patterns.

Strings: Introduction, Getting the length of a string using len, Traversal through a string with a loop, String slices, Strings are immutable, Looping and counting, The in operator, String comparison, string methods, Parsing strings, Format operator.

Files: Persistence, Opening files, Text files and lines, Reading files Searching through a file, Using try, except, and open, Writing files.

Lists, tuples and dictionaries: list operators, replacing, inserting, removing an element searching and sorting lists; dictionary literals, adding and removing keys, accessing and replacing values; traversing dictionaries.

Classes and OOP: classes, objects, attributes and methods; defining classes; design with classes, data modeling; persistent storage of objects, inheritance, polymorphism, operator overloading (`_eq_`, `_str_`, etc); abstract classes; exception handling, try block.

Recommended Books

- Guzdial, M. J., & Ericson, B. (2015). Introduction to computing and programming in python. Pearson.
- Langtangen, H. P. (2014). A primer on scientific programming with Python (Vol. 6). Springer.
- Ceder, N. (2018). The quick Python book. Simon and Schuster.

Course Code	Course Name	L-T-P	Credits
CS 953	Programming in R	4-0-0	4

Course Learning Outcomes (CLO):

CLO.1 Use R skills in various fields of Data Science, Machine Learning and Artificial Intelligence.

CLO.2 Logic building using looping and decision statements.

CLO.3 Develop problem solving abilities using R

CLO.4 Learn building packages and modules for reusability.

CLO.5 Learn GUI development using Widgets in R.

Course Outline

Basic R features; introduction to the main data types and visualization, More on vectors and other data types

Introduction to functions. More on lists and data frames, Programming structures: relational and logical operations; flow control, Environment and scope, more on data frames

Math and simulations in R, Debugging, introduction to strings and regular expressions
Introduction to graphics, the Grammar of Graphics, Data shaping and transformation; split-transform-recombine, Reshaping and tidying data, exploring large data sets
Dates and times, statistical models in R, Overview of main domain-specific libraries, TBA
Project using R.

Recommended Books:

- Bolker, B. M. (2008). Ecological models and data in R. In Ecological Models and Data in R. Princeton University Press.
- Peter, D. (2008). Introductory statistics with R.
- Hothorn, T., & Everitt, B. S. (2006). A handbook of statistical analyses using R. Chapman and Hall/CRC.
- Maindonald, J., & Braun, J. (2007). Data Analysis and Graphics Using R./Cambridge University Pres. 2nd edition.

Course Code	Course Name	L-T-P	Credits
CS 954	Advanced Programming in Java	4-0-0	4

Course Learning Outcomes (CLO):

- CLO.1 Use the syntax and semantics of java programming language and basic concepts of OOP.
CLO.2 Develop reusable programs using the concepts of inheritance, polymorphism, interfaces and packages.
CLO.3 Apply the concepts and will be skilled to use Multithreading and Exception handling to develop efficient and error free codes.
CLO.4 Design event driven GUI and web related applications which mimic the real word scenarios.

Course Outline

UNIT I

Introduction: Introduction to java, java buzzword, data types, dynamic initialization, scope and life time, operators, control statements, arrays, type conversion and casting, finals & blank finals. Classes and Objects: Concepts, methods, constructors, usage of static, access control, this key word, garbage collection, overloading, parameter passing mechanisms, nested classes and inner classes. Inheritance: Basic concepts, access specifiers, usage of super key word, method overriding, final methods and classes, abstract classes, dynamic method dispatch, Object class.

UNIT II

Interfaces: Differences between classes and interfaces, defining an interface, implementing interface, variables in interface and extending interfaces. Packages: Creating a Package, setting CLASSPATH, Access control protection, importing packages. Exception Handling: Concepts of Exception handling, types of exceptions, usage of try, catch, throw, throws and finally keywords, Built-in exceptions, creating own exception sub classes.

UNIT III

Periods Strings: Exploring the String class, String buffer class, Command-line arguments. Library: Date class, Wrapper classes. Multithreading: Concepts of Multithreading, differences between process and thread, thread life cycle, Thread class, Runnable interface, creating multiple threads, Synchronization, thread priorities, inter thread communication, daemon threads, deadlocks. I/O Streams: Streams, Byte streams, Character streams, File class, File streams.

UNIT IV

Applets: Concepts of Applets, life cycle of an applet, creating applets, passing parameters to applets, accessing remote applet, Color class and Graphics Event Handling: Events, Event sources, Event classes, Event Listeners, Delegation event model, handling events. AWT: AWT Components, windows, canvas, panel, File Dialog boxes, Layout Managers, Event handling model of AWT, Adapter classes, Menu, Menu bar.

Recommended Books:

- Sierra, K., & Bates, B. (2003). Head first java. " O'Reilly Media, Inc."
- Long, J., & Bastani, K. (2017). Cloud Native Java: Designing Resilient Systems with Spring Boot, Spring Cloud, and Cloud Foundry. " O'Reilly Media, Inc."
- Bloch, J. (2008). Effective java (the java series). Prentice Hall PTR.
- Schildt, H., & Coward, D. (2014). Java: the complete reference (p. 1312). New York: McGraw-Hill Education.

Course Code	Course Name	L-T-P	Credits
CS 955	Virtual Private Network	4-0-0	4

Course Learning Outcomes (CLO):

- CLO.1 Use highly secure VPN communications, with access rights tailored to individual users.
- CLO.2 Use VPN products to add new sites or users, without significantly expanding your existing infrastructure
- CLO.3 Extend skills of corporate networks, applications, and collaboration tools by using VPN
- CLO.4 Reduce communications costs while increasing flexibility

Course Outline

Introduction to VPN: Understanding VPNs, Evolution of VPNs, VPN Tunneling Protocols, Advantages and Disadvantages of VPNs
 VPN Considerations, Types of VPNs, Remote Access VPNs, Intranet VPNs, Extranet VPNs
 VPN Requirements, Building Blocks, and Architectures: VPN Requirements: Security, Availability and Reliability Quality of Service, Manageability, Compatibility
 Building Blocks of a VPN, VPN Hardware, VPN Software
 Security Infrastructure of the Organization, Service Provider's Supporting Infrastructure, Public Networks
 VPN Architectures, Implementer-based VPN Architectures, Security-based VPN Architectures,

Layer-based
VPN Architectures, Class-based VPN Architectures
Layer-based VPN Architectures, Class-based VPN Architectures
User Authentication and Access Control, Authenticating Users, Controlling Access, Encrypting Data
Symmetric Cryptosystems, Asymmetric Cryptosystems
Public Key Infrastructure
PKI Components, PKI-based Transactions, Implementing PKI

Recommended Books

- Brown, S. (2001). Implementing virtual private networks. McGraw-Hill, Inc..
- Press, C. (1999). Building Cisco Remote Access Networks.
- <http://sites.inka.de/sites/bigred/devel/cipe.html>
- <http://www.bitpipe.com/tlist/VPN.html>

Course Code	Course Name	L-T-P	Credits
CSL4641	Big Data Technology	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

CLO.1 Understand and implement classical models and algorithms in machine learning as well as python programming concepts.

CLO.2 Analyze the data, identify the problems.

CLO.3 Learn the skills to analyze relevant models and algorithms to turn available data into valuable and useful Information.

CLO.4 Understand the comparative study of the related approaches.

CLO.5 Explore new techniques and ideas that can be used to improve the effectiveness of current AI tools.

Course Outline

Big Data: Why and Where: Big Data landscape including examples of real world big data problems including the three key sources of Big Data: people, organizations, and sensors.

Characteristics of Big Data and Dimensions of Scalability: Explain the V’s of Big Data (volume, velocity, variety, veracity, valence, and value) and impact of each characteristic on data collection, monitoring, storage, analysis and reporting.

Data Science: Getting Value out of Big Data: Getting value out of Big Data by using a 5-step process to structure your analysis.

Foundations for Big Data Systems and Programming: Explanation of the architectural components and programming models used for scalable big data analysis.

Systems: Getting Started with Hadoop: Summarization of the features and value of core Hadoop stack components including the YARN resource and job management system, the HDFS file system and the Map Reduce programming model. Installation and running a program using Hadoop.

Introduction to Pig: Overview, Architecture, Installation, Execution, Grunt Shell; Pig Latin basics; Reading Data, Storing data, Diagnostic Operators, Describe Operator, Group operator, Co-group operator, Join operator, Cross operator, union operator, split operator, Distinct operator, foreach operator, order by, limit operator;

Recommended Books

- Understanding Big Data by Chris Eaton, Paul Zikopoulos
- Mining of Massive Datasets by Jure Leskovec, Anand Rajaraman, Jeffrey D. Ullman

Course Code	Course Name	L-T-P	Credits
CS 956	Bioinformatics	4-0-0	4

Course Learning Outcomes:

CLO.1 Demonstrate mastery of the core concepts of Bioinformatics, including computational biology, database design and implementation, and probability and statistics.

CLO.2 Demonstrate the ability to apply skills in a professional environment via an industrial or academic internship in Bioinformatics.

CLO.3 use and describe some central bioinformatics data and information resources

CLO.4 implement solutions to basic bioinformatics problems.

CLO.5 describe how bioinformatics methods can be used to relate sequence, structure and function.

Course Outline

Module 1: Introduction to Bioinformatics

Module 2: Biological Databases and Data Generation

Module 3: Biostatistics I

Module 4: Biostatistics II

Module 5: Biomolecules

Module 6: Cell Biology and Genetics

Module 7: Molecular Biology

Module 8: Structural Bioinformatics and Proteome based Technology

Module 9: Concepts and Principle of 2D and 3D QSAR

Module 10: Computational Molecular Biology and Computational tools

Module 11: Bioprogramming and Bioinformatics Softwares

Module 12: Introduction to Big Data Analytics

Module 13: Pharmaceutical and Healthcare Data Management

Module 14: Implementation of Big Data Analytics in Pharmaceuticals and Healthcare Industry

Recommended Books:

- Jain, A., Flynn, P., & Ross, A. A. (2007). Handbook of biometrics. Springer Science & Business Media.
- Boulgouris, N. V., Plataniotis, K. N., & Micheli-Tzanakou, E. (Eds.). (2009). Biometrics: theory, methods, and applications. John Wiley & Sons.
- Nanavati, T. (2002). Biometrics. John Wiley & Sons.
- Jain, A., Bolle, R., & Pankanti, S. (Eds.). (1999). Biometrics: personal identification in networked society (Vol. 479). Springer Science & Business Media.
- Li, H., Toh, K. A., & Li, L. (Eds.). (2011). Advanced topics in biometrics. World Scientific.

