

Academic Programme Guide

Master of Engineering Computer Science and Engineering

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



w.e.f.

Academic Year: 2019-20

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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 meets 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.

PO11: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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 the written test followed by an interview.

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	CS921	Advanced Computer Networks	3-0-0	3
3	CS922	Advanced Computer Networks Lab	0-0-2	1
2	CS924	Digital Image Processing	3-0-0	3
3	CS925	Digital Image Processing Lab	0-0-2	1
4	RS991	Intellectual Property Rights and Publishing Research - I	1-0-0	1
		Total Credits		13

Semester-2				
S.No	Course Code	Course Title	L-T-P	Credits
1	CS903	Cryptography & Network Security	4-0-0	4
2	CS913	Advanced Operating Systems	4-0-0	4
3	RS992	Intellectual Property Rights and Publishing Research - II	1-0-0	1
4	CS908	Advanced Database Management System	3-0-0	3
5	CS909	Advanced Database Management System Lab	0-0-2	1
		Total Credits		13

Semester-3				
S.No	Course Code	Course Title	L-T-P	Credits
1	CS906	Advanced Data Structures	3-0-0	3
2	CS907	Advanced Data Structures Lab	0-0-2	1
3	RS993	Research Methodology	3-0-0	3
4		Elective – I	4-0-0	4
		Total Credits		11

Semester-4				
S.No	Course Code	Course Title	L-T-P	Credits
1	CS910	Distributed Computing	3-0-0	3
2	CS911	Distributed Computing Lab	0-0-2	1
3		Elective – II	4-0-0	4
4		Elective – III	4-0-0	4
5		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				
Elective I				
S.No	Course Code	Course Title	L-T-P	Credits
1	CS951	Programming in C#	4-0-0	4
2	CS952	Programming in Python	4-0-0	4
Elective II				
S.No	Course Code	Course Title	L-T-P	Credits
1	CS954	Advanced Programming in Java	4-0-0	4
2	CS955	Virtual Private Network	4-0-0	4
3	CS956	Bioinformatics	4-0-0	4
4	CS957	Software testing & Quality Assurance	4-0-0	4
5	CS958	S/W Project Management	4-0-0	4
6	CS959	Cloud Computing & Virtualization	4-0-0	4
7	CS960	Natural Language Processing	4-0-0	4
8	CS961	Pattern Recognition	4-0-0	4
9	CS962	Next Generation Wireless & Sensor Networks	4-0-0	4
Elective III				
S.No	Course Code	Course Title	L-T-P	Credits
1	CS953	Programming in R	4-0-0	4
2	CS963	Big Data Analytics	4-0-0	4
3	CS964	Soft Computing	4-0-0	4
4	CS965	Communication Network and Protocols	4-0-0	4
5	CS962	NEXT GENERATION WIRELESS AND SENSOR NETWORKS	4-0-0	4

6. Assessment and Evaluation

The evaluation will be continuous and the weight-age of various components is as given in Tables specified for each type of course. The evaluation of all courses will be detailed in the course handout document prepared by the course coordinator with the approval of

Head of Department. The document will be shared with students before the start of the session.

Evaluation for Core / Elective / Specialization Course:

Courses can be evaluated in one of these three ways depending upon the course					
Evaluation Component	Weightage (%)	Evaluation Component	Weightage (%)	Evaluation Component	Weightage (%)
Quizzes/Assignments/ Class Tests/Case Studies	10	Formative Assessments (FAs)	20	Sessional Tests (STs)	40
Sessional Tests (STs)	30	Sessional Tests (STs)	30		
End Term Examination	60	End Term Examination	50	End Term Examination	60
Total	100	Total	100	Total	100

Evaluation components for Theory Courses

There are three Sessional Tests (STs) for all theory papers, the average of the best two are considered. However, the course coordinator, with the approval of Head of Department may decide the number of STs required for a specific course. The policy on the evaluation component – ‘Quizzes / Tutorials / Assignments’ (if applicable else weightage is merged in STs) as decided by the course coordinator and Head of Department and is announced separately for each course.

The evaluation components for Lab Courses have weightage for regular lab performances, internal viva-voce, conducted at the end of the academic semester. The End Term Examination for lab courses includes the conduct of experiments and an oral examination (viva voce).

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

Evaluation Components for Lab Courses

Thesis Evaluation Components	
Evaluation Component	Weightage (%)
Synopsis	20
Mid Term	30

Viva	50
Total	100

Evaluation Component for Thesis

7. Rules for Attendance

The program being highly rigorous, all the students are expected to show utmost regularity in attendance. Even a day's absence is detrimental to a student's interest. Therefore, the University's requirements in this regard are very stringent.

The University expects its students to be regular in attending the classes. 75% attendance (of all held sessions – lectures, tutorials, project work) is compulsory in a course to be eligible to appear for End Term Examination. The students are also encouraged for participation in co-curricular activities and can do so in 25% cushion provided in the attendance requirements. 10% concession in attendance requirements is possible only in case of extreme circumstances and at the sole discretion of the Vice-Chancellor.

8. Grading System

The list of Letter Grades is given below:

% Marks Range of total	Grade	Grade Point	Qualitative Meaning
80-100	O	10	Outstanding
70-79	A+	9	Excellent
60-69	A	8	Very Good
55-59	B+	7	Good
50-54	B	6	Above Average
45-49	C	5	Average
40-44	P	4	Pass
0-39	F	0	Fail
	AB		Absent

If a student obtains grade P or above, he/she is declared pass in that course. The grade F is equivalent to failing in that course, in which case, the student has to reappear in the end term examination of that course again, whenever its exam is conducted again with the regular examination, after payment of appropriate examination fee. The rules for grading in reappear exam will be applicable as per the examination policy of the University.

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

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 the student for any particular semester. Formulas for calculation of SGPA and CGPA have been provided as below:

$$SGPA_i = \frac{\sum_{j=1}^n C_{ij} G_j}{\sum_{j=1}^n C_{ij}}$$

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

Where n = number of courses in the semester; N = number of semesters; SGPA_i = SGPA for the ith semester; C_{ij} = number of credits for the jth course in the ith semester; and G_j = Grade point corresponding to the grade obtained in the jth 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 given below. Column - II in the table below depicts the number of credits, which those courses carried. At the end of the semester, the student was awarded 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.

Courses in which student registered (Column – I)	Credits (Column – II)	Letter Grade (Column – III)	Grade Value (Column – IV)	Credit Value (Column – V)	Grade Points (Column – VI)
Course W	3	B+	7	3 x 7	21
Course X	3	A	8	3 x 8	24
Course Y	3	A+	9	3 x 9	27
Course Z	2	O	10	2 x 10	20
Total	11			Total	92

Thus, the total SGPA of the student would be

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

Suppose the SGPA of the student in two successive semesters is 7.0 and 8.0 with respective course credits being 12 and 11, then the CGPA would be

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

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) in which he/she is declared fail. The student shall have to pass all papers within the stipulated maximum duration as prescribed by the University to qualify for the award of the degree.

All students are eligible to register for next semester irrespective of the number of backlogs.

A student is not permitted to register in a term if

- (a) He / She has dues outstanding to the University, hostel, or any recognized authority or body of the University, or
- (b) His / Her grade sheet in his/her immediately preceding term is withheld, or
- (c) 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. Students 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 the following reasons:

- (a) If the registration of a student in a course is not found to be as per 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 case 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.

A student who is duly registered in a term is considered to be on the rolls of the university. After registration, if he/she withdraws from the term, or has been given prior permission to temporarily withdraw from the University for the term, or has been asked to stay away by an appropriate authority of the University will be considered to be on the rolls of the University for that term. While such a student retains the nominal advantage of being on the rolls of the University the loss of time from studies and its consequences cannot be helped by the University.

If for any valid reason a student is unable to register in a term, he/she must seek prior permission of Head of the Department to drop the term. If such permission has not been requested or after a request, the permission has been denied, his/her name would be struck off the rolls of the University and he would no longer be a student of the University. His/her case will be automatically processed and the file will be closed. However, if such a student, after his/her name has been struck off the rolls of the University, is permitted to come back, his/her case can be considered at the sole discretion of the competent authority of the University with the provision that all his/her previous records as a former student are revived under the current academic and administrative structure, regulations and schedule of fees.

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 Master of 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 21 courses of which 8 are core courses and 3 are elective courses. 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):

Students will be able to:

- 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 analyze data.
- 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**

Data Warehousing - Operational Database Systems vs. Data Warehouses - Data Warehouse Architecture-Components - Multidimensional Data Model - Schemas for Multidimensional Databases - OLAP Operations - Indexing – OLAP Queries & Tools. Introduction to KDD process - Knowledge Discovery from Databases - Classifications of Data Mining Systems - Need for Data Preprocessing - Data Cleaning - Data Integration and Transformation - Data Reduction - Data Discretization - Data Generalization and Concept Hierarchy Generation. 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.

Recommended Books:

- Elmars, Navathe, Somayajulu, Gupta, “Fundamentals of Database Systems”, 4thEdition, 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”, 8thEdition Pearson Education, 2007
- Singh S.K., “Database System Concepts, design and application”, Pearson Education, 2006.
- Silberschatz, Korth, Sudarshan, “Database System Concepts”, Mcgraw Hill, 6thEdition, 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
CS921	Advanced Computer Networks	3-0-0	3

Course Learning Outcomes (CLO):

Students will be able to:

- 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**

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.

Introduction to UDP and TCP – User Datagram Protocol (UDP) – TCP and Reliable Byte Stream Service – Congestion Control – Fairness – Recent TCP Versions – TCP Wireless Links - Packet Switching in Routers - Queuing Model – Networks of Queues. 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:

- 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
CS922	Advanced Computer Networks lab	0-0-2	1

Course Learning Outcomes (CLO):

Students will be able to:

- 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**

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
CS924	Digital Image Processing	3-0-0	3

Course Learning Outcomes (CLO):

Students will be able to:

- 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: 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**

Fundamentals of Image Processing: What is Digital Image Processing? Review of Digital Image Processing fundamentals- Elements of visual perception, Image sampling & quantization, Color image models-Image transforms-DFT, DCT, Haar, Hadamard transform 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. Finger print classification-face recognition-Iris recognition- Digital watermarking for image-Medical image processing-Industrial machine vision applications-remote

sensing application.

Recommended Books:

Rafael C. Gonzalez & Richard E. Woods, Digital Image Processing, Pearson Education (2nd edition)

Course Code	Course Name	L-T-P	Credits
CS925	Digital Image Processing Lab	0-0-2	1

Course Learning Outcomes (CLO):

Students will be able to:

CLO1: 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**

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 Image with Disk-shaped Structuring Element

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

Recommended Books:

Rafael C. Gonzalez & Richard E. Woods, Digital Image Processing with MATLAB, Pearson Education (2nd edition)

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

Course Learning Outcomes (CLO):

Students will be able to:

- 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: 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**

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, 2000 Criteria 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.

Introduction and the need for intellectual property right (IPR) –IPR in India – Genesis and Development – IPR in abroad – Important examples of IPR– Copyrights, Trademarks, Patents, Designs, Utility Models, Trade Secrets and Geographical Indications – Industrial Designs. Concept of Patent – Product / Process Patents & Terminology– Duration of Patents – Law and Policy Consideration Elements of Patentability -- Patentable Subject Matter– Procedure for Filing of Patent Application and types of Applications – Procedure for Opposition – Revocation of Patents – Working of Patents- Patent Agent– Qualification and Registration Procedure – Patent databases and information system – Preparation of patent documents – Process for examination of patent application- Patent infringement– Recent developments in patent system

Recommended Books and References:

- B.L.Wadehra; Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal law Publishing Pvt. Ltd., India 2000
- Ajit Parulekar and Sarita D' Souza, Indian Patents Law – Legal & Business Implications; Macmillan India ltd , 2006
- P. Narayanan; Law of Copyright and Industrial Designs; Eastern law House, Delhi, 2010.
- E. T. Lokganathan, Intellectual Property Rights (IPRs): TRIPS Agreement & Indian Laws Hardcover, 2012
- Alka Chawla, P N Bhagwati , Law of Copyright Comparative Perspectives 1st Edition, LexisNexis, 2013
- V. K. Ahuja, Law Relating to Intellectual Property Rights 2nd Edition, LexisNexis, 2nd Edition, 2013

Semester II

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

Course Learning Outcomes (CLO):

Students will be able to:

- CLO1: 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.
Analyze 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**

Security problem in computing, 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, S/MIME. Security Programs – Non-malicious program Errors – Virus and other Malicious Code – Targeted Malicious Code – Control against program threats. Networks intrusion detection system (NIDS) and its role in Perimeter defense, Intrusion prevention systems (IPS) and its limitations, Viruses.

Recommended Books:

- Network Security Essentials by William Stallings, 4th Edition, Pearson Publication
- Applied Cryptography by Bruce Schneier, Edition 2001, Wiley& Sons Inc
- Network security and Cryptography’ by Bernard Menezes, 1st Edition, Cengage Learning Publication.

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

Course Learning Outcomes (CLO):

Students will be able to:

- 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.
- CLO4: To create your own operating system.

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

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 Book(s)

- Operating System Concepts, 9th edition Peter B. Galvin, Greg Gagne, Abraham Silberschatz, John Wiley & Sons, Inc.

- Modern Operating Systems -By Andrew S. Tanenbaum (PHI) Operating Systems 5th Edition, William Stallings, Pearson Education India

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

Course Learning Outcomes (CLO):

Students will be able to:

- CLO1: To appreciate 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**

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:

- Handbook on Intellectual Property Rights in INDIA by Rajkumar S. Adukia
- 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
CS908	Advanced DBMS	3-0-0	3

Course Learning Outcomes (CLO):

Students will be able to:

- CLO.1: Understand the functionality of the various database systems

CLO.2: Practice the codes and study about the case studies

CLO.3: Implement procedures, functions, cursors and triggers and become proficient in PL/SQL programming skills

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.

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, 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):

- Elmarsi, Navathe, Somayajulu, Gupta, “Fundamentals of Database Systems”, 4thEdition, 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”, 8thEdition Pearson Education, 2007
- Singh S.K., “Database System Concepts, design and application”, Pearson Education, 2006.
- Silberschatz, Korth, Sudarshan, “Database System Concepts”, McGraw Hill, 6thEdition, 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
CS909	Advanced Database Management Systems Lab	0-0-2	1

Course Learning Outcomes (CLO):

Students will be able to:

- CLO.1: Learn the installation of the software.
- CLO.2: Design a commercial relational database system, skilled in Oracle, MySQL.

Course Outline:

Table Normalization & EER

- Creating Master Table
- Creating Transaction Tables
- Ensuring Null Integrity & Referential Integrity Constraints
- Testing Normal forms with Joins

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.

Semester III

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

Course Learning Outcomes (CLO):

Students will be able to:

- CLO1: Learn the various data structures used.
CLO2: Understand the data visualization.

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

Introduction to Data Structures: Basic Terminology, Classification of data structures, operations on data structures, Abstract Data Types, The List ADT – Implementation of Lists- Applications of List- The Stack ADT –Stack Model-Implementation of Stacks-Applications of Stack– The Queue ADT – Queue Model-Implementation of Queues– Applications of Queue. 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. General idea of Hashing – Hash function – Separate Chaining – Hash Tables without Linked lists – Rehashing - Binary Heap – Applications of Priority Queues – d-Heaps. 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:

- 'Data Structures' by Schaums' Outlines Indian Adapted Edition 2006 by Seymour Lipschutz, Published by Tata McGraw-Hill Edition
- Tanenbaum, Augenstein, & Langsam, Data Structures using C and C++, Prentice Hall of India, Second edition
- Data structure Theory Problem in Algorithm by R.S Salaria, by Salaria Publisher
- Data Structures in C by Reema Thareja , Oxford Publication, 3rd Edition
- Fundamentals of Algorithm by Sahni and Horowitz 2nd Edition

- Introduction to Algorithms by Cormen 3rd Edition

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

Course Learning Outcomes (CLO):

Students will be able to:

CLO1: Learn the installation of software.

CLO2: Write loops, functions and pass arguments.

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

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.

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

Course Learning Outcomes (CLO):

Students will be able to:

CLO1: Start a carrier in research.

CLO2: Can decide 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**

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 Book(s)

- PanneerSelvam - Research Methodology (Prentice Hall of India, Edition 2008).
- Kothari C R – Research Methodology Methods & Techniques (New Age International Publishers, 2nd Edition, 2004)

Semester IV

Course Code	Course Name	L-T-P	Credits
CS910	Distributed Computing	3-0-0	3

Course Learning Outcomes (CLO):

Students will be able to:

CLO.1: Develop and apply knowledge of parallel and distributed computing skills and methodologies.

CLO.2: Apply design, development, and performance analysis of parallel and distributed applications.

CLO.3: Use the application of fundamental Computer Science methods and algorithms in the development of parallel applications.

CLO.4: Explain the design, testing, and performance analysis of a software system, and to be able to communicate that design to others.

CLO.5: Develop and apply knowledge of parallel and distributed computing techniques and methodologies.

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

Introduction: What is Distributed Computing, Distributed Vs Parallel Computing, History, Characteristics and Need of Distributed Computing, Advantages and Disadvantages, Issues and Challenges, Distributed computing environment, Examples of Distributed Systems.

Distributed System Architecture: Introduction, Middleware, Client – server architectures, Layered Application architecture, Three-tier Architecture, Distributed Object Architecture, Peer-to-peer Architecture, Service Oriented architecture

Message Passing: Introduction, Inter process Communication, Desirable Features of Good Message Passing System, Issues in IPC by Message, Synchronization, Buffering, Multi-datagram Messages, Encoding and Decoding of Message Data, Process Addressing, Failure Handling, Group Communication.

Remote Procedure Calls: Introduction, Remote Procedure Call, Client and Server Stubs, RPC Issues, RPC Model, Marshalling Arguments, Asynchronous RPC, RPC Binding, Practical RPC Systems

Distributed Shared Memory: Introduction, Shared memory, issues of DSM, NUMA Multiprocessors, Granularity, Consistency Models, Replacement strategy, Thrashing

Synchronization: Introduction, Clock Synchronization, Event Ordering, Mutual Exclusion, Election Algorithms.

Resource Management: Introduction, Task assignment approach, Load Balancing approach, Load Sharing Approach, Process Migration, Process Management, Threads, Processor allocation, Real time distributed Systems.

Recommended Books:

- “Distributed Systems: Principles and Paradigms”, Andrew S. Tanenbaum, John Wiley & Sons.
- “Distributed Operating Systems”, Tanenbaum S., Pearson Education.

Course Code	Course Name	L-T-P	Credits
CS911	Distributed Computing Lab	0-0-2	1

Course Learning Outcomes (CLO):

Students will be able to:

CLO.1: Implement and apply knowledge of parallel and distributed computing skills and methodologies.

CLO.2: Implement and design, development, and performance analysis of parallel and distributed applications.

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

S. No.	Experiment Detail
1-2	Implement concurrent echo client-server application <ul style="list-style-type: none"> ○ Implement Client program ○ Implement Server program
3-4	Implementation of Chat application using socket programming in Java <ul style="list-style-type: none"> ○ Implement Chat Client ○ Implement Chat Server
5-6	Create RMI based server-client application <ul style="list-style-type: none"> ○ Implement remote interface ○ Implement the remote object by implementing the remote interface. ○ Implement the client program.
7-8	Create RMI based server-client based Calculator application <ul style="list-style-type: none"> ○ Implement remote interface ○ Implement the remote object by implementing the remote interface. ○ Implement the client program.
9-10	Create CORBA based server-client application <ul style="list-style-type: none"> ○ Implement remote interface ○ Implement the remote object by implementing the remote interface. ○ Implement the client program.

Recommended Books:

- “Distributed Systems: Principles and Paradigms”, Andrew S. Tanenbaum, John Wiley & Sons.
- “Distributed Operating Systems”, Tanenbaum S., Pearson Education.

Electives – I

Course Code	Course Name	L-T-P	Credits
CS951	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#.

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 WriteLine 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, Overload able 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:

- 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
CS952	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.

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.

Decorator basics- coding function decorators- coding class decorators – managing functions and classes –the metaclass model- declaring metaclasses-coding metaclasses-inheritance and instance-metaclass methods

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

Electives – II

Course Code	Course Name	L-T-P	Credits
CS954	Advanced Programming in Java	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

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.

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
CS955	Virtual Private Network	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

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

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 and Reference(s):

- 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
CS956	Bioinformatics	4-0-0	4

Course Learning Outcomes:

Students will be able to:

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.

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.

Course Code	Course Name	L-T-P	Credits
CS957	Software testing & Quality Assurance	4-0-0	4

Course Learning Outcomes:

Students will be able to:

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

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. The future of software quality assurance (p. 257). Springer Nature.

Course Code	Course Name	L-T-P	Credits
CS958	Software Project Management	4-0-0	4

Course Learning Outcomes:

Students will be able to:

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.

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:

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

Course Code	Course Name	L-T-P	Credits
CS959	Cloud Computing & Virtualization	4-0-0	4

Course Learning Outcomes:

Students will be able to:

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.

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.
- Dhamdhare, S. N. (Ed.). (2013). Cloud computing and virtualization technologies in libraries. IGI Global.

Course Code	Course Name	L-T-P	Credits
CS960	Natural Language Processing	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

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.

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 algorithm. Early parser. Designing a little grammar, and parsing with it on some test data. Probability Introduction to probability theory Joint and conditional probability, marginal, 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
CS961	Pattern Recognition	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

- 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.

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
CS962	Next Generation Wireless & Sensor Networks	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

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 their understanding 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.

Module1: 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; beam forming and MIMO, cognitive radio, software defined radio, communication relays, spectrum sharing.

Module 3: Multiple access techniques in wireless communication: contention-free multiple access schemes (FDM/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.

Electives - III

Course Code	Course Name	L-T-P	Credits
CS953	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.

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:

- 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
CS963	Big Data Analytics	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

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 Infosphere Big Insights Big Data Recommendations.

CLO.7 Apply Machine Learning Techniques using R.

INTRODUCTION TO BIG DATA AND HADOOP

Types of Digital Data, Introduction to Big Data, Big Data Analytics, History of Hadoop, Apache Hadoop, Analyzing Data with Unix tools, Analyzing Data with Hadoop, Hadoop Streaming, Hadoop Echo System, IBM Big Data Strategy, Introduction to Infosphere 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
CS964	Soft Computing	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

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.

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 - Kohnen'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
CS965	Communication Network and Protocols	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

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 security threats of a network.

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.

Course Code	Course Name	L-T-P	Credits
CS962	NEXT GENERATION WIRELESS AND SENSOR NETWORKS	4-0-0	4

Course Learning Outcomes (CLO):

Students will be able to:

CLO.1 Understand the basics of sensor communication, networking, internet and their importance.

CLO.2 Analyze the services and features of various protocol layers

CLO.3 Differentiate sensed and wireless computer networks

CLO.4 Analyse protocols.

CLO.5 Recognize the different internet devices and their functions.

CLO.6 Identify the basic security threats of a sensor network.

INTRODUCTION: Challenges for wireless sensor networks, Comparison of sensor network with ad hoc network, Single node architecture, Hardware components, Energy consumption of sensor nodes, Network architecture, Sensor network scenarios, Design principles. (8+6) **SENSOR LOCALIZATION AND TIME SYNCHRONIZATION:** Localization and positioning: Possible approaches, single hop localization, positioning in multihop environments. Time synchronization: Time synchronization problem, protocols based on sender to receiver and receiver to receiver synchronization in WSN. (8+6) **MAC AND ROUTING PROTOCOLS:** Fundamentals of wireless MAC protocols, low duty cycle protocols and wakeup concepts, contention-based protocols, Schedule-based protocols. **ROUTING PROTOCOLS** - Gossiping and agent-based unicast forwarding, Energy-efficient unicast, Broadcast and multicast, geographic routing, Data centric routing, Data aggregation. (8+10) **SENSOR NETWORK PROGRAMMING:** Programming Challenges in Wireless Sensor Networks, Tiny Operating System, Contiki OS, Event-Driven Programming, Techniques for Protocol Programming. **Simulators:** GloMosim, Sensor Sim, ToSSIM and Power TOSSIM.

Recommended Books:

- Sitharama Iyengar S, Nandan Parmeshwaran, Balkrishnan N and Chuka D, “Fundamentals of Sensor Network Programming, Applications and Technology”, John Wiley & Sons, 2011.
- Fei Hu and Xiaojun Cao, “Wireless Sensor Networks Principles and Practice”, CRC Press, 2010.
- Jean Philippe Vasseur and Adam Dunkels, “Interconnecting Smart Objects with IP, The Next Internet”, Morgan Kaufmann, Elsevier, 2010.
- Holger Karl and Andreas willig, “Protocol and Architecture for Wireless Sensor Networks”, John Willey Publication, Oct 2007.
- Feng zhao and Leonidas guibas, “Wireless Sensor Networks: an Information Processing Approach”, Elsevier Publication, 2004.

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	CLO.1: Understand the functionality of the various data mining and data warehousing components.										M				
			CLO.2: Appreciate the strengths and limitations of various data mining and data warehousing models					L									
			CLO.3: To acquire knowledge about data preprocessing, quality, manage, manipulate, clean and analyse data.		M												
			CLO.4: To acquire knowledge about modeling and design of data warehouses.	M													
			CLO.5: To implement various data clustering and classification approaches.		L												

2	CS924	Digital Image Processing	CLO.1: Understand fundamental steps of digital image processing.	M												
			CLO.2: Examine various types of images, intensity transformations and spatial filtering.					M								
			CLO.3: Understand, implement and compare various image enhancement techniques.								L					
			CLO.4: Implement and compare various image compression techniques.								M					
			CLO.5: Apply image processing algorithms in practical applications.		H											
3	CS925	Digital Image Processing Lab	CLO.1: Understand the installation of software		H											
			CLO.2: Practice the codes on software to gain better knowledge		H											
4	CS921	Advanced Computer	CLO.1: Understand the main abstract concepts related to the layered communication	M												

		Networks	architecture.												
			CLO.2: 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					
			CLO.3: Understand basics and principles of new generation of computer networking infrastructure (VoIP, SIP, RTP).	M											
			CLO.4: Practice Networking Simulating skills as employed in Industry for Planning and Design (CISCO Packet Tracer).		H										
5	CS922	Advanced Computer Networks Lab	CLO.1: understand the captured data by using the relevant tools and focus on the involvement of layered approach in data transmission.										H		
			CLO.2: enhance the analytical skills of the students to understand and simulate the									M			

			working of TCP/IP reference model.												
6	RS991	Intellectual Property Rights and Publishing Research (I)	CLO.1: Understand the Basics and Need of IPRs.	H											
			CLO.2: Fill the invention disclosure form for patenting of an idea.								M				
			CLO.3: Conduct the prior art to decide the patentability of the idea.									H			
			CLO.4: Draft provisional/complete specifications of the patent application.									H			
			CLO.5: Understand the challenges of the country in cause of promoting high quality research.	M											
			CLO.6: Better appreciate the meaning of some basic terminologies related to general parameters used for gauging the	H											

			research outcome.												
			CLO.7: Use the Nature Master Class solution to their advantage, which will further help them in writing better quality research papers.							M					
7	RS992	Intellectual Property Rights and Publishing Research (II)	CLO.1: appreciate the need of involving himself in cause of research.				H								
			CLO.2: understand different aspects involved in a research article which make that a great paper.				M								
			CLO.3: prepare a good summary of the literature survey carried out before starting to write a research paper himself.							M					
			CLO.4: full-fledged research paper which can submitted to flagship journals and conferences.					L							
8	CS908	Advanced DBMS	CLO.1: Understand the functionality of the various	M						L					

			database systems.													
			CLO.2: Practice the codes and study about the case studies.										M			
			CLO.3: Implement procedures, functions, cursors and triggers and become proficient in PL/SQL programming skills	M					L							
9	CS909	Advanced DBMS Lab	CLO.1: Learn the installation of the software.		M	L										
			CLO.2: Design a commercial relational database system, skilled in Oracle, MySQL.		M								L			
10	CS913	Advanced Operating Systems	CLO.1: Create Cloud using multiple operating systems simultaneously.					M								
			CLO.2: Detailed case study on Linux family.					M								H
			CLO.3: Live experiments on concurrency, threads and deadlocks.		H											
			CLO.4: To create your own			H				L						

			operating system.												
11	CS903	Cryptography & Network Security	CLO.1: Identify common network security vulnerabilities/attacks.			L									M
			CLO.2: Explain the foundations of Cryptography and network security.				L							M	
			CLO.3: Critically evaluate the risks and threats to networked computers.						M						
			CLO.4: Demonstrate detailed knowledge of the role of encryption to protect data. Analyze security issues arising from the use of certain types of technologies.						L						
			CLO.5: Identify the appropriate procedures required to secure networks.								M				
12	RS993	Research Methodology	CLO.1: Start a carrier in research.	H											
			CLO.2: Can decide about various tools and techniques w										M		

			high will help them in research for analysis, ethics, presentation and writing of research.												
13	CS906	Advanced Data Structures	CLO.1: Learn the various data structures used.	H											
			CLO.2: Understand the data visualization.								H				
14	CS907	Advanced Data Structures Lab	CLO.1: Learn the installation of software.		H										
			CLO.2: Write loops, functions and pass arguments.						M						
15	CS910	Distributed Computing	CLO.1: After Completing this course, the students will be able to Analyze the data, identify the problems.						M						
			CLO.2: The students will able to choose the relevant models and algorithms to turn available data into valuable and useful information.		M							L			
			CLO.3: The students will able to apply different machine learning	H											

			problems.													
			CLO.4: The students will be able to evaluate the performance of models.		M										L	
			CLO.5: Expose students to new techniques and ideas that can be used to improve the effectiveness of current BI tools.		M						L					
16	CS911	Distributed Computing Lab	CLO.1: Implement and apply knowledge of parallel and distributed computing skills and methodologies.								M					
			CLO.2: Implement and design, development, and performance analysis of parallel and distributed applications.		M											
17	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												
18	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		
19	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		

20	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				
21	CS956	Bioinformatics	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				
22	CS957	Software Testing and Quality Assurance	CLO:1 Understand software testing and quality assurance as a fundamental component of software life cycle		M	M									L
			CLO:2 Infer various software models concepts and skills for making the software.			M						L			
			CLO:3 Analyse software creating requirements to									M			

			determine the entities involved in the system and their relationship to one another.												
			CLO:4 To make sure that the result meets the business and user requirements Software testing plays an instrumental role.			M									
			CLO:5 Also, to satisfies the BRS that is Business Requirement Specification and SRS			M									L
23	CS958	S/W Project Management	CLO:1 To acquire presentation and communication skills			M						L			
			CLO:2 Undertake problem identification, formulation and solution to make students employable.									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				
24	CS959	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,								M				

			hybrid cloud, etc.												
			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 various cloud computing solutions.	M								L			
			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			
25	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 techniques.		M							L				
			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											
26	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											
27	CS962	Next Generation Wireless and Sensor	CLO:1 Implement skill based knowledge of routing mechanisms and the three classes of approaches: proactive, on-demand, and hybrid	M										L		

		Networks	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				
28	CS953	Programming in R	CLO:1 Use R skills in various fields of Data Science, Machine Learning and Artificial Intelligence.				M								
			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
29	CS963	Big Data Analytics	CLO:1 Understand and implement classical models and algorithms in machine learning as								M				

			well as python programming concepts.												
			CLO:2 Analyze the data, identify the problems		M										
			CLO:3 Learn the skills to analyze relevant models and algorithms to turn available data into valuable and useful Information.		M								L		
			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										
30	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									
31	CS964 3	Communication Network and Protocols	CLO:1 Skilled to use and implement internet technology			M									
			CLO:2 To understand the functioning of Frame Relay, ATM. and security issues related to data communication in networks			M	L								