NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

CURRICULUM

OF

BACHELOR OF TECHNOLOGY IN COMPUTER SCIENCE AND ENGINEERING

2023 ONWARD ADMISSION BATCH

V0:

First Year Curriculum Recommended by members of UGAC	19.08.2023
First Year Curriculum Approved by the Chairman, Senate	19.08.2023
First Year Curriculum & Syllabus ratified in the 71st Senate meeting (Item No. 71.5(b))	18.12.2023
Entire Curriculum and Syllabus Recommended by UGAC	09.12.2024
Entire Curriculum and Syllabus Approved by the 73rd Senate (Item No. 73.8)	23.03.2025

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

Program Name: Bachelor of Technology in Computer Science & Engineering

DETAILED CURRICULUM

CURRICULUM OF 2021 ONWARD UNDERGRADUATE ADMISSION BATCH FOR COMPUTER SCIENCE & ENGINEERING- B.TECH.

L= Lecture hour/ week; T= Tutorial hour/ week; S= Sessional/ practical hour/ week

C= Subject credit point; H= Subject contact hour/ week.

GROUP – 1

FIRST SEMESTER

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics - I	3	1	0	4	4
2	CSC01	Computer Programming	2	1	0	3	3
3	XEC01	Engineering Mechanics	2	1	0	3	3
4	XEC02*	Basic Electrical and Electronics Engineering	3	0	0	3	3
5	ESC01	Ecology and Environment	2	0	0	2	2
6	CYC01	Engineering Chemistry	3	0	0	3	3
7	CSS51	Computer Programming Laboratory	0	0	3	2	3
8	XES52	Basic Electrical and Electronics Engineering Laboratory	0	0	3	2	3
9	CYS51	Engineering Chemistry Laboratory	0	0	2	1	2
		TOTAL	**15**	**3**	**8**	**23**	**26**

***From the AY2025-26,** L-T-P of XEC02 is 3-1-0, Credit = 4

SECOND SEMESTER

Semester - II							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC02	Mathematics - II	3	1	0	4	4
2	CSC02	Data Structure and Algorithms	2	1	0	3	3
3	PHC01	Engineering Physics	2	1	0	3	3
4	HSC01	Professional Communication	2	0	2	3	4
5	CSS52	Data Structure and Algorithms Laboratory	0	0	3	2	3
6	XES51	Engineering Graphics	0	1	3	3	4
7	PHS51	Engineering Physics Laboratory	0	0	2	1	2
8	XXS51	Extra Academic Activities	0	0	2	1	2
		TOTAL	9	4	12	20	25

GROUP – 2

FIRST SEMESTER

Semester - I							
Sl. No	Code	Subject	L	T	S	C	H
1	MAC01	Mathematics - I	3	1	0	4	4
2	CSC01	Computer Programming	2	1	0	3	3
3	XEC01	Engineering Mechanics	2	1	0	3	3
4	PHC01	Engineering Physics	2	1	0	3	3
5	HSC01	Professional Communication	2	0	2	3	4
6	CSS51	Computer Programming Laboratory	0	0	3	2	3
7	XES51	Engineering Graphics	0	1	3	3	4
8	PHS51	Engineering Physics Laboratory	0	0	2	1	2
9	XXS51	Extra Academic Activities	0	0	2	1	2
		TOTAL	**11**	**5**	**12**	**23**	**28**

SECOND SEMESTER

Semester - II							
Sl. No	Code	Subject	L	T	S	C	H
1	MAC02	Mathematics - II	3	1	0	4	4
2	CSC02	Data Structure and Algorithms	2	1	0	3	3
3	XEC02*	Basic Electrical and Electronics Engineering	3	0	0	3	3
4	ESC01	Ecology and Environment	2	0	0	2	2
5	CYC01	Engineering Chemistry	3	0	0	3	3
6	CYS51	Engineering Chemistry Laboratory	0	0	2	1	2
7	CSS52	Data Structure and Algorithms Laboratory	0	0	3	2	3
8	XES52	Basic Electrical and Electronics Engineering Laboratory	0	0	3	2	3
		TOTAL	**13**	**2**	**8**	**20**	**23**

***From the AY2025-26,** L-T-P of XEC02 is 3-1-0, Credit = 4

THIRD SEMESTER

Semester-III							
Sl.	Code	Subject	L	T	S	C	H
1	**MAC331**	**Mathematics - III**	**3**	**1**	**0**	**4**	**4**
2	**CSC301**	**Discrete Mathematics**	**3**	**1**	**0**	**4**	**4**
3	**CSC302**	**Digital Logic Design**	**3**	**1**	**0**	**4**	**4**
4	**CSC303**	**Algorithm Design and Analysis- I**	**3**	**1**	**0**	**4**	**4**
5	**CSC304**	**Object Oriented Programming**	**3**	**1**	**0**	**4**	**4**
6	**CSS351**	**Digital Logic Design Laboratory**	**0**	**0**	**3**	**2**	**3**
7	**CSS352**	**Algorithms Design Laboratory**	**0**	**0**	**3**	**2**	**3**
8	**CSS353**	**Object Oriented Programming Laboratory**	**0**	**0**	**3**	**2**	**3**
		TOTAL	**15**	**5**	**9**	**26**	**29**