S. No.	Experiment Detail
1	To study fundamentals of image processing and write program to read and display different types of digital images.
2	To perform basic geometric transformations (2-D DFT, FFT etc.) on Digital Images.
3	To write program for zooming and shrinking of digital images and compare Nearest Neighbor interpolation, Bilinear interpolation and Bicubic interpolation methods of zooming.
4	To Perform enhancement in spatial domain on digital images and write programs for gray-level transformations, histogram processing and image averaging and subtraction.
5	To Perform Spatial domain Enhancement using Filtration of digital images.

6	To Perform Frequency domain Enhancement using Filtration of digital images.
7	To study and perform Image Restoration using Wiener Filters.
8	To perform Color Image Processing: Finding color negatives, histograms, smoothing and sharpening of color images.
9	(i)To Perform erosion and dilation operation on the image (ii)Use Morphological Closing to Fill Gaps in an Image and Morphologically Open Image with Disk-shaped Structuring Element
10	To perform detection of discontinuities: point, line and edges in a given image and study image Segmentation.

Recommended Book(s):

- Rafael C. Gonzalez & Richard E. Woods, “Digital Image Processing”, Pearson Education, Third Editon
- W.K. Pratt, “Digital Image Processing”, “McGraw Hill, Second Editon
- R.C. Gonzalez and R. E. Woods, “Digital Image Processing”,;Addison Wesley/ Pearson Education, Second Editon
- Gonzalez, “Digital Image Processing”, Pearson International Edition, Third Editon
- Silberschatz, Korth, Sudarshan, “Database System Concepts”, Mcgraw Hill, 6thEdition, 2006
- D. Maier, “The Theory of Relational Databases”, 1993, Computer Science Press, Rokville, Maryland

Course Code	Course Name	L-T-P	Credits
CSL4502	Advanced Computer Networks	4-0-0	4

Course Learning Outcomes:

Students will be able to:

- CLO.1: Understand the main abstract concepts related to the layere communication architecture
- CLO.2: Analyze and implement some of the most advanced routing and congestio control algorithms. Evaluate the performances of computer network

(through mathematical modeling and simulation).

- CLO.3: Understand basics and principles of new generation of computer networking infrastructure (VoIP, SIP, RTP).
- CLO.4: Practice Networking Simulating skills as employed in Industry for Planning and Design (CISCO Packet Tracer).

Course Outline

Reference Models Introduction, Seven-Layer ISO-OSI architecture of networking, Concepts of Layer Protocols and Layer interface, TCP model with TCP/IP protocol stack, Comparison of ISO-OSI and TCP models, Topologies, mode of transfer, Guided Transmission Media, Wireless Transmission, Ethernet cabling standards (Cat-1, Cat-2, Cat-3, Cat-4, Cat-5, Cat-5e, Cat-6a), T-568A Straight-Through Ethernet Cable, T-568B Straight-Through Ethernet Cable. Error- Detection and Error-Correction numerical techniques (CRC, Hamming Code, Parity Bit, checksum), Elementary data link protocols -simplest, stop-and-wait protocol, sliding window protocols- 1-bit sliding window protocol, go back-n, selective repeat. Channel allocation, Multiple access protocols: random access (Aloha, Pure Aloha, slotted Aloha).IP protocol (IPv4 and IPv6), IP addresses (Classful and Classless), CIDR, Subnets, Supernetting VLSM, Routing algorithms (Static and Dynamic): Basic commands of Routers: hostname, password, Show Run, Show IP int brief, Assigning IP addresses to interfaces, Configuration of Static Routing, Configuration of Dynamic Routing: RIP V1 and RIP V2, Design and configuration of OSPF (Open Shortest Path First) in single area. Design and configuration of EIGRP Routing. WWW(world wide web), DNS(Domain Name System)- generic domain, country domain, inverse domain, SNMP(Simple Network Management Protocol), Cryptography-(Cryptographic Techniques, Computer-based Symmetric and Asymmetric Key Cryptographic Algorithms, Public Key Infrastructure (PKI), Internet Security Protocols, Network Security.), Firewalls, Digital Signature, Design and configuration of ACL: Standard and Extended, Design and Configuration of NAT (Network Address Translation): Static, Dynamic, PAT, Design and configuration of VPN Virtual private networks, Switching configuration concepts, Design and configuration of VLAN (Virtual Local Area Networks).

Recommended Book(s):

- Data Communications and Networking' by Forouzan, Fourth edition.
- Data and computer Communications' by William Stallings, 8th edition, Pearson.
- CCNA study guide Sybex Publications by Todd Lammle.

Course Code	Course Name	L-T-P	Credits
CSP1502	Advanced Computer Networks Lab	0-0-2	1

Course Learning Outcomes:

Students will be able to:

- CLO.1: Understand the captured data by using the relevant tools and focus on the involvement of layered approach in data transmission.
- CLO.2: Enhance the analytical skills of the students to understand and simulate the working of TCP/IP reference model.

Course Outline

1. Introduction of Cables, Network Devices: Hub, Switches, Router.
2. To design and perform IP addressing in network.
3. To design and implement peer to peer connectivity and share resources.
4. To design and implement a computer network demonstrating Star Topology.
5. Basic commands of Routers: hostname, password, Show Run, Show IP int brief, Assigning IP addresses to interfaces.
6. To design and simulate Static Routing.
7. To design and simulate Dynamic Routing: RIP V1 and RIP V2.
8. To design and simulate routing with OSPF (Open Shortest Path First) in single area.
9. To design and simulate EIGRP Routing.
10. To create and implement ACL: Standard and Extended.
11. To design and implement NAT (Network Address Translation): Static, Dynamic, PAT.

Recommended Book(s):

- CCNA Study Guide by Sybex Publication
- CCNA Preparation Guide by Cisco Press

Course Code	Course Name	L-T-P	Credits
ECL2601	Publishing Research	2-0-0	2

Course Learning Outcomes:

Students will be able to:

- CLO.1 Understanding of ethical issues related to Research and Publication.
- CLO.2 Gain skills to write research papers/thesis following publication ethics. Related issues.
- CLO.3 Gain skills to Publish ethically.
- CLO.4 Gain skills to for avoiding plagiarism.

Course Outline

Introduction to Academic Writing, Structure of Academic Articles, Types of Academic Articles, choosing where to publish, Finding, keeping and disseminating information, submitting a manuscript, Delays in the publishing process, Refereeing, six differences in academic writing, how to conduct revision, Procrastination and writer's block, Plagiarism and How to prevent it, how to write letters to Editors.

Recommended Book(s):

- Viktor Wang, Handbook of Research on Learning Outcomes and Opportunities in the Digital Age (2 Volumes), December, 2015
- Medhi, J., Stochastic Processes, New Age International

Elective I

Course Code	Course Name	L-T-P	Credits
CSL4625	Programming in C#	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

- CLO.1 Implement the concept of object-oriented techniques and methodologies using c#
- CLO.2 Use Exception Handling concepts and skills for a Robust Application in c#.
- CLO.3 Demonstrate an understanding of c# Input and Output
- CLO.4 Develop applications using multithreading concept of c#.

Course Outline

Understanding .NET: The C# Environment: The .Net Strategy, The Origins of .NET Technology, The .NET Framework, The Common Language Runtime, Framework Base Classes, User and Program Interfaces, Visual Studio .NET, .NET Languages, Benefits of the .NET Approach, C# and the .NET

Overview of C#: What is C#, Why C#, Evolution and Characteristics of C#, Applications of C#, How does C# Differ from C++ and Java, Introduction to C# Program, Namespaces, Adding Comments, Main Returning a Value, Using Aliases for Namespace Classes, Passing String Objects to Write Line Method, Command Line Arguments, Main with a Class, Providing Interactive Input, Using Mathematical Functions, Multiple Main Methods, Compile Time Errors, Program Structure, Program Coding Style

Literals, Variables and Data Types: Introduction to Literals, Variables, Data Types, Value Types, Reference Types, Declaration of Variables, Initialization of Variables , Default Values, Constant Variables, Scope of Variables, Boxing and Unboxing

Operators and Expressions: Arithmetic Operators, Relational Operators, Logical Operators, Assignment Operators, Increment and Decrement Operators, Conditional Operator, Bitwise Operators, Special Operators, Arithmetic Expressions, Evaluation of Expressions, Precedence of Arithmetic Operators, Type Conversions, Operator Precedence and Associativity, Mathematical Functions

Decision Making and Branching: Decision Making with if Statement , Simple if Statement , The if... else Statement , Nesting of if...else Statements , The else if Ladder , The Switch Statement , The ? : Operator , The while Statement ,The do Statement , The for Statement , The foreach Statement , Jumps in Loops

Methods in C#: Declaring Methods , The Main Method , Invoking Methods, Nesting of Methods, Method Parameters , Pass by Value, Pass by Reference, The Output Parameters, Variable Argument Lists, Methods Overloading

Handling Arrays and Manipulating Strings: One-Dimensional Arrays , Creating an Array , Two-Dimensional Arrays , Variable-Size Arrays , The System. Array Class ,ArrayList Class, Creating Strings , String Methods , Inserting Strings , Comparing Strings , Finding Substrings , Mutable Strings , Arrays of Strings , Regular Expressions

Structures and Enumerations: Structures,Structs with Methods, Nested Structs, Differences between Classes and Structs, Enumerations, Enumerator Initialization , Enumerator Base Types , Enumerator Type Conversion

Classes and Objects: Basic Principles of OOP , Defining a Class , Adding Variables , Adding Methods , Member Access Modifiers , Creating Objects , Accessing Class Members , Constructors , Overloaded Constructors , Static Members , Static Constructors , Private Constructors , Copy Constructors , Destructors , Member Initialization , The this Reference , Nesting of Classes , Constant Members , Read-only Members , Properties , Indexers

Inheritance and Polymorphism

Classical Inheritance , Containment Inheritance , Defining a Subclass , Visibility Control , Defining Subclass Constructors , Multilevel Inheritance , Hierarchical Inheritance , Overriding Methods , Hiding Methods , Abstract Classes , Abstract Methods, Sealed Classes: Preventing Inheritance , Sealed Methods , Polymorphism

Interfaces: Multiple Inheritance and Operator Overloading: Defining an Interface , Extending an Interface , Implementing Interfaces , Interfaces and Inheritance , Explicit Interface Implementation, Abstract Class and Interfaces, Overloadable Operators, Need for Operator Overloading, Defining Operator Overloading , Overloading Unary Operators , Overloading Binary Operators , Overloading Comparison Operators

Delegates and Managing Console I/O Operations: Delegates , Delegate Declaration , Delegate Methods , Delegate Instantiation , Delegate Invocation , Using Delegates , Multicast Delegates , Events, The Console Class, Console Input, Console Output, Formatted Output, Numeric Formatting, Standard Numeric Format, Custom Numeric Format

Windows and Web-based Application Development on .NET: Understanding Microsoft Visual Studio, Creating and Running a Sample WinApp Windows Application, Creating and Running a SampleWinApp2 Windows Application, Web-based Application on .NET

Collections and Generics - Collection classes are specialized classes for data storage and retrieval. These classes provide support for stacks, queues, lists, and hash tables. Most collection classes implement the same interfaces. Generics allow you to delay the specification of the data type of programming elements in a class or a method, until it is actually used in the program

Recommended Books:

- Jesse Liberty, “Programming C#”, Second Edition, O’Reilly Press, 2002.
- Svetlin Nakov & Co., “Fundamentals of Computer Programming With C# “, 2013.

Course Code	Course Name	L-T-P	Credits
CSL4626	Programming in Python	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

CLO.1 Run basic python programs.

CLO.2 Use python skills in various fields of Data Science, Machine Learning and Artificial Intelligence.

CLO.3 Logic building using looping and decision statements.

CLO.4 Develop problem solving abilities using Python.

CLO.5 Learn building packages and modules for reusability.

CLO.6 Learn GUI development using Widgets in Python.

Course Outline

Introduction: Variables, expressions, and statements: Values and types, Variables, Variable names and keywords, Statements, Operators and operands, Expressions. Order of operations, Expressions, Order of operations, Modulus operator, String operations, Asking the user for input, Comments, Choosing mnemonic variable names.

Conditional execution: Boolean expressions, Logical operators, Conditional execution, Alternative execution, Chained conditionals, Nested conditionals, catching exceptions using try and except, Short-circuit evaluation of logical expressions.

Functions: Function calls, Built-in functions, Type conversion functions, Random numbers, Math functions, Adding new functions, Definitions and uses, Flow of execution, Parameters and arguments. Flow of execution, Parameters and arguments.

Iteration: Updating variables, while statement, Infinite loops, “Infinite loops” and break, Finishing iterations with continue, Definite loops using for, Loop patterns.

Strings: Introduction, Getting the length of a string using len, Traversal through a string with a loop, String slices, Strings are immutable, Looping and counting, The in operator, String comparison, string methods, Parsing strings, Format operator.

Files: Persistence, Opening files, Text files and lines, Reading files Searching through a file, Using try, except, and open, Writing files.

Lists, tuples and dictionaries: list operators, replacing, inserting, removing an element searching and sorting lists; dictionary literals, adding and removing keys, accessing and replacing values; traversing dictionaries.

Classes and OOP: classes, objects, attributes and methods; defining classes; design with classes, data modeling; persistent storage of objects, inheritance, polymorphism, operator overloading (`_eq_`, `_str_`, etc); abstract classes; exception handling, try block.

Python is open source – Python is developed under an OSI-approved open source license,

making it freely usable and distributable, even for commercial use. Python’s license is administered by the Python Software Foundation.

Recommended Books

- “Programming in Python: A complete introduction to the python Language(second edition)”, Mark Summerfield, ISBN:978-0-321-68056-3(pbk: all paper).
- “Core Python Programming”, Wesley.J.Chun (First edition), ISBN: 0-13-0260-36-3, 816 pages

Course Code	Course Name	L-T-P	Credits
CSL4661	Programming in R	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

- CLO.1 Use R skills in various fields of Data Science, Machine Learning and Artificial Intelligence.
- CLO.2 Logic building using looping and decision statements.
- CLO.3 Develop problem solving abilities using R
- CLO.4 Learn building packages and modules for reusability.
- CLO.5 Learn GUI development using Widgets in R.

Course Outline

Basic R features; introduction to the main data types and visualization, More on vectors and other data types
 Introduction to functions. More on lists and data frames, Programming structures: relational and logical operations; flow control, Environment and scope, more on data frames
 Math and simulations in R, Debugging, introduction to strings and regular expressions
 Introduction to graphics, the Grammar of Graphics, Data shaping and transformation; split-transform-recombine, Reshaping and tidying data, exploring large data sets
 Dates and times, statistical models in R, Overview of main domain-specific libraries, TBA
 Project using R.
 DPLYR PACKAGE - Load data into dataframe, Viewing the data, Selecting columns
 Selecting rows, Reordering the rows, Pipe operator, Group operations

Recommended Books:

- Benjamin M. Bolker. Ecological Models and Data in R. Princeton University Press, 2008. ISBN 978-0-691-12522-0.

- Peter Dalgaard. Introductory Statistics with R. Springer, 2nd edition, 2008. ISBN 978-0-387-79053-4.
- Brian Everitt and Torsten Hothorn. A Handbook of Statistical Analyses Using R. Chapman & Hall/CRC, Boca Raton, FL, 2006. ISBN 1-584-88539-4.
- John Maindonald and John Braun. Data Analysis and Graphics Using R. Cambridge University Press, Cambridge, 2nd edition, 2007. ISBN 978-0-521-86116-8.

Course Code	Course Name	L-T-P	Credits
CSL4635	Advanced Database Management Systems	4-0-0	4

Course Learning Outcomes:

Students will be able to:

- CLO.1: Understand and gain skills functionality of the various database systems.
- CLO.2: Practice the codes and study about the case studies.

Course Outline

Relational Databases: Integrity Constraints revisited, Extended ER diagram, Relational Algebra & Calculus, Functional, Multivalued and Join Dependency, Normal Forms, Rule about functional dependencies. Query Processing and Optimization: Valuation of Relational Operations, Transformation of Relational Expressions, Indexing and Query Optimization Limitations of Relational Data Model.

Object Oriented and Object Relational Databases: Modeling Complex Data Semantics Specialization, Generalization, Aggregation and Association, Objects, Object Identity Equality and Object Reference, Architecture of Object Oriented and Object Relational Databases Parallel and Distributed Databases: Distributed Data Storage-Fragmentation & Replication, Location and Fragment Transparency Distributed Query Processing and Optimization, Distributed Transaction Modeling and concurrency Control, Distributed Deadlock, Commit Protocols.

Advanced Transaction Processing: Nested and Multilevel Transactions, Compensation Transactions, Weak Levels of Consistency, Transaction Work Flows and Transaction Processing Monitors. Active Database and Real Time Databases: Triggers in SQL Multimedia Databases: Modeling and Storage of Image and Multimedia Data, Data Structures –R-tree, k-d tree, Quad trees, Content Based Retrieval, Geographic Information Systems (GIS)

WEB Database: Accessing Databases through WEB, WEB Servers, XML Databases

Commercial Systems. Data Warehousing: Data Warehousing Architecture, Multidimensional Data Model, Update Propagation OLAP Queries. Data Mining: Knowledge Representation Using Rules, Association and Classification Rules, Sequential Patterns, Algorithms for Rule Discovery Case Study: Oracle Xi

Recommended Book(s):

- Elmars, Navathe, Somayajulu, Gupta, “Fundamentals of Database Systems”, 4th Edition, Pearson Education, 2007
- Garcia, Ullman, Widom, “Database Systems, The complete book”, Pearson Education, 2007
- R. Ramakrishnan, “Database Management Systems”, McGraw Hill International Editions, 1998
- Date, Kannan, Swaminathan, “An Introduction to Database Systems”, 8th Edition Pearson Education, 2007
- Singh S.K., “Database System Concepts, design and application”, Pearson Education, 2006.
- Silberschatz, Korth, Sudarshan, “Database System Concepts”, McGraw Hill, 6th Edition, 2006
- D. Maier, “The Theory of Relational Databases”, 1993, Computer Science Press, Rokville, Maryland
- Ullman, J. D., “Principals of database systems”, Galgotia publications, 1999
- Oracle Xi Reference Manual

Course Code	Course Name	L-T-P	Credits
CSP1635	Advanced Database Management Systems Lab	0-0-2	1

Course Learning Outcomes:

Students will be able to:

- CLO.1: Learn the installation of the software.
- CLO.2: Practice the codes to gain better skills of knowledge.

Course Outline

Table Normalization & EER

- Creating Master Table
- Creating Transaction Tables
- Ensuring Null Integrity & Referential Integrity Constraints

- Testing Normal forms with Joins
- Drawing EER Diagrams

Study of EER diagram.

- Objective To get familiar with basic EER concepts
- (generalization and specialization)
- Study of ODL schema.
- To get familiar object structure, naming mechanism and ODL.

Implement Abstract data type.

- To get familiar User defined data types.
- Implement Varrays.
- V arrays help in storing repeating attributes of a record in a single row.
- Implement object Table.

Implement Nested tables.

- Implement Member procedure
- Implement Member Function.

Implement Partitioning on the tables.

- Implement XML command.

Suggested Book(s)

- Elmars, Navathe, Somayajulu, Gupta, “Fundamentals of Database Systems”, 4th Edition, Pearson Education, 2007
- Garcia, Ullman, Widom, “Database Systems, The complete book”, Pearson Education, 2007
- R. Ramakrishnan, “Database Management Systems”, McGraw Hill International Editions, 1998
- Date, Kannan, Swaminathan, “An Introduction to Database Systems”, 8th Edition Pearson Education, 2007
- Singh S.K., “Database System Concepts, design and application”, Pearson Education, 2006.
- Silberschatz, Korth, Sudarshan, “Database System Concepts”, McGraw Hill, 6th Edition, 2006
- D. Maier, “The Theory of Relational Databases”, 1993, Computer Science Press, Rokville, Maryland
- Ullman, J. D., “Principals of database systems”, Galgotia publications, 1999
- Oracle Xi Reference Manual

Course Code	Course Name	L-T-P	Credits
ECL4602	Next Generation Wireless and Sensor Networks	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

CLO.1 Implement skill based knowledge of routing mechanisms and the three classes of approaches: proactive, on-demand, and hybrid

CLO.2 Study about the issues pertaining to major obstacles in establishment and efficient management of Ad-hoc and sensor networks.

CLO.3 Identify the issues and challenges in providing QoS

CLO.4 Explain about the energy management in ad-hoc networks

CLO.5 Demonstrate various types of mesh networks.

Course Outline

Wireless Network Architecture: Wireless Network Logical Architecture; Network Layer Technologies; Data Link Layer Technologies; Physical Layer Technologies; Wireless Communication; RF Spectrum; Wireless Multiplexing and Multiple Access Techniques; Wireless LAN Standards; Implementing Wireless LANs; Implementing Wireless PANs; WLAN Security Measures; Troubleshooting using WLAN Analyzers.

The Future of Wireless Networking Technology: Wireless Mesh Network Routing; Network Independent Roaming; Gigabit Wireless LANs; Cognitive Radio; ZigBee; DASH7; RuBee; EnOcean; 6LoWPAN; Wireless USB; Ofcom and 5G; Li-Fi.

Motivation for a Network of Wireless Sensor Nodes: Definitions and Background, Challenges and constraints; Applications of wireless sensor networks; Node Architecture; The Sensing Subsystem - Analog-to-Digital Converter; The Processor Subsystem; Communication Interfaces; Prototypes.

Medium Access Control: Wireless MAC Protocols; Characteristics of MAC Protocols in Sensor Networks; Contention-Free MAC Protocols; Contention-Based MAC Protocols; Hybrid MAC Protocols

Network Layer: Routing Metrics; Flooding and Gossiping; Data-Centric Routing; Proactive Routing; On-Demand Routing; Hierarchical Routing; Location-Based Routing; QoS-Based Routing Protocols

Transport Layer: Traditional Transport Control Protocols; Transport Protocol Design Issues; Examples of Existing Transport Control Protocols; Performance of Transport Control Protocols

Power Management & Time Synchronization: Local Power Management Aspects;

Dynamic Power Management; Conceptual Architecture; Clocks and the Synchronization Problem; Time Synchronization in Wireless Sensor Networks; Basics of Time Synchronization; Time Synchronization Protocols.

Sensor Network Programming: Challenges in Sensor Network Programming; Node-Centric Programming; Macro programming; Dynamic Reprogramming; Sensor Network Simulators.

Recommended Book(s):

- C. S. Raghavendra, Krishna M. Sivalingam and Taieb Znati, “Wireless sensor networks”, kluwer academic publishers.
- Feng Zhao and Leonidas J. Guibas, “Wireless Sensor Networks: An Information Processing Approach”, Elsevier.
- Robert Faludi, “Building Wireless Sensor Networks”, O’Reilly.
- Holger Karl and Andreas Willig, “Protocols and Architectures for Wireless Sensor Networks”, John wiley and sons.
- JYH – CHENG CHEN, TAO ZHANG, “IP – Based Next Generation Wireless Networks (Systems, Architectures and Protocols)”, Wiley.
- Rajeev Shorey, A. Ananda, Mun Choon Chan and Wei Tsang Ooi, “Mobile, wireless, and Sensor networks - technology, applications, and future directions”, Wiley.

Course Code	Course Name	L-T-P	Credits
ECL4627	System Implementation of Vision	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

- CLO.1 Identify basic skills of concepts, terminology, theories, models and methods in the field of computer vision,
- CLO.2 Describe known principles of human visual system
- CLO.3 Describe basic methods of computer vision related to multi-scale representation, edge detection and detection of other primitives, stereo, motion and object recognition,
- CLO.4 Suggest a design of a computer vision system for a specific problem

Course Outline

Image acquisition, Image properties. Intel Arduino/Galileo interfacing and Understanding of video components Practical significance of Fourier transform and convolution in image understanding. Quantization, Basic relationship between pixels, Linear and Non-Linear operations. The algorithm to track lines in the image. Pattern recognition techniques.

Introduction to Python and its implementation: Constants and Variables, First Program, Conditional Programming Loops and Iterations, Image Acquisition, Implementing pattern recognition, Decision making Motion Vision Shaping with binary and shaded images Binary image processing Stereo photogrammetry Computational Vision (Machine learning and vision) Performance Evaluation Projects using Machine vision (Any of the following) Vision in Agriculture, Vision in Natural Language Processing, Vision in Biomedical, Vision in Education.

Robot Vision
Basic introduction to Robotic operating System (ROS) – Real and Simulated Robots – Introduction to OpenCV, Open NI and PCL, installing and testing ROS camera Drivers, ROS to OpenCV – The cv_bridge Package.

Recommended Books

- “Learning OpenCV: Computer Vision with the OpenCV Library”, By Gary Bradski, Adrian Kaehler.
- “Computer Vision: Algorithms and Applications”, Richard Szeliski.

Course Code	Course Name	L-T-P	Credits
CS 957	Software testing & Quality Assurance	4-0-0	4

Course Learning Outcomes:

- CLO.1 Understand software testing and quality assurance as a fundamental component of Software life cycle.
- CLO.2 Define the scope of SW T&QA projects
- CLO.3 Efficiently perform T&QA activities using modern software tools
- CLO.4 Estimate cost of a T&QA project and manage budgets
- CLO.5 Prepare test plans and skilled to schedules for a T&QA project
- CLO.6 Develop T&QA project staffing requirements
- CLO.7 Effectively manage a T&QA project

Course Outline

Software system quality components and activities that support software quality QA objectives: reliability, correctness, testability, maintainability, flexibility, portability, efficiency, integrity, usability, reusability, and interoperability. Theoretical background: program correctness proofs, cyclomatic complexity, software reliability modeling. Software unit testing to verify unit specifications, Integration testing to verify design specifications. System testing to verify requirements specifications, Usability testing, Performance, reliability, and regression testing, Alpha, beta and acceptance testing, Software testing and quality

assurance tools. Open source testing using NUnit and JUnit. Software testing and QA project, planning, organizing, and budgeting test procedures, Cost management of test projects: cost estimating, cost budgeting, project, financing, cash flow management, Time management of test projects: schedule development, resource planning and allocation, network diagrams
Project quality management: standards, documentation, objectives, planning and control
Human resource management: QA project HR planning, staff acquisition and deployment, team building and training, team management, managing outsourced QA projects: virtual team management, offshore team management.

Recommended Books:

- Naik, K., & Tripathy, P. (2011). Software testing and quality assurance: theory and practice. John Wiley & Sons.
- Beizer, B. (1984). Software system testing and quality assurance. Van Nostrand Reinhold Co..
- Gao, J., Tsao, H. S., & Wu, Y. (2003). Testing and quality assurance for component-based software. Artech House.
- Pezzè, M., & Young, M. (2008). Software testing and analysis: process, principles, and techniques. John Wiley & Sons.
- Goericke, S. (2020). The future of software quality assurance (p. 257). Springer Nature.

Course Code	Course Name	L-T-P	Credits
CSL4669	Biometric Security	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

- CLO.1 Apply biometric matching for identification
- CLO.2 Identify algorithms for finger biometric technology
- CLO.3 Apply skills of facial biometrics for identification.
- CLO.4 Apply iris biometric, voice biometric, physiological biometrics etc. for identification.

Course Outline

Biometrics- Introduction- benefits of biometrics over traditional authentication systems - benefits of biometrics in identification systems-selecting a biometric for a system – Applications - Key biometric terms and processes - biometric matching methods - Accuracy in biometric systems.

Physiological Biometric Technologies: Fingerprints - Technical description – characteristics - Competing technologies - strengths – weaknesses – deployment - Facial scan - Technical description - characteristics - weaknesses-deployment - Iris scan - Technical description – characteristics - strengths – weaknesses – deployment - Retina vascular pattern

Technical description – characteristics - strengths – weaknesses – deployment - Hand scan - Technical description-characteristics - strengths – weaknesses deployment – DNA biometrics. Behavioral Biometric Technologies: Handprint Biometrics - DNA Biometrics.

Signature and handwriting technology - Technical description – classification – keyboard / keystroke dynamics- Voice – data acquisition - feature extraction - characteristics - strengths – weaknesses-deployment.

Multi biometrics and multi factor biometrics - two-factor authentication with passwords - tickets and tokens – executive decision - implementation plan.

Recommended Books:

- Samir Nanavathi, Michel Thieme, and Raj Nanavathi : “Biometrics -Identity verification in a network”, 1st Edition, Wiley Eastern, 2002.
- John Chirillo and Scott Blaul : “Implementing Biometric Security”, 1st Edition, Wiley Eastern Publication, 2005.
- John Berger: “Biometrics for Network Security”, 1st Edition, Prentice Hall, 2004.

Course Code	Course Name	L-T-P	Credits
CSL4667	Network Programming	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

- CLO.1 Describe and analyze the hardware, software, components of a network and the interrelations.
- CLO.2 Explain networking protocols and their hierarchical relationship hardware and software.
- CLO.3 Compare protocol models and select appropriate protocols for a particular design.
- CLO.4 Manage multiple operating systems, systems software, network services and security.
- CLO.5 Explain concepts and theories of networking and apply them to various situations, classifying networks, analyzing performance and implementing new technologies.
- CLO.6 Imparting skills to analyze, specify and design the topological and routing strategies for an IP based networking infrastructure
- CLO.7 Identify infrastructure components and the roles they serve, and design infrastructure including devices, topologies, protocols, systems software, management and security.
- CLO.8 Effectively communicate technical information verbally, in writing, and in presentations.

Course Outline

INTRODUCTION

Overview of UNIX OS, Environment of a UNIX process, Process control, Inter process Communication, Process synchronization using semaphores.

BASICS OF TCP SOCKETS

Introduction to Socket Programming ,Introduction to Sockets , Socket address Structures , Byte ordering functions ,address conversion functions , Elementary TCP Sockets ,socket, connect, bind, listen, accept, read, write , close functions.

TCP SOCKET MULTIPLEXING

TCP Echo Server , TCP Echo Client ,boundary conditions: Server process Crashes, Server host Crashes, Server Crashes and reboots, Server Shutdown , I/O multiplexing , I/O Models , select function ,TCP echo Server (with multiplexing) ,poll function, TCP echo Client (with Multiplexing)

ELEMENTARY UDP SOCKETS

Elementary UDP sockets, UDP echo Server, UDP echo Client, Multiplexing TCP and UDP sockets, Domain name system, get host by name function, get host by adr function

ADVANCED SOCKETS

Threaded servers, Thread creation and termination, TCP echo server using threads, socket options, raw sockets, raw socket creation, raw socket output, raw socket input, ping program.

Programming Across Machine Boundaries - Telnet and remote access, FTP and SFTP, Transferring files with FTP, Secure file transfer with SFTP

Web Services - Introducing Web services, REST and SOAP, Web services in Python

Recommended Books

- W. Richard Stevens, B. Fenner, A.M. Rudoff, “Unix Network Programming – The Sockets Networking API”, 3rd edition, Pearson, 2004.
- W. Richard Stevens, S.A Rago, “Programming in the Unix environment”, 2nd edition, Pearson, 2005

Course Code	Course Name	L-T-P	Credits
CS 958	Software Project Management	4-0-0	4

Course Learning Outcomes:

- CLO.1 Acquire presentation and communication skills
- CLO.2 Undertake problem identification, formulation and solution to make students employable.
- CLO.3 Design engineering solutions to complex problems utilizing a systems approach
- CLO.4 Implement learning in real life problem for skill development
- CLO.5 Propose multiple solution to any given problem and find best out of those.

Course Outline

Tools and Techniques: software project planning, understand the Project Needs, Create the Project Plan, Diagnosing Project Planning Problems

Estimation: Elements of a Successful Estimate, Wideband Delphi Estimation, Other Estimation Techniques, Diagnosing Estimation Problems

Project Schedules: Building the Project Schedule, Managing Multiple Projects, Use the Schedule to Manage Commitments, Diagnosing Scheduling Problems,

Reviews: Inspections, Deskchecks, Walkthroughs, Code Reviews, Pair Programming, Use Inspections to Manage Commitments, Diagnosing Review Problems

Software Requirements: Requirements Elicitation, Use Cases, Software Requirements Specification Change Control, Introduce Software Requirements Carefully, Diagnosing Software Requirements Problems

Design and Programming: Review the Design, Version Control with Subversion, Refactoring, Unit Testing, Use Automation, Diagnosing Design and Programming Problems

Software Testing: Test Plans and Test Cases, Test Execution, Defect Tracking and Triage, Test Environment and Performance Testing, Smoke Tests, Test Automation, Postmortem Reports, Using Software Testing Effectively, Diagnosing Software Testing Problems

Understanding Change: Why Change Fails, how to Make Change Succeed

Management and Leadership: Take Responsibility, Manage the Organization, and Manage Your Team

Managing an Outsourced Project: Prevent Major Sources of Project Failure, Management Issues in Outsourced Projects, Collaborate with the Vendor

Process Improvement: Life Without a Software Process, Software Process Improvement

Introduction to UML: Object-Oriented Analysis and Design with Use-Case View, Different types of views in UML, Use-Case Diagrams, Creating Use Cases, Class Diagrams, Finding Classes, Discovering Object Interaction, Specifying Relationships, Object Diagrams, Software Design and Software Engineering, The Design Process, Design Principles, Design Concepts, Effective Modular Design, Design Concepts and Principles with UML, Collaboration Diagrams, Sequence Diagrams, State Diagrams, Activity Diagrams, Component Diagrams and Deployment Diagrams.

Recommended Books:

- Stelman, A., & Greene, J. (2005). Applied software project management. " O'Reilly Media, Inc."
- Cotterell, M., & Hughes, B. (1995). Software project management. International Thomson Computer Press.
- Stelman, A., & Greene, J. (2005). Applied software project management. " O'Reilly Media, Inc."
- Stelman, A., & Greene, J. (2005). Applied software project management. " O'Reilly Media, Inc."

Course Code	Course Name	L-T-P	Credits
CSL4651	Engineering Education	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

CLO.1 Attain a position solving real-world problems using mechanical engineering skills and principles developed while studying at Seattle University;

CLO.2 Participate in ongoing personal and professional growth by actively seeking additional skills and experiences, for example engaging in continuing education and/or pursuing advanced degrees;

CLO.3 Contribute to society through involvement in professional organizations, developing mentorship relationships, taking on leadership roles, and other service activities.

Course Outline

Engineering Education – concept, significance in Indian context, scope of Engineering Education and Role of Engineer and Technicians, Educating the engineers of new century - Generic Skills appropriate to engineering practices: speaking, listening, reading, writing, decision making, problem solving, team building, creativity, and adaptability: their concepts, importance and strategies for enhancing these skills), Educational Technology : Concept, Types of Educational Technology- Technology in Education, Technology of Education and Systems Approach to Educational Technology, Planning and Organizing for Instruction in engineering contexts : Steps in Instructional Planning – Understanding learners; task analysis; writing instructional objectives; instructional methods (Problem Based Learning, Case Study and Cooperative Learning); selecting evaluation techniques; Developing lesson plans (Theory and Practical); Development of instructional resources (handouts, instructional sheets, tutorial sheets, exercises, PowerPoint), Implementing Instruction: Motivating students Concept, types and techniques, Ensuring student - involvement through Integration of media (internet and computer), Evaluation of learning outcomes and teacher effectiveness: Concept, dimensions, Evaluating learning outcomes (cognitive, psychomotor & affective) , Teacher effectiveness (self, peer and superior evaluation).

Suggested Book(s):

- Bhattacharya, SK (2006) Educational Technology. New Delhi: Abhishek Publications 2006

- Cole PG and Chan LKG (1987) Teaching Principles & Practice New York: Prentice Hall
- Duffy Judy Lever, McDonald Jean (2010) Teaching and Learning with Technology.
- Gagne, RM & Briggs LJ (1980) Principles of instructional design. New York: Holt, Rinohart &Winston.Inc.
- Kulkarni, SS (1986) Introduction to Educational Technology. New Delhi: Oxford & IBH Publishing company

Course Code	Course Name	L-T-P	Credits
ICP4306	Mobile Application Development	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

- CLO.1 Install and configure Android application development tools.
 CLO.2 Design and develop user Interfaces for the Android platform.
 CLO.3 Save state information across important operating system events.
 CLO.4 Apply Java programming skills and concepts to Android application development.

Course Outline

Introduction to Mobile Application Development: Definition of Mobile Computing, Devices: Mobile devices vs. desktop devices, Web-Based Applications, Native Applications, History of Mobile Platforms, Internet Protocols for Mobile Apps, Content vs. Applications. Mobile and Cell Phone Technologies, Internet Terms, Transport, Secure Connections. Power Management, Screen resolution, Touch interfaces, Application deployment, App Store, Google Play, Windows Store.

HTML5/JS/CSS3/DOM/JQuery: Quick recap of technologies, Mobile-specific enhancements, Browser-detection, Touch interfaces, Geolocation, Screen orientation, Mobile browser “interpretations” (Chrome/Safari/Gecko/IE), jQuery, JavaScript and XML.

Android/iOS/Win 8 Survival and basic apps: App-structure, built-in Controls, file access, basic graphics, Building a simple “Hello World” App in all three applications, DB access, network access, contacts/photos/etc.

Mobile User Interface and Server-access: Overview, Definition of Usability, Task Analysis and Contextual Inquiry, Development Cycle, Mobile User Interface Types, Mobile Application Development Design Considerations, XML Http Request Implementations by Browser.

Mobile Application Evaluation, Mobile Browsers and Mobile Platforms: Mobile Device User Interaction Patterns, Evaluating Mobile User Interfaces, Mobile Browsers

and Browsers, Mobile Browser Evolution, URIs for Mobile Apps, Native Runtime Platforms, Cross-Platform Development

Location - Mobility and Location Based Services, Android

Putting It All Together (as time allows) - Packaging and Deploying, Performance Best Practices, Android Field Service App

Storage and Geolocation: Need for Storage, Local Storage with HTML5, Storage on the Web, Geolocation.

Recommended Books:

- “Professional Android 4 Application Development”, Reto Meier, Wiley India
- “Professional iOS Programming: Covers iOS 7”, Peter Van De Put , Wiley India

Course Code	Course Name	L-T-P	Credits
CSL4666	Modelling and Simulation	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

CLO.1 Understand the techniques of modelling in the context of hierarchy of

CLO.2 Gain skill and knowledge about a system and develop the capability to apply the same to study systems through available software.

CLO.3 Students will learn different types of simulation techniques.

CLO.4 Students will learn to simulate the models for the purpose of optimum control by using software.

Course Outline

Introduction to Modelling and Simulation. Application areas, definition and types of system, model and simulation, introduction to discrete-event and continuous simulation.

Simulation Basics - Handling Stepped and Event-based Time in Simulations, Discrete versus Continuous Modelling, Numerical Techniques, Sources and Propagation of Error

Simulation Methods: Discrete-event Simulation, Time advance Mechanisms, Components and organization of Discrete event simulation, Flowchart of next-event time advance approach, Continuous Simulation, Random Number generation methods.

Queuing Models: Single server queuing system, introduction to arrival and departure time, flowcharts for arrival and departure routine. Event graphs of queuing model. Determining the events and variables.

Distribution Functions Stochastic activities, Discrete probability functions, Cumulative distribution function, Continuous probability functions. Generation of random numbers following binomial distribution, poisson distribution, continuous distribution, normal distribution, exponential distribution, uniform distribution.

Programming in MATLAB: Introduction, Branching statements, loops, functions, additional data types, plots, arrays, inputs/outputs etc.

Programming in GPSS and C/C++: Basic Introduction to Special Simulation Languages:-GPSS and Implementation of Queuing Models using C/C++.

Introduction to Simulators: Introduction regarding features and usage of any Network simulator.

Recommended Books:

- Averill M. Law and W. David Kelton “Simulation Modeling and Analysis”, Tata McGraw-Hill Publication.
- Geoffery Gordon ““System Simulation”, Prentice-Hall of India.
- Rudra Pratap “Getting Started with MATLAB 7”, Oxford University Press.

Course Code	Course Name	L-T-P	Credits
CS 959	Cloud Computing & Virtualization	4-0-0	4

Course Learning Outcomes:

CLO.1 Understand the concept of Cloud Computing.

CLO.2 Understand the concept of Virtualization.

CLO.3 Apply the skill on different Cloud Types and Cloud Service Deployment Models (IaaS*, PaaS*, SaaS*).

CLO.4 Learn How to Create Virtual Machines (VM) using Hypervisors (type-2).

CLO.5 Understand Computer Networks and IP Addressing.

Course Outline

Cloud Computing: Concept, Definition, Cloud Types and Service Deployment Models.

Concept of Virtualization

Demonstration of Virtualization using Type-2 Hypervisor and VMs

Creating a VM and install Kali Linux on the VM

Demonstration of IaaS, PaaS and SaaS through real life examples

Computer Networks: Concept, Gateway, Router, Local Area Network (LAN), Wide Area Network (WAN).

IP Address: Concept, Public IP, Private IP, IPv4, Subnet.

AAA (Accounting, Authentication and Authorization): Concept, Real Life Demonstration of AAA.

Recommended Books:

- Le, D. N., Kumar, R., Nguyen, G. N., & Chatterjee, J. M. (2018). Cloud computing and virtualization. John Wiley & Sons.

- Le, D. N., Kumar, R., Nguyen, G. N., & Chatterjee, J. M. (2018). Cloud computing and virtualization. John Wiley & Sons.
- Baun, C., Kunze, M., Nimis, J., & Tai, S. (2011). Cloud computing: Web-based dynamic IT services (Vol. 100). Heidelberg: Springer.
- Dhamdhere, S. N. (Ed.). (2013). Cloud computing and virtualization technologies in libraries. IGI Global.

Course Code	Course Name	L-T-P	Credits
CS 960	Natural Language Processing	4-0-0	4

Course Learning Outcomes (CLO):

- CLO.1 Learning the basic concepts and skills of Artificial Intelligence.
- CLO.2 Represent Knowledge using propositional calculus and predicate calculus.
- CLO.3 Use inference rules to produce predicate calculus expression.
- CLO.4 Demonstrate awareness of informed search and uninformed search techniques.
- CLO.5 Explain about AI techniques for planning, knowledge representation and management.
- CLO.6 Outline the process involved in Expert systems and in building such systems.

Course Outline

Introduction and Overview What is Natural Language Processing, hands-on demonstrations. Ambiguity and uncertainty in language. The Turing test. Regular Expressions Chomsky hierarchy, regular languages, and their limitations. Finite-state automata. Practical regular expressions for finding and counting language phenomena. A little morphology. Exploring a large corpus with regex tools. Programming in Python An introduction to programming in Python. Variables, numbers, strings, arrays, dictionaries, conditionals, iteration. The NLTK (Natural Language Toolkit) String Edit Distance and Alignment Key algorithmic tool: dynamic programming, a simple example, use in optimal alignment of sequences. String edit operations, edit distance, and examples of use in spelling correction, and machine translation.

Context Free Grammars Constituency, CFG definition, use and limitations. Chomsky Normal Form. Top-down parsing, bottom-up parsing, and the problems with each. The desirability of combining evidence from both directions Non-probabilistic Parsing Efficient CFG parsing with CYK, another dynamic programming algorithms. Early parser. Designing a little grammar, and parsing with it on some test data. Probability Introduction to probability theory Joint and conditional probability, marginals, independence, Bayes rule, combining evidence. Examples of applications in natural language. Information Theory The "Shannon game"--motivated by language! Entropy, cross entropy, information gain. Its application to some language phenomena.

Language modeling and Naive Bayes Probabilistic language modeling and its applications. Markov models. N-grams. Estimating the probability of a word, and smoothing. Generative models of language. Part of Speech Tagging and Hidden Markov Models, Viterbi Algorithm for Finding Most Likely HMM Path Dynamic programming with Hidden Markov Models, and its use for part-of-speech tagging, Chinese word segmentation, prosody, information extraction, etc.

Probabilistic Context Free Grammars Weighted context free grammars. Weighted CYK. Pruning and beam search. Parsing with PCFGs A tree bank and what it takes to create one. The probabilistic version of CYK. Also: How do humans parse? Experiments with eye-tracking. Modern parsers. Maximum Entropy Classifiers The maximum entropy principle and its relation to maximum likelihood. Maximum entropy classifiers and their application to document classification, sentence segmentation, and other language tasks

Maximum Entropy Markov Models & Conditional Random Fields Part-of-speech tagging, noun-phrase segmentation and information extraction models that combine maximum entropy and finite-state machines. State-of-the-art models for NLP. Lexical Semantics Mathematics of Multinomial and Dirichlet distributions, Dirichlet as a smoothing for multinomial's. Regulations Information Extraction & Reference Resolution- Various methods, including HMMs.

Recommended Books

- Dhamdhere, S. N. (Ed.). (2013). Cloud computing and virtualization technologies in libraries. IGI Global.
- Manning, C., & Schutze, H. (1999). Statistical natural Language processing.
- Allen, J. (1988). Natural language understanding. Benjamin-Cummings Publishing Co., Inc..
- Charniak, E. (1996). Statistical language learning. MIT press.
- Jelinek, F. (1998). Statistical methods for speech recognition. MIT press.

Course Code	Course Name	L-T-P	Credits
CS 961	Pattern Recognition	4-0-0	4

Course Learning Outcomes (CLO):

- CLO.1 Understand and gain skills of basic concepts in pattern recognition
- CLO.2 Gain knowledge about state-of-the-art algorithms used in pattern recognition research
- CLO.3 Understand pattern recognition theories, such as Bayes classifier, linear discriminant analysis.
- CLO.4 Apply pattern recognition techniques in practical problems.

Course Outline

PATTERN RECOGNITION OVERVIEW Pattern recognition, Classification and Description— Patterns and feature Extraction with Examples—Training and Learning in PR systems—Pattern recognition Approaches

STATISTICAL PATTERN RECOGNITION Introduction to statistical Pattern Recognition— supervised Learning using Parametric and Non Parametric Approaches.

LINEAR DISCRIMINANT FUNCTIONS AND UNSUPERVISED LEARNING AND CLUSTERING (9 hours) Introduction—Discrete and binary Classification problems— Techniques to directly Obtain linear Classifiers -- Formulation of Unsupervised Learning Problems—Clustering for unsupervised learning and classification.

SYNTACTIC PATTERN RECOGNITION Overview of Syntactic Pattern Recognition—
Syntactic recognition via parsing and other grammars—Graphical Approaches to syntactic pattern
recognition—Learning via grammatical inference.

NEURAL PATTERN RECOGNITION Introduction to Neural networks—Feedforward Networks
and training by Back Propagation—Content Addressable Memory Approaches and Unsupervised
Learning in Neural PR.

Recommended Books

- Robert, J. S. (1992). Pattern Recognition: Statistical, Structural and Neural Approaches. New York.
- Bezdek, J. C., Keller, J., Krisnapuram, R., & Pal, N. (1999). Fuzzy models and algorithms for pattern recognition and image processing (Vol. 4). Springer Science & Business Media.
- Duda, R. O., & Hart, P. E. (2006). Pattern classification. John Wiley & Sons.
- Hart, P. E., Stork, D. G., & Duda, R. O. (2000). Pattern classification. Hoboken: Wiley.
- Bishop, C. M. (1995). Neural networks for pattern recognition. Oxford university press.

Course Code	Course Name	L-T-P	Credits
CSL4211	Advanced Algorithms	4-0-0	4

Course Learning Outcomes:

Students will be able to:

CLO.1 Analyze algorithms and algorithm correctness.

CLO.2 Analyze time complexities of algorithms using asymptotic analysis.

CLO.3 Summarize searching and sorting techniques.

CLO.4 Describe stack, queue and linked list operation. Compare different data structures and pick an appropriate data structure for a design situation.

CLO.5 Explain the major graph and tree algorithms and their analysis skills. Employ graphs to model engineering problems.

Course Outline

Analysis of Algorithm: The efficient algorithm, Average, Best and worst case analysis, Amortized analysis, Asymptotic Notations, Analyzing control statement, Loop invariant and the correctness of the algorithm, Sorting Algorithms and analysis: Shell sort, Heap sort, Sorting in linear time: Bucket sort, Radix sort and Counting sort

Dynamic Programming

Introduction, The Principle of Optimality, Problem Solving using Dynamic Programming – Calculating the Binomial Coefficient, Making Change Problem, Assembly Line-Scheduling, Knapsack problem, Shortest path, Matrix chain multiplication, Longest Common Subsequence.

Backtracking and Branch and Bound: Introduction, The Eight queen problem, Knapsack problem, Travelling Salesman problem, Minimax principle

Introduction to NP-Completeness: The class P and NP, Polynomial reduction, NP-Completeness Problem, NP-Hard Problems. Travelling Salesman problem, Hamiltonian problem, Approximation algorithms

Randomized Algorithms: Introduction, Type of Randomized Algorithms, Min- Cut, 2-SAT; Game Theoretic Techniques, Random Walks.

Parallel Algorithms

PRAM. Pointer Jumping and Parallel Prefix. Tree Contraction. Divide and Conquer. Randomized Symmetry Breaking. Maximal Independent Set.

External-Memory Algorithms

Accounting for the Cost of Accessing Data from Slow Memory. Sorting. B-trees. Buffer Trees. Cache-oblivious Algorithms for Matrix Multiplication and Binary Search.

Recommended Books:

- Introduction to Algorithms, Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, PHI.
- Fundamental of Algorithms by Gills Brassard, Paul Bratley, PHI.
- Introduction to Design and Analysis of Algorithms, AnanyLevitin, Pearson.
- Foundations of Algorithms, Shailesh R Sathe, Penram
- Design and Analysis of Algorithms, Dave and Dave, Pearson.

Course Code	Course Name	L-T-P	Credits
CSL4664	Requirement Elicitation	4-0-0	4

Course Learning Outcomes:

Students will be able to:

- CLO.1 Establish a structure and process for gathering skill and information through interviews and group sessions
- CLO.2 Conduct a successful skillful information gathering session
- CLO.3 Identify and deal with interview and meeting problems
- CLO.4 Catch and clarify assumptions and misinformation
- CLO.5 Facilitate and mediate among the participants

Course Outline

The essential software requirement: Software requirements defined, Some interpretations of requirement”, Levels and types of requirements, Working with the three levels, Product vs. project requirements, Requirements development and management, Requirements development, Requirements management, When bad requirements happen to good people, Insufficient user involvement, Inaccurate planning, Creeping user requirements, Ambiguous requirements, Gold plating, Overlooked stakeholders, Benefits from a high-quality requirements process

A requirements development process framework: Requirements elicitation, Requirements analysis, Requirements specification, Requirements validation, Requirements management, Knowledge & Project management, getting started with new practices

Establishing the business requirements: Defining business requirements, Identifying desired business benefits, Product vision and project scope, Conflicting business requirements, Vision and scope document, Business requirements, Scope and limitations, Business context, Scope representation techniques, Context diagram, Ecosystem map, Feature tree, Event list, Keeping the scope in focus, Using business objectives to make scoping decisions, Assessing the impact of scope changes, Vision and scope on agile projects, Using business objectives to determine completion

Requirements elicitation: Requirements elicitation techniques, Interviews, Workshops, Focus groups, Observations, Questionnaires, System interface analysis, User interface analysis, Document analysis, Planning elicitation on your project, Preparing for elicitation

Writing excellent requirements: Characteristics of excellent requirements, Characteristics of requirement statements, Characteristics of requirements collections, Guidelines for writing requirements, System or user perspective, writing style, Level of detail, Representation techniques, avoiding ambiguity, Avoiding incompleteness

Modelling the requirements: From voice of the customer to analysis models, Selecting the right representations, Data flow diagram, Swimlane diagram, State-transition diagram and state table, Dialog map, Decision tables and decision trees, Event-response tables, A few words about UML diagrams, Modelling on agile projects, Scenario, User Considerations, Involving Clients, Use Cases, Wireframes, Storyboards, Product Backlog, Story Maps.

Recommended Books

- Software Requirements by Karl Wiegers and Joy Beatty, Third Edition, Microsoft Press

Course Code	Course Name	L-T-P	Credits
CS 962	Next Generation Wireless & Sensor Networks	4-0-0	4

Course Learning Outcomes (CLO):

- CLO.1 Introduction to wireless networks, architectures and technologies.
- CLO.2 Wireless sensor network platforms: Hardware and Software.
- CLO.3 Communication architecture and protocols for WSN (MAC, Link, Routing).
- CLO.4 Apply the sensor data acquisition, processing and handling.
- CLO.5 Demonstrate learning skills on functioning of wireless communication system and evolution of different wireless communication systems and standards.
- CLO.6 Explain the architecture, functioning, protocols, capabilities and application of various wireless communication networks.

Course Outline

Module 1: Overview of wireless communication, cellular communication, different generations and standards in cellular communication system, satellite communication including GPS, wireless local loop, cordless phone, paging systems, RFID.

Module 2: Recent wireless technologies: multicarrier modulation, OFDM, MIMO system, diversity multiplexing trade-off, MIMO-OFDM system, smart-antenna; beamforming and MIMO, cognitive radio, software defined radio, communication relays, spectrum sharing.

Module 3: Multiple access techniques in wireless communication: contention-free multiple access schemes (FDMA TDMA, CDMA, SDMA and Hybrid), contention-based multiple access schemes (ALOHA and CSMA).

Introduction and overview of Wireless Sensor Networks (WSN), Commercial and Scientific Applications of WSN, Category of Applications of WSN, Challenges for WSN, Enabling Technologies for WSN.

Single node Architecture: Hardware Components, Energy Consumption of Sensor nodes, Operating Systems and Execution Environments, Examples of Sensor Nodes, Network **Architecture:** WSN Scenarios, Optimization Goals and figures of Merits, Design principles for WSNs, Service Interfaces for WSNs, Gateway Concepts.

Physical Layer: Wireless Channel and Communication Fundamentals, Physical Layer & Transceiver Design Considerations in WSN, MAC Protocols: Fundamentals, MAC Protocols for WSNs, IEEE802.15.4 MAC Protocol, Routing Protocols: Gossip and agent based unicast protocols, Energy Efficient Unicast, Broadcast and Multicast, Geographic Routing, Transport Control Protocols: Traditional Protocols, Design Issues, Examples of Transport Protocols, Performance of Transport Control Protocols.

Sensor Tasking and Control: Information-Based Sensor Tasking, Joint Routing Information Aggregation, Sensor Network Databases: Challenges, Query Interfaces, In-Network Aggregation, Data Centric Storage, Data Indices and Range queries, Distributed Hierarchical Aggregation, Temporal Data.

Recommended Books:

- Chilamkurti, N., Zeadally, S., & Chaouchi, H. (Eds.). (2013). Next-generation wireless technologies: 4G and beyond. Springer Science & Business Media.

- Shorey, R., Ananda, A., Chan, M. C., & Ooi, W. T. (Eds.). (2006). Mobile, wireless, and sensor networks: technology, applications, and future directions. John Wiley & Sons.
- Ullah, S., Rodrigues, J. J., Khan, F. A., Verikoukis, C., & Zhu, Z. (2014). Protocols and architectures for next-generation wireless sensor networks. International Journal of Distributed Sensor Networks, 10(12), 705470.
- Behzad, M., Abdullah, M., Hassan, M. T., Ge, Y., & Khan, M. A. (2019). Performance optimization in IoT-based next-generation wireless sensor networks. In Transactions on Computational Collective Intelligence XXXIII (pp. 1-31). Springer, Berlin, Heidelberg.

Course Code	Course Name	L-T-P	Credits
CS 963	Big Data Analytics	4-0-0	4

Course Learning Outcomes (CLO):

- CLO.1 Identify Big Data and its Business Implications.
- CLO.2 List the components of Hadoop and Hadoop Eco-System
- CLO.3 Access and Process Data on Distributed File System
- CLO.4 Skilled to manage Job Execution in Hadoop Environment
- CLO.5 Skilled to develop Big Data Solutions using Hadoop Eco System
- CLO.6 Analyze Info sphere Big Insights Big Data Recommendations.
- CLO.7 Apply Machine Learning Techniques using R.

Course Outline

INTRODUCTION TO BIG DATA AND HADOOP

Types of Digital Data, Introduction to Big Data, Big Data Analytics, History of Hadoop, Apache Hadoop, Analysing Data with Unix tools, Analysing Data with Hadoop, Hadoop Streaming, Hadoop Echo System, IBM Big Data Strategy, Introduction to Info sphere Big Insights and Big Sheets.

HDFS (Hadoop Distributed File System)

The Design of HDFS, HDFS Concepts, Command Line Interface, Hadoop file system interfaces, Data flow, Data

Ingest with Flume and Scoop and Hadoop archives, Hadoop I/O: Compression, Serialization, Avro and File-Based

Data structures.

Map Reduce

Anatomy of a Map Reduce Job Run, Failures, Job Scheduling, Shuffle and Sort, Task Execution, Map Reduce Types and Formats, Map Reduce Features.

Hadoop Eco System

Pig : Introduction to PIG, Execution Modes of Pig, Comparison of Pig with Databases, Grunt, Pig Latin, User Defined Functions, Data Processing operators.

Hive : Hive Shell, Hive Services, Hive Metastore, Comparison with Traditional Databases, HiveQL, Tables, Querying Data and User Defined Functions.

Hbase : HBasics, Concepts, Clients, Example, Hbase Versus RDBMS.

Big SQL : Introduction

Data Analytics with R

Machine Learning : Introduction, Supervised Learning, Unsupervised Learning, Collaborative Filtering.

Big Data Analytics with BigR.

Recommended Books:

- White, T. (2012). Hadoop: The definitive guide. " O'Reilly Media, Inc.".
- Acharya, S., & Chellappan, S. (2015). Big data and analytics. Book.

Course Code	Course Name	L-T-P	Credits
CS 964	Soft Computing	4-0-0	4

Course Learning Outcomes (CLO):

CLO.1 Learn about soft computing skills and techniques of their applications

CLO.2 Analyze various neural network architectures

CLO.3 Understand perceptrons and counter propagation networks.

CLO.4 Define the fuzzy systems

CLO.5 Analyze the genetic algorithms and their applications.

Course Outline

Intelligent Agents: Agents Behavior and Environments, Structure of Agents, Planning Problem, Planning with state Space Search, Partial order Planning, GRAPHPLAN, Planning in logic, Planning in non-deterministic domains, hierarchical task planning, Multi agent planning, execution.

Probabilistic Reasoning Fuzzy Logic: Knowledge representation under uncertainty, Bayesian theorem, Bayesian Networks, Dempster Shafer theory, Representing vagueness, Fuzzy sets, operation on fuzzy sets, reasoning with fuzzy logic, Fuzzy Automata, Fuzzy Control methods, Fuzzy decision making, inference in temporal models, Hidden Markov Models, Kalman Filters.

Neural Networks: Basic concepts, Single layer perception, Multilayer Perception, Supervised and Unsupervised learning - Backpropagation networks - Kohonen's self organizing networks - Hopfield network. Introduction to Artificial Neural Systems - Perceptron - Representation - Linear separability - Learning – Training algorithm -Adaptive networks based Fuzzy interface systems - Classification and Regression Trees - Data clustering algorithms - Rule based structure identification - Neuro-Fuzzy controls - Simulated annealing.

Genetic Algorithms: Evolutionary computation. Survival of the Fittest - Fitness Computations - Cross over – Mutation, Reproduction - Rank method - Rank space method.

Recommended Book:

- Russell, S. J. (2010). Artificial intelligence a modern approach. Pearson Education, Inc..
- Michael, N. (2005). Artificial intelligence a guide to intelligent systems.
- Yegnanarayana, B. (2009). Artificial neural networks. PHI Learning Pvt. Ltd..
- Hagan, M. T., Demuth, H. B., & Beale, M. (1997). Neural network design. PWS Publishing Co..
- Goldberg, D. E. (2006). Genetic algorithms. Pearson Education India.

Course Code	Course Name	L-T-P	Credits
CS 965	Communication Network and Protocols	4-0-0	4

Course Learning Outcomes (CLO):

- CLO.1 Understand the basics of data communication, networking, internet and their importance.
- CLO.2 Analyze the services and features of various protocol layers in data networks.
- CLO.3 Differentiate wired and wireless computer networks
- CLO.4 Analyse TCP/IP and their protocols.
- CLO.5 Recognize the different internet devices and their functions.
- CLO.6 Identify the basic skills on security threats of a network.

Course Outline

Data communication-data representation, data flow, components. Definition of node, link, branch, network, network criteria. Physical structures-types of connection, working of different network topologies, network configuration and their advantages, concepts and comparison of LAN, MAN, WAN. Switching - concepts of circuit switching, packet switching & message switching and their applications.

Protocol layering-Scenarios, principles. Logical connection-connection oriented and connection less. Protocols in computer communications, OSI reference model - functions of all layers. Data link control- concept of framing, flow control and error control.MAC protocol- addressing mechanism. Concept of encapsulation and decapsulation.

Local area network-wired LANs features and classification. Ethernet- properties, frame format (IEEE 802.3), addressing, simple problems on addressing. virtual LAN- working, advantages. Access method–CSMA/CD. Token passing LANS- properties, token bus maintenance and working. Token ring properties, mechanism. FDDI –operation, self healing, Wireless LANS - features, Bluetooth architecture (IEEE 802.15). Basic concepts of WIMAX, cellular telephony, satellite networks.

TCP/IP-Model, protocols layers, INTERNET Address, logical address, Physical address, UDP/IP Datagram Format, classes of IP address, Dotted Decimal notation of IP address, basics of IPv4 and IPv6, simple problems on addressing. Address mapping –static mapping, dynamic mapping. ARP-need, methods, need of RARP and ICMP. Definition of fragmentation and reassembly. Features of TCP, relationship between TCP and IP.

Concepts of Ports and Sockets. Domain Name System (DNS) -name system, name space, working of DNS server. Email- architecture, protocols, advantages of IMAP. Basics of FTP, FTP Connections - Control and Data transfer Connection. Frame relay- Need, Working of frame relay, ATM- Architecture, characteristics.

Internetworking-need and concept. Connecting Devices-discussion on Routers, switches, repeaters, Bridges, Switches and Gateways. Ways of accessing the internet- Dial-up access, SLIP, PPP, leased lines, DSL basics, internet access by cable. Modems-basics, types, operation, applications. Network security-basics of threats and fire wall.

Recommended Book:

- Higginbottom, G. N. (1998). Performance evaluation of communication networks. Artech House, Inc..
- Boukerche, A. (Ed.). (2008). Algorithms and protocols for wireless and mobile ad hoc networks. John Wiley & Sons.
- Ilyas, M., & Mahgoub, I. (2018). Smart Dust: Sensor network applications, architecture and design. CRC press.
- Tonguz, O. K., & Ferrari, G. (2006). Ad hoc wireless networks: a communication-theoretic perspective (Vol. 5). Hoboken: Wiley.

13. Appendix A: Mapping of Programme Outcomes with Course Outcomes

S. No.	Course Code	Title of the course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12		
1	CS902	Data Warehouse & Mining	CO1: Understand the functionality of the various data mining and data warehousing components.										M				
			CO2: Appreciate the strengths and limitations of various data mining and data warehousing models					L						M			
			CO3: To acquire knowledge about data preprocessing, quality, manage, manipulate, clean and analyse data.		M												
			CO4: To acquire knowledge about modeling and design of data warehouses.	M													L
			CO5: To implement various data clustering and		L												

			classification approaches.												
2	CS903	Cryptography & Network Security	CO1: Identify common network security vulnerabilities/attacks.			L									
			CO2: Explain the foundations of Cryptography and network security.			L							H		
			CO3: Critically evaluate the risks and threats to networked computers.					M							
			CO4: Demonstrate detailed knowledge of the role of encryption to protect data. Analyze security issues arising from the use of certain types of technologies.						L						
			CO5: Identify the appropriate procedures required to secure networks.								M				
3	CS906	Advanced	CO1: Learn the various data	H										L	

		Data Structures	structures used.												
			CO2: Understand the data visualization.								H				
4	CS907	Advanced Data Structures Lab	CO1: Learn the installation of software.		H										
			CO2: Write loops, functions and pass arguments.					M							H
5	CS921	Advanced Computer Networks	CO1: Understand the main abstract concepts related to the layered communication architecture.	M											
			CO2: Analyze and implement some of the most advanced routing and congestion control algorithms. Evaluate the performances of computer networks (through mathematical modeling and simulation).							M					

			CO3: Understand basics and principles of new generation of computer networking infrastructure (VoIP, SIP, RTP).	M										
			CO4: Practice Networking Simulating skills as employed in Industry for Planning and Design (CISCO Packet Tracer).		H							H		
6	CS922	Advanced Computer Networks Lab	CO1: understand the captured data by using the relevant tools and focus on the involvement of layered approach in data transmission.								M			
			CO2: enhance the analytical skills of the students to understand and simulate the working of TCP/IP reference model.											

7	RS991	Intellectual Property Rights and Publishing Research (I)	CLO:1 Understand the basics and need of IPRs.																				
			CLO:2 Fill the invention disclosure form for patenting of an idea.																				
			CLO:3 Conduct the prior art to decide the patentability of the idea.																				
			CLO:4 Skilled to draft provisional/complete specifications of the patent application.																				
			CLO:5 Understand the challenges of the country in cause of promoting high quality research.																				
			CLO:6 Better appreciate the meaning of some basic terminologies related to general parameters used for gauging the research outcome.																				
			CLO:7 Use the Nature Master Class solution to their advantage, which will further																				

			help them in writing better quality research papers.													
8	EC909	Digital Image Processing	CLO1: Understand fundamental steps of digital image processing.	M												
			CLO2: Examine various types of images, intensity transformations and spatial filtering.					M							L	
			CLO3: Understand, implement and compare various image enhancement techniques.									L				
			CLO4: Implement and compare various image compression techniques.									M				
			CLO5: Apply image processing algorithms in practical applications.		H											
9	EC910	Digital Image	CLO1: Understand the installation of software		H											

		Processing Lab	CLO2: Practice the codes on software to gain better knowledge		H										L			
10	CS913	Advanced Operating Systems	CLO1: Create Cloud using multiple operating systems simultaneously.					M										
			CLO2: Detailed case study on Linux family.					M										
			CLO3: Live experiments on concurrency, threads and deadlocks.			H												
			CLO4: To create your own operating system.				H					L						
11	RS992	Intellectual Property Rights and Publishing Research (II)	CLO1: appreciate the need of involving himself in cause of research.					H										
			CLO2: understand different aspects involved in a research article which make that a great paper.						M									

			CLO3: prepare a good summary of the literature survey carried out before starting to write a research paper himself.						M					
			CLO4: full-fledged research paper which can submitted to flagship journals and conferences.					L						
12	CS904	Machine Learning	CLO1: After Completing this course, the students will be able to Analyze the data, identify the problems.					M					H	
			CLO2: The students will able to choose the relevant models and algorithms to turn available data into valuable and useful information.		M						L			
			CLO3: The students will able to apply different machine learning problems.	H										

			CLO4: The students will be able to evaluate the performance of models.		M									
			CLO5: Expose students to new techniques and ideas that can be used to improve the effectiveness of current BI tools.		M					L				
13	CS905	Machine Learning Lab	CLO1: Recognize the characteristics of machine learning that make it useful to real-world problems.							M				
			CLO2: Characterize machine learning algorithms as supervised, semi-supervised, and unsupervised.		M									
			CLO3: Effectively use machine learning toolboxes.		H									
			CLO4: Implement machine learning solutions to classification, regression, and							M				

			clustering problems.															
			CLO5: Understand how to perform evaluation of learning algorithms and model selection.										L					
14	CS952	Programming in Python	CLO1: Demonstrate python lexical features, structures and flow control.															L
			CLO2: Use lists, tuples, and dictionaries in Python programs	H														
			CLO3: Write loops and decision statements in Python.		M													
			CLO4: Use indexing and slicing to access data in Python programs.			H												
15	CS951	Programming in C#	CLO:1 Implement the concept of object-oriented techniques and methodologies using c#		M													L

			CLO:2 Use Exception Handling concepts and skills for a Robust Application in c#.		M						L			
			CLO:3 Demonstrate an understanding of c# Input and Output								M			
			CLO:4 Develop applications using multithreading concept of c#.		M									
16	CS952	Programming in Python	CLO:1 Run basic python programs.	M									L	
			CLO:2 Use python skills in various fields of Data Science, Machine Learning and	M						L				
			CLO:3 Artificial Intelligence.							M				
			CLO:4 Logic building using looping and decision statements.	M			M							
			CLO:5 Develop problem solving abilities using Python.				M						L	
			CLO:6 Learn building packages and modules for reusability.										M	
17	CS953	Programming in R	CLO:1 Use R skills in various fields of Data Science, Machine Learning				M							

			and Artificial Intelligence.											
			CLO:2 Logic building using looping and decision statements.			M								
			CLO:3 Develop problem solving abilities using R			M						L		
			CLO:4 Learn building packages and modules for reusability.									M		
			CLO:5 Learn GUI development using Widgets in R.			M								L
18	CS954	Advanced Programming in Java	CLO.1 Design the website.			M						L		
			CLO.2 Develop project using Spring framework skill.									M		
			CLO.3 Maintain and enhance existing web platform.			M	M							
			CLO.4 Implement several Data structures using Collection Framework.				M						L	
			CLO.5 Use database connectivity for a complete Java application.										M	

19	CS955	Virtual Private Network	CLO:1 Use highly secure VPN communications, with access rights tailored to individual users				M							
			CLO:2 Use VPN products to add new sites or users, without significantly expanding your existing infrastructure		M								L	
			CLO:3 Extend skills of corporate networks, applications, and collaboration tools by using VPN		M					L				
			CLO:4 Reduce communications costs while increasing flexibility							M				
20	CS956	Biometric Security	CLO:1 Apply biometric matching for identification		M									
			CLO:2 Identify algorithms for finger biometric technology		M								L	
			CLO:3 Apply skills of facial biometrics for identification.		M					L				
			CLO:4 Apply iris biometric, voice biometric, physiological biometrics etc. for identification.							M				

			CLO:3 Design engineering solutions to complex problems utilizing a systems approach			M								
			CLO:4 To implement learning in real life problem for skill development		M								L	
			CLO:5 To propose multiple solution to any given problem and find best out of those.		M					L				
23	CSL959	Cloud Computing and Virtualization	CLO:1 Students will be able to identify the architecture and infrastructure of cloud computing, including SaaS, PaaS, IaaS, public cloud, private cloud, hybrid cloud, etc.							M				
			CLO:2 Students will be able to explain the core issues of cloud computing such as security, privacy, and interoperability.		M									
			CLO:3 Students will be able to identify problems, and explain, analyze, and evaluate	M								L		

			various cloud computing solutions.											
			CLO:4 Students will be able to provide the appropriate cloud computing solutions and recommendations according to the applications used.	M						L				
			CLO:5 Students will be able to build skills to generate new ideas and innovations in cloud computing.	M								L		
24	CS960	Natural Language Processing	CLO:1 Learning the basic concepts and skills of Artificial Intelligence.	M						L				
			CLO:2 Represent Knowledge using propositional calculus and predicate calculus.							M				
			CLO:3 Use inference rules to produce predicate calculus expression.	M	M								L	
			CLO:4 Demonstrate awareness of informed search and uninformed search		M						L			

			techniques.											
			CLO:5 Explain about AI techniques for planning, knowledge representation and management.							M				
			CLO:6 Outline the process involved in Expert systems and in building such systems.		M									
25	CS961	Pattern Recognition	CLO:1 Understand and gain skills of basic concepts in pattern recognition		M								L	
			CLO:2 Gain knowledge about state-of-the-art algorithms used in pattern recognition research		M					L				
			CLO:3 Understand pattern recognition theories, such as Bayes classifier, linear discriminant analysis.							M				
			CLO:4 Apply pattern recognition techniques in practical problems.		M									
26	CS962	Next Generation Wireless and Sensor Networks	CLO:1 Implement skill based knowledge of routing mechanisms and the three classes of approaches: proactive, on-demand, and hybrid	M									L	

			CLO:2 Study about the issues pertaining to major obstacles in establishment and efficient management of Ad-hoc and sensor networks.	M						L				
			CLO:3 Identify the issues and challenges in providing QoS							M				
			CLO:4 Explain about the energy management in ad-hoc networks	M										
			CLO:5 Demonstrate various types of mesh networks.		M								L	
			CLO:6 Implement skill based knowledge of routing mechanisms and the three classes of approaches: proactive, on-demand, and hybrid		M						L			
27	CS963	Big Data Analytics	CLO:1 Understand and implement classical models and algorithms in machine learning as well as python programming concepts.								M			
			CLO:2 Analyze the data, identify the problems		M									
			CLO:3 Learn the skills to analyze relevant models and algorithms to turn available		M								L	

			data into valuable and useful Information.											
			CLO:4 Understand the comparative study of the related approaches.		M						L			
			CLO:5 Explore new techniques and ideas that can be used to improve the effectiveness of current AI tools.								M			
			CLO:6 Understand and implement classical models and algorithms in machine learning as well as python programming concepts.		M									
28	CS964	Soft Computing	CLO:1 Learn about soft computing skills and techniques of their applications		M								L	
			CLO:2 Analyze various neural network architectures		M						L			
			CLO:3 Understand perceptrons and counter propagation networks.								M			
			CLO:4 Define the fuzzy systems		M									
			CLO:5 Analyze the genetic algorithms and their applications.		M	L								