Semester-IV							
Sl.	Code	Subject	L	T	S	C	H
1	CSC401	Computer Organization and Architecture	3	1	0	4	4
2	CSC402	Theory of Computation	3	1	0	4	4
3	CSC403	Operating Systems	3	1	0	4	4
4	CSC404	Database Management Systems	3	1	0	4	4
5	CSS451	Computer Organization Laboratory	0	0	3	2	3
6	CSS452	Operating Systems Laboratory	0	0	3	2	3
7	CSS453	Database Managements System Laboratory	0	0	3	2	3
		TOTAL	12	4	9	22	25
Semester-V							
Sl.	Code	Subject	L	T	S	C	H
1	CSC501	Compiler Design	3	1	0	4	4
2	CSC502	Data Communication and Computer Networks	3	1	0	4	4
3	CSC503	Embedded Systems	3	1	0	4	4
4	CSC504	Algorithm Design and Analysis- II	3	1	0	4	4
5	CSE5XX	Depth Elective - 1	3	0	0	3	3
6	CSS551	Compiler Laboratory	0	0	3	2	3
7	CSS552	Embedded System Laboratory	0	0	3	2	3
		TOTAL	15	4	6	23	25
Semester-VI							
Sl.	Code	Subject	L	T	S	C	H
1	HSC631	Economics and Management Accountancy	3	0	0	3	3
2	CSC601	Software Engineering	3	1	0	4	4
3	CSC602	Artificial Intelligence and Machine Learning	3	1	0	4	4
4	CSE6XX	Depth Elective – II	3	0	0	3	3
5	CSE6XX	Depth Elective – III	3	0	0	3	3
6	CSS 651	Data Communication and Computer Networks Laboratory	0	0	3	2	3
7	CSS652	Software Engineering Laboratory	0	0	3	2	3
8	CSS653	Artificial Intelligence and Machine Learning Laboratory	0	0	3	2	3
		TOTAL	15	2	9	23	26
Semester-VII							
Sl.	Code	Subject	L	T	S	C	H
1	MSC731	Principles of Management	3	0	0	3	3
2	CSC 701	Data Science	3	1	0	4	4
3	CSE7XX	Depth Elective – IV	3	0	0	3	3
4	CSE7XX	Depth Elective - V	3	0	0	3	3
5	YYO74*	Open Elective - I	3	0	0	3	3
6	CSS751	Data Science Laboratory	0	0	3	2	3
7	CSS752	Internet Technologies Laboratory	0	0	3	2	3
8	CSS753	Summer Internship	0	0	2	1	3
9	CSS754	Project-I	0	0	3	1	3

		TOTAL	15	1	11	22	28
Semester-VIII							
Sl.	Code	Subject	L	T	S	C	H
1	CSS851	Project – II	0	0	15	6	15
2	CSS852	Comprehensive Viva	0	0	0	1	0
		TOTAL	0	0	15	7	15

CREDIT UNIT OF THE PROGRAM:

Semester	I+II	III	IV	V	VI	VII	VIII	TOTAL
Credit Unit	43	26	22	23	23	22	7	166

DEPTH ELECTIVE COURSE BASKETS

THE STUDENTS PRIMARILY WILL OPT FROM THE DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER BY HIS/ HER OWN DEPARTMENT. HOWEVER, A STUDENT CAN OPT FOR DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED BY OTHER DEPARTMENT IN A PARTICULAR SEMESTER, WITH THE PERMISSION/ CONSENT FROM HIS/ HER HEAD OF THE DEPARTMENT AND THE CONCERNED TEACHER OF THAT SUBJECT.

Basket of Depth Elective – I

5th Semester

CSE5XX	System Software
CSE5XX	Graph Theory
CSE5XX	Advanced Computer Architecture
CSE5XX	Electronic Design Automation
CSE5XX	Digital Image Processing
CSE5XX	Game Theory and its Applications
CSE5XX	Advanced Database Systems
CSE5XX	Object Oriented System Design

Basket of Depth Elective – II, III

6th Semester

CSE6XX	Internet and Web Technologies
CSE6XX	Mobile Computing
CSE6XX	Internet of Things (IoT)
CSE6XX	Optical Networks
CSE6XX	Distributed Systems
CSE6XX	Semantic Web Technology
CSE6XX	Multimedia Information Systems

CSE6XX	Cloud Computing
CSE6XX	Big Data Modeling and Management
CSE6XX	Complex Network Theory
CSE6XX	Pattern Recognition
CSE6XX	Data Warehousing and Data Mining
CSE6XX	Soft Computing
CSE6XX	Knowledge Management
CSE6XX	Ethics Society and Computer Science
CSE6XX	Computational Intelligence
CSE6XX	Mathematics for AI and ML
CSE6XX	Parallel Algorithms
CSE6XX	Logic for Computer Science
CSE6XX	Digital Systems Testing
CSE6XX	Computational Number Theory
CSE6XX	Optimization Techniques
CSE6XX	Advanced Algorithms

Basket of Depth Elective – IV, V

7th Semester

	DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
CSE7XX	Wireless Adhoc and Sensor Networks
CSE7XX	Information Coding Theory
CSE7XX	Cryptography and Cyber Security
CSE7XX	Biometrics
CSE7XX	Hardware Security
CSE7XX	Blockchain Technology
CSE7XX	Human Computer Interaction
CSE7XX	Speech Processing
CSE7XX	Information Retrieval
CSE7XX	Quantum Computing
CSE7XX	Cellular Automata and its Application
CSE7XX	Computational Geometry
CSE7XX	Incentive Mechanism in Computer Science
CSE7XX	Software Project and Quality Management
CSE7XX	Advanced Optimization Techniques
CSE7XX	Micro-service Architecture
CSE7XX	Computability and Complexity Theory
CSE7XX	Electronic Design Automation
CSE7XX	Explainable AI
CSE7XX	Big Data Analysis
CSE7XX	Natural Language Processing
CSE7XX	Computer Vision
CSE7XX	Expert Systems
CSE7XX	Introduction to Cognitive Computing
CSE7XX	Deep Learning

OPEN ELECTIVE COURSE BASKETS

Basket of Open Elective – I (7thSemester)

CSO7XX	Software Engineering
CSO7XX	Multimedia Technologies
CSO7XX	Computer Networks
CSO7XX	Computational Biology and its Applications
CSO7XX	Data Analytics
CSO7XX	Distributed Computing
CSO7XX	Game Theory and its Applications
CSO7XX	Information Security
CSO7XX	Optical Network
CSO7XX	Internet and Web Technologies
CSO7XX	Soft Computing Techniques
CSO7XX	Quantum Computing
CSO7XX	Object Oriented Technology
CSO7XX	Digital Computer Design
CSO7XX	Fundamental of Algorithms
CSO7XX	Database Management Systems
CSO7XX	Advanced Algorithms
CSO7XX	Compiler Design
CSO7XX	Operating Systems

DETAILED SYLLABUS

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DETAILED SYLLABUS
First Semester

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC01	MATHEMATICS -	PCR	3	1	0	4	4
Pre-requisites		Basic concepts of function, limit, differentiation and integration.					
Course Outcomes	• CO1: learn the fundamentals of differential calculus of single and several variables. • CO2: learn the basic concepts of convergence of infinite series. • CO3: understand the basic concepts of integral calculus along with its various applications. • CO4: acquire the theoretical knowledge of vector calculus and its engineering applications.						
Topics Covered	**Functions of Single Variable:** Review of limit, continuity and differentiability. Mean value theorems: Rolle's Theorem, Lagrange's Mean Value Theorem (MVT), Cauchy's MVT, Taylor's theorem, Taylor's and Maclaurin's series. (8) **Functions of several variables:** Limit, continuity and differentiability of functions of several variables, partial derivatives and their geometrical interpretation, derivatives of composite and implicit functions, derivatives of higher order and their commutativity, Homogeneous function, Euler's theorem and its converse, Exact differential, Jacobian, Taylor's & Maclaurin's series, Maxima and Minima, Necessary and sufficient condition for maxima and minima (no proof). (11) **Sequences and Series:** Real sequences and their convergence, Series of positive terms, Necessary and sufficient condition for convergence, p-series, geometric series, Comparison test, D Alembert's ratio test, Cauchy's root test, Alternating series, Leibnitz's rule, Absolute and conditional convergence. (6) **Integral Calculus:** Review of the idea of integration as a limit of a sum, Mean value theorems of integral calculus, Area and length in Cartesian and polar co-ordinates, Volume and surface area of solids of revolution in Cartesian and polar forms, Improper integrals and their convergence, Beta and Gamma functions. (12) **Multiple Integrals:** Evaluation of double and triple integrals, Change of order of integration, Change to better coordinates, Area and volume by double integration, Volume by triple integration. (10) **Vector Calculus:** Vector valued functions and its differentiability, Line integral, Surface integral, Volume integral, Gradient, Curl, Divergence, Green's theorem in the plane (including vector form), Stokes' theorem, Gauss's divergence theorem and their engineering applications. (9)						
Text Books, and/or reference material	**Text Books:** 1. Kreyszig, E., Advanced Engineering Mathematics: 10th edition, Wiley India Edition, 2010. 2. Murray, D.A., Differential and Integral Calculus, FB & C Limited, 2018. 3. Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2014. 4. Murray Spiegel, Schaum's Outline of Vector Analysis, Tata McGraw Hill .Education, 1980 **Reference Books:**						

	1. Tom Apostal, Calculus-Vol-I & II, Wiley Student Edition, 2011. 2. Thomas and Finny: Calculus and Analytic Geometry, 11th Edition, Addison Wesley.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	2	3	2	3	1	1	-	-	1	1	1	2
	CO2	2	3	2	3	-	1	-	-	1	1	2	2
	CO3	2	3	2	3	-	1	1	-	-	2	2	2
	CO4	3	3	2	3	1	1	-	1	-	2	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC01	**COMPUTER PROGRAMMING**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic knowledge of computer.		CT+MT+EA					
Course Outcomes	• CO1: To understand basics of computer programming, program flow, and programming constructs. • CO2: Develop concepts on basic and complex data types, conditional and iterative statements. • CO3: Exercise the concepts of user defined functions to solve real time problems. • CO4: Inscribe C programs that use Pointers to access arrays, strings and functions. • CO5: Exercise user defined data types including structures and unions to solve problems.						
Topics Covered	**Introduction to C**: Phases of developing a running computer program in C. (2L) Data types, size and values. Char, Unsigned and Signed data types. Number systems and representations. Constants, Overflow. (3L) Data concepts in C: Constants, Variables, Expressions, Operators, and operator precedence in C. (2L) Statements: Declarations, Input-Output Statements, Compound statements, Selection Statements. (2L) Conditions, Logical operators, Precedences. Repetitive statements, While construct, Do-while Construct, For construct. (3L) Arrays. Strings. Multidimensional arrays and matrices. (3L) **Pointers:** Pointer variables. Declaring and dereferencing pointer variables. Pointer Arithmetic. Examples. Accessing arrays through pointers. Pointer types, Pointers and strings. String operations in C. (6L) Dynamic memory allocation. (2L)						

	Modular Programming: Functions: The prototype declaration, Function definition. (3L) Function call: Passing arguments to a function, by value, by reference. Scope of variable names. Recursive function calls, Tail recursion. (4L) Sorting problem: Sorting in arrays with an example of Bubble sort. Sorting in strings. (3L) Search problem: Linear search and binary search. (2L) **More Data-types in C:** Structures in C: Motivation, examples, declaration, and use. Operations on structures. Passing structures as function arguments. type defining structures. (4L) File input-output in C. Streams. Input, output and error streams. Opening, closing and reading from files. Programming for command line arguments. (3L)
Text Books, and/or reference material	**Text Books:** 1. P. Deitel, H. Deitel. C How to Program. Pearson Education India, 7th Ed. 2. B. W. Kernighan, Dennis M. Ritchie. The C Programming. Prentice Hall Software Series, 2nd Ed. **Reference Books:** 1. P. Dey and M. Ghosh. Computer fundamentals and programming in C. Oxford press, 2013. 1. Y. Kanetkar. Let Us C. BPB Publications, Sixteenth edition, 2017.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC01	CO1	2	2	1	-	1	2	-	-	-	-	-	-
	CO2	3	2	1	-	1	1	1	-	-	-	-	-
	CO3	2	2	1	-	-	2	-	-	-	-	-	-
	CO4	3	2	2	-	-	1	-	-	-	-	-	-
	CO5	3	1	2	-	1	2	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XEC01	**ENGINEERING MECHANICS**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: Acquire knowledge of mechanics and ability to draw free body diagrams. • CO2: Apply knowledge of mechanics for solving special problems like truss and frame analysis. • CO3: Ability to calculate centroid, moments of inertia for various shapes. • CO4: Learn momentum and energy principles.						

	• CO5: Knowledge on virtual Work Principle and its application
Topics Covered	Engineering Mechanics; measurement and SI units. [1] Vectors and force as a vector; Resultant of a system of forces on a particle; free body diagram and conditions of equilibrium of a particle; problems on particles; equilibrium of particles in space. [2] Resultant of a system of forces and couples on a rigid body; conditions of equilibrium of a rigid body; free body diagrams of rigid bodies subjected to different types of constraints; simple space problems of rigid bodies. [4] Coefficients of static and kinetic friction; problems involving friction; theories of friction on square threaded power screw and flat belt. [5] Simple trusses; analysis of trusses by method of joints and method of sections. [5] Centre of gravity and centre of mass; centroids of lines, curves and areas; first moment of area; second moment of area; polar moment of inertia; radius of gyration of an area; parallel axis theorem; mass moment of inertia. [4] Path, velocity, acceleration; rectilinear and curvilinear motion; motion of system of particles; introduction to the concept of plane kinematics of rigid bodies. [6] Newton's second law of motion; dynamic equilibrium and D'Alembert's principle; linear momentum; angular momentum; rectilinear and curvilinear motion; principles of work–energy and impulse–momentum; impact of system of particles; introduction to the concept of plane kinetics of rigid bodies. [12] Principle of Virtual Work, Solution of Problems on Mechanics using Principle of Virtual Work [3]
Text Books, and/or reference material	1) S P Timoshenko and D H Young, Engineering Mechanics, 5th Edition 2) J L Meriam and L G Kraige, Engineering Mechanics, 5th Edition, Wiley India 3) F P Beer and E R Johnston, Vector Mechanics for Engineers 4) I H Shames, Engineering Mechanics

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHC01	Engineering Physics	PCR	2	1	0	3	3
Pre-requisites:		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	• CO1: To realize and apply the fundamental concepts of physics such as superposition principle, simple harmonic motion to real world problems. • CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field. • CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization. • CO4: Acquire basic knowledge related to the working mechanism of lasers and signal propagation through optical fibers.
Topics Covered	**Harmonic Oscillations** - Linear superposition principle, Superposition of two perpendicular oscillations having same and different frequencies and phases, Free, Damped and Forced vibrations, Equation of motion, Amplitude resonance, Velocity resonance, Quality factor, sharpness of resonance, [8] **Wave Motion**: Longitudinal waves, Transverse waves, Wave equation, phase velocity and group velocity, Maxwell's equations, Electro-magnetic waves in free space. [3] **Introductory Quantum Mechanics** - Inadequacy of classical mechanics, Blackbody radiation, Planck's quantum hypothesis, de Broglie's hypothesis, Heisenberg's uncertainty principle and applications, Schrodinger's wave equation and applications to simple problems: Particle in a one-dimensional box, Simple harmonic oscillator, Tunnelling effect. [8] **Interference & Diffraction** - Huygens' principle, Young's experiment, Superposition of waves, Conditions of sustained Interference, Concepts of coherent sources, Interference by division of wavefront, Interference by division of amplitude with examples, The Michelson interferometer and some problems; Fraunhofer diffraction, Single slit, Multiple slits, Resolving power of grating. [13] **Polarisation** - Polarisation, Qualitative discussion on Plane, Circularly and elliptically polarized light, Malus law, Brewster's law, Double refraction (birefringence) - Ordinary and extra-ordinary rays, Optic axis etc.; Polaroid, Nicol prism, Retardation plates and analysis of polarized lights. [5] **Laser and Optical Fiber** - Spontaneous and stimulated emission of radiation, Population inversion, Einstein's A & B co-efficient, Optical resonator and pumping methods, He-Ne laser. Optical Fibre– Core and cladding, Total internal reflection, Calculation of numerical aperture and acceptance angle, Applications. [5]
Text Books, and/or reference material	**TEXT BOOKS**: 1. The Physics of Vibrations and Waves, H. John Pain, Willy and Sons 2. A Text Book of Oscillations and Waves, M. Goswami and S. Sahoo, Scitech Publications 3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill. **REFERENCE BOOKS**: 1. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press 2. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons 3. Fundamental of Optics, Jankins and White, McGraw-Hill 4. Optics, A. K. Ghatak, Tata McGraw-Hill 5. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill 6. Lasers and Non-linear Optics, B. B. Laud, New Age International Pvt Lt

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1

	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC01	**Engineering Chemistry**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					

Course Outcomes

- CO1: Students will get the knowledge of fundamentals as well industrial applications of polymer, petroleum products, organometallic compounds and others.
- CO2: Students will be able to elucidate the structure of different organic compounds and to analyze the structure-property correlation.
- CO3: Students will be aware on the role played by different metals in biological systems and also the ecological impact of metals.
- CO4: Students will be able to understand and analyze thermodynamical, kinetic as well as electrochemical aspects of chemical systems and apply the understanding in the technical field.

Topics Covered

ORGANIC CHEMISTRY

i. **Polymer chemistry and polymer engineering:** Fundamental concept on polymer chemistry; synthesis and application of important polymers, Rubber and plastic materials; vulcanization, structure-property correlation: Concept of Molecular weight of polymer, Glass transition temperature. Engineered polymer: Thermally stable, flame retardant, Conducting polymer. (5L)

ii. **Petroleum Engineering and oil refinery:** Origin of petroleum, separation principle and techniques of distillation of crude oil, thermal and catalytic cracking of petroleum, uses of different fractions, knocking, anti-knock compounds, octane number and cetane number. High octane and Aviation fuel. Bio-diesel. (3L)

iii. **Structure elucidation of organic compounds by modern spectroscopic methods:** Application of UV-Visible (Lambert-Beers law), concept of chromophore, auxochrome, hypso-, hyper-, bathochromic, red shift. FT-IR spectroscopy and Mass spectroscopy (including instrumentation). (4L)

INORGANIC CHEMISTRY

i. **Coordination Chemistry:** Crystal Field Theory of octahedral and tetrahedral complexes, colour and magnetic properties, LMCT, MLCT, IVCT. Isomerism and stereochemistry.(5L)

ii. **Bioinorganic Chemistry:** Metal ions in biological systems: Fe, Cu (2L)

iii. **Industrial applicationof Organometallic complexes:** π-acid ligands, stabilization of metal low oxidation state and 18 electron rules, metal carbonyls and nitrosyls, metal-alkene complexes, Various catalytic cycles of industrial importance. (4L)

	iv. **Environmental Chemistry:** Metal toxicity (As, Hg, Pb and Cd) and its remediation (1L) **PHYSICAL CHEMISTRY** i. **Chemical Thermodynamics:** 2nd law of thermodynamics: Concept of thermodynamic engine (Carnotand reverse Carnot cycle), entropy, free energy. Temperature and pressure dependence of entropy and free energy. Change in phase: phase diagram of single component system. Cryogenics: Joule Thomson experiment. (5L) ii. **Chemical Kinetics:** Rate expression of Reversible reaction, parallel reaction, and Consecutive reaction with proper examples. Temp effect on reaction rate.(3L) iii. **Catalysis:** Types of catalysis, Rate expression for Catalysed reaction, Acid-base and Enzyme catalysis.(2L) iv. **Electrochemistry:** EMF, Nernst Equation, Application of electrochemistry in chemical processes. Electrochemical cell, Fuel cell, Li-ion battery (3L).
Text Books, and/or reference material	Suggested Text Books: (i) Physical Chemistry by P. Atkins, Oxford (ii) A guidebook to mechanism in Organic chemistry: Peter Sykes; Pearson Edu. (iii) Inorganic Chemistry Part-I & II, R. L. Dutta, The new book stall Suggested Reference Books: **Organic Chemistry**: (i) Basic stereochemistry of organic molecules: S. Sengupta; Oxford University press (ii) Engineering Chemistry: Wiley (iii) Elementary Organic Spectroscopy: William Kemp, ELBS with Macmillan **Inorganic Chemistry:** (i) Inorganic Chemistry: Principle structure and reactivity, J. E. Huheey, E. A. Keiter and R. L. Keiter, Pearson Education (ii) Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introductionand Guide, 2nd Edition, Wolfgang Kaim, Brigitte Schwederski, Axel Klein. (iii) Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford **Physical Chemistry:** (i) Physical Chemistry by G.W Castellan (ii) Physical Chemistry by P. C. Rakshit

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYC 01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
ESC01	**Ecology and Environment**	PCR	2	0	0	2	2

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
NIL	CT+MT+EA

Course Outcomes	• CO1: Understand the importance of environment and ecosystem. • CO2: Understand the fundamental aspect of pollutant tracking and its implementation in natural and anthropogenic pollution of air and water system. • CO3: Understand the scientific basis of local and as well as global issues. • CO4: Apply of knowledge to develop sustainable solution.
Topics Covered	**UNIT – I: INTRODUCTION (2)** Multidisciplinary nature of Environmental Studies: Definition, Scope, and Importance. **UNIT–II: FUNDAMENTALS OF ECOLOGY (9)** Definition, Components of Environment; Fundamentals of Ecology and Ecosystem; Components and Classification of Ecosystem; Energy flow in Ecosystem: Tropic level, Food Chain, Food Web, Ecological Pyramid; Biogeochemical cycles: Carbon, Nitrogen, Sulphur, Phosphorus, and Water Cycle; Biosphere and Biodiversity; Conservation. **UNIT–III: FUNDAMENTALS OF ENVIRONMENT (10)** **Environmental Pollution:** Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Solid Wastes, and Natural hazards: Floods, earthquakes, cyclones, and landslides. **Environmental Issues:** Climate change and global warming; acid rain; and ozone layer depletion. **Environment Quality:** Ambient air quality standards, Water quality parameters and standards: pH, Turbidity, Hardness, Sulphate, Phosphates, Iron, Dissolved Oxygen, BOD, and COD. **UNIT– IV: NATURAL RESOURCES (3)** Mineral Resources, Energy Resources: Conventional and Non-Conventional. **UNIT- V- GREEN TECHNOLOGY & ENVIRONMENTAL ETHICS (4)** Sustainability: Carbon Sequestration, Green building practices, Green computing; Carrying capacity; and Environment Protection Acts/laws.
Text Books, and/or reference material	1. A Basic Course in Environmental Studies. Deswal & Deswal. Pub. Dhanpat Rai & Sons 2. Ecology. Odum. Pub. Oxford & IBH 3. Environmental Engineering. Peany et.al. Pub. McGraw Hill 4. A Text Book of Environmental Engg. Venugpal Rao. Pub. PHI 5. A Basic Course in Environmental Studies. Deswal & Deswal. Pub. Dhanpat Rai & Sons 6. Environmental Studies. Bharucha. Pub. University of Press 7. Environmental Chemistry and Pollution, S. S. Dara & D. D. Mishra, S. Chand Publishing

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
<tr><td>HSC01</td><td>Professional Communication</td><td>PCR</td><td>2</td><td>0</td><td>2</td><td>4</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">None</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Learners will acquire linguistic proficiency in terms of improvement in their listening, speaking, reading, and writing skills.
• CO2: Learners will acquire better communicative ability.
• CO3: The course will help learners improve their social connectivity skill.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Vocabulary
1. Word Formation, Use of Prefixes and Suffixes (1)
2. Synonyms, Antonyms (1)
3. Prefixes and Suffixes from Foreign Languages, Words from Foreign Languages (1)
4. Abbreviations and Acronyms (1)
5. Technical Vocabulary (1)
Grammar
1. Identifying Common Errors in Articles and Prepositions (1)
2. Common Errors in Noun-Pronoun Agreement and Subject-Verb Agreement (1)
3. Misplaced Modifiers and Tenses (1)
4. Redundancies and Clichés (1)
Reading
1. Reading and Its Importance, Techniques of Effective Reading (1)
2. Improving Comprehension Skills, Techniques for Good Comprehension (1)
3. Skimming and Scanning (1)
4. Comprehension, Intensive and Extensive Reading (2)
Writing
1. Sentence Structures, Phrases and Clauses, Punctuation (2)
2. Organising Principles of Paragraphs (2)
3. Formal Letters, Letters of Complaint, Requisition Letters, Job Application, and Résumé (2)
4. Nature and Style of Sensible Writing, Defining, Describing, Classifying, Providing Examples and Evidence (2)
5. Essay Writing (2)
6. Précis Writing (2)
7. Report Writing (2)
Oral Communication
1. Listening Comprehension (4)
2. Pronunciation, Intonation, Stress, and Rhythm (4)
3. Communication at the Workplace (4)
4. Everyday Conversation (4)</td></tr>
</table>

	5. Group Discussion (4) 6. Interviews (4) 7. Formal Presentations (4)
Text Books, and/or reference material	**Text Book:** 1. English for Engineers –Sudharshana & Savitha (Cambridge UP) **Reference Books:** 2. *English*—Kulbhushan Kumar (Khanna Book Publishing) 3. *Remedial English Grammar*—F. T. Wood (Macmillan)

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
HSC01	CO1	1	--	--	1	--	1	--	1	2	3	1	--
	CO2	1	--	--	1	--	2	--	2	2	3	2	--
	CO3	--	--	--	1	--	3	--	3	3	3	2	--

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Second Semister

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC02	**MATHEMATICS - I**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic concepts of set theory, differential equations, and probability.		CT+MT+EA					
Course Outcomes	• CO1: learn the basic concepts of linear algebra and be able to apply the same to solve various engineering problems. • CO2: understand fundamentals of ordinary differential equations and their applications. • CO3: acquire the theoretical knowledge of Fourier Series, Fourier & Laplace transforms, and learn about their applications. • CO4: learn the basic concepts of probability theory.						
Topics Covered	**Introduction to Algebraic structures:** Group, subgroup, ring, subring, integral domain, and field. (3) **Linear Algebra:** Vector spaces over field, linear dependence and independence of vectors, linear span of a set of vectors, basis and dimension of finite dimensional vector space, elementary row/column operations, rank of a matrix, solutions of system of linear (homogeneous and non-homogeneous) equations, eigenvalues and eigenvectors, characteristic polynomials, Cayley-Hamilton theorem (without proof), Diagonalization of matrices. (15) **Ordinary Differential Equations (ODE):** Review of first order ODE, Picard's theorem (Statement Only), ODE of first order and of the first degree (exact ODE, rules for finding integrating factors), ODE of first order and of the higher degree (ODE solvable for x, solvable for y; Clairaut's equation, singular solution), homogeneous and non-homogeneous linear ODE with constant coefficients and variable coefficients (Euler–Cauchy type), linear dependence of solutions, Wronskian determinant, Solution of simultaneous ODEs ($dx/P = dy/Q = dz/R$; $dx/dt = ax + by$, $dy/dt = cx + dy$), properties of nonlinear ODEs, phase plane analysis. (18) **Fourier series:** Piecewise smooth and periodic functions, Fourier series of a function in an interval, Dirichlet conditions, Convergence of Fourier series, Fourier sine and cosine series, Complex form of Fourier series. (4) **Fourier Transforms:** Fourier Integral Theorem (statement only), Different forms of Fourier Integrals, Fourier Transform and its inversion formula, Properties of Fourier Transform, Convolution. (7) **Laplace Transforms:** Laplace transforms and its Properties, Inverse Laplace transforms, Convolution theorem, Applications to ODE. (4) **Probability:** Random variables and probability distributions (discrete and continuous), Binomial, Poisson, Uniform and Normal distributions. (5)						

Text Books, and/or reference material	**Text Books:** 1. Kreyszig, E., Advanced Engineering Mathematics: 10th edition, Wiley India Edition (2010). 2. Strang, G., Linear algebra and its applications (4th Edition), Thomson (2006). 3. Murray, D.A., Introductory Course in Differential Equations, Khosla Publishing House (2021). 4. Debnath, L., Integral Transforms and Their Applications, CRC Press (1995). 5. Baisnab, A.P., Jas, M., Elements of Probability and Statistics, McGraw Hill Education (2017). **Reference Books:** 1. Kumaresan, S., Linear algebra - A Geometric approach, Chaukhamba Auriyantaliya (2017). 2. Ross, S.L., Differential Equations, 3rd Edition, Wiley Student Edition (2017). 3. Shivamoggi, A., Integral Transforms for Engineers, PHI (2003). 4. Grinstead, C.M., Snell, J.L., Introduction to probability, American Mathematical Society (2012).

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC02	CO1	3	3	2	1	2	-	2	-	-	-	1	2
	CO2	3	3	2	2	2	-	2	-	-	1	-	2
	CO3	3	3	2	2	3	1	1	-	1	1	1	2
	CO4	3	2	1	3	2	1	1	1	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC02	Data Structure and Algorithms	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
CSC01 (Computer Programming)		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		• CO1: Understanding the fundamental concepts of abstract data types, data structures, algorithms and time complexity analysis of algorithms. • CO2: Implementation of different abstract data types (array, linked list, stack, queue, tree, graph). • CO3: Implementation of different sorting and searching techniques along with their performance evaluation. • CO4: Analysis of the suitability/compatibility of different data structures based on the types of applications. • CO5: Design and development of algorithms for real-life applications.					

Topics Covered	**Introduction:** Abstract Data Type (ADT), Data Structures, Concept of static and dynamic memory allocation, Algorithm, Analysis of time and space complexity of algorithms, Asymptotic notations: Big Oh, Big Omega and Big Theta notations, Impact of data structure on the performance of an algorithm. (6L) **Array:** Array as an ADT, Single and multi-dimensional array, Memory representation (row major and column major) of array, Address calculation for array elements. (2L) **Linked list:** Linked list as an ADT, Memory allocation and deallocation for a linked list, Linked list versus array, Types of linked lists: singly linked list, doubly linked list and circular linked list, Operations on linked list: creation, display, insertion and deletion (in different positions), Concatenation, Searching, Sorting, Applications of linked list: Representations and operations on polynomials, sparse matrices, etc., Array vs. Linked List. (6L)
	Stack: Stack as an ADT, Push and pop operations on stacks, Array implementation of stack, Linked list implementation of stack, Applications of stack: Recursion, Function call, Evaluation of postfix expression using stack, Conversion of infix to postfix using stack. (5L) **Queue:** Queue as an ADT, Enqueue and dequeue operations, Array implementation of queue, Limitation of array implementation, Circular queue, Linked list implementation of queue, Priority queue. (4L) **Binary Tree:** Binary Tree, Definition and properties, Representation of binary tree in memory: linked representation, array representation, Binary tree traversal (Preorder, Inorder and Postorder), Binary search tree, Heap (8L) **Searching Algorithms:** Linear search and binary search. (2L) Sorting Algorithms: Selection sort, Insertion sort, Quick sort, and Merge sort. (5L) **Graphs Algorithms:** Graph representation using Adjacency matrix and Adjacency list, Breadth First Search and Depth First Search algorithms. (4L)
Text Books, and/or reference material	**Text Books:** 1. R. F. Gilberg and B. A. Forouzan, "Data Structures: A pseudocode approach with C", 2nd Edition, CENGAGE Learning. 2. A. V. Aho, J. D. Ullman and J. E. Hopcroft, “Data Structures and Algorithms”, Addition Wesley. 3. Lipschutz, “Data Structures (Schaum’s Outline Series)”, Tata Mcgraw Hill. 4. E. Horowitz, S. Sahni, S. Anderson-Freed, “Fundamentals of Data Structures in C”, Universities Press; Second edition (2008). **Reference Books:** 1. Y. Langsam, M. J. Augenstein and A. N. Tanenbaum, "Data Structures using C and C++", Pearson, 2006. 2. Knuth, Donald E. The Art of Computer Programming. 3rd ed. Vols 1&2. Reading, MA: Addison-Wesley, 1997. ISBN: 0201896834. ISBN: 0201896842. ISBN: 0201896850. 3. Kleinberg and Eva Tardos. Algorithm Design. Addison-Wesley 2005 ISBN-13: 978-0321295354.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC02	CO1	3	-	1	1	1	-	-	-	-	-	-	-
	CO2	3	2	1	2	2	-	-	-	-	-	-	1

	CO3	3	2	1	2	2	-	-	-	-	-	-	1
	CO4	3	3	2	3	3	-	-	-	-	-	-	1
	CO5	3	3	3	3	3	-	-	-	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XEC02	**Basic Electrical and Electronics Engineering**	PCR	3	0	0	3	3
Pre-requisites			Course Assessment methods				
(10+2) level mathematics and physics			CT+MT+EA				
Course Outcomes	CO1: Learn the fundamentals of electric circuits and analyze the circuits using laws and network theorems. CO2: Gain the knowledge about magnetic circuits, electromagnetism and the basics of generation of alternating voltage. CO3: Understand the behaviour of single phase and poly-phase AC circuits. CO4: Understand the fundamentals of semiconductor devices. CO5: Analyze the design and characteristics of transistor-based electronic circuits. CO6: Evaluate operational amplifier-based circuits and logic gates.						
Topics Covered	1. Introduction to Electrical systems, Fundamentals of Electric Circuits: Ohm's laws, Kirchhoff's laws, Independent and Dependent sources, Analysis of simple circuits. (4) 2. Network theorems (DC): Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem. (5) 3. Magnetic circuits: Review of fundamental laws of electromagnetic induction, Self and mutual inductances, Solution of magnetic circuits. (3) 4. Generation of alternating voltage and current, E.M.F. equation, Average and R.M.S. value, Phase and phase difference, Phasor representation of alternating quantity, Behaviour of AC circuits, Resonance in series and parallel R-L-C circuits. (6) 5. Poly-phase system, Advantages of 3-phase system, Generation of 3-phase voltages, Voltage, current and power in a star and delta connected systems, 3-phase balanced and unbalanced circuits. (3) 6. Semiconductor Devices: Construction, working and V-I characteristics of diode, Zener diode, Zener diode as a voltage regulator, LED. (6) 7. Transistors: Introduction to BJT, FET, MOSFET; CMOS, working principle, and V-I characteristics of Transistors, biasing of BJT circuits-fixed bias, emitter bias, feedback bias, voltage divider bias, transistor as an amplifier. (8) 8. Operational amplifier: Introduction, applications: inverting, non-inverting amplifier, unity follower, integrator, differentiator, summing circuit .(4) 9. Introduction of logic gates, memory: ROM, RAM. (3)						
Text Books, and/or reference material	**TEXT BOOKS** 1. Electrical & Electronic Technology by Hughes, Pearson Education India. 2. Introduction Electronic Devices & Circuit Theory, 11/e, 2012, Pearson: Boylestad & Nashelsky. 3. Electronics: Fundamentals and Applications By D. Chattopadhyay, P.						

	C. Rakshit; New Age Int. Publication. **REFERENCE BOOKS** 1. Advanced Electrical Technology by H. Cotton, Reem Publication Pvt. Ltd. 2. Electrical Engineering fundamentals by Vincent Deltoro, Pearson Edu. India. 3. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill. 4. Electronics - Circuits and Systems, Fourth Edition by Owen Bishop. 5. Electronics Fundamentals: Circuits, Devices & Applications (8e) by Thomas L. Floyd & David M. Buchla.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC02	CO1	3	3	3	3	3	1	1	1	1	1	1	1
	CO2	3	3	3	3	2	1	2	1	1	1	1	1
	CO3	3	3	3	3	3	2	2	1	1	1	1	1
	CO4	2	3	2	2	-	1	-	-	-	-	-	1
	CO5	3	2	1	2	2	1	-	-	2	-	-	1
	CO6	3	2	2	2	3	-	-	-	2	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS51	**COMPUTER PROGRAMMING LABORATORY**	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	CO1: To understand the principle of operators, loops and branching statements. CO2: Implementation of function, recursion, arrays, and pointers based several types of assignments. CO3: To detail out the operations of strings. CO4: To understand structure and union. CO5: Application of C-programming to solve various types of problems.						
Topics Covered	**List of Experiments:** 1. Programs on expression evaluation. 2. Programs on conditional statements and branching 3. Programs on iterations/loops. 4. Applications of Arrays 5. Programs on basics of functions and pointers. 6. Programs on string using array and pointers. 7. Programs on recursion. 8. Programs on structures, union. 9. Programs on File Operations. 10. Case Studies.						

Text Books, and/or reference material	**Text Books:** 1. Y. Kanetkar, "Let Us C", BPB Publications, Sixteenth edition, 2017. 2. B. S. Gottfried, "Programming with C", McGraw Hill Education, 4th Ed., 2018. 3. E. Balagurusamy, "Computing Fundamentals and C Programming", McGraw Hill Education; Second edition, 2017. **Reference Books:** 1. P. Dey and M. Ghosh, "Computer fundamentals and programming in C", Oxford press, 2013. 2. R. Thareja, "Computer fundamentals and programming in C", Oxford press, 2013. 3. Schaum's Outline, Programming with C.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS51	CO1	3	3	2	-	-	2	-	-	-	-	-	-
	CO2	2	2	1	-	-	1	-	-	-	-	-	-
	CO3	3	2	2	-	-	1	-	-	-	-	-	-
	CO4	2	3	2	-	-	2	1	-	-	-	-	-
	CO5	3	3	3	-	1	2	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	**Title of the course**	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours**				**Credit**
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	
PHS51	**Physics Laboratory**	PCR	**0**	**0**	**2**	**2**	**1**
Pre-requisites		Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))					
NIL		CE+EA					
Course Outcomes	CO1: To realize and apply different techniques for measuring refractive indices of different materials. CO2: To realize different types of waveforms in electrical signals using CRO. CO3: To understand charging and discharging mechanism of a capacitor. CO4: To understand interference, diffraction and polarization related optical phenomena. CO5: To acquire basic knowledge of light propagation through fibers.						
Topics Covered	1. Find the refractive index of a liquid by a travelling microscope. 2. Determine the refractive index of the material of prism using spectrometer. 3. Determination of amplitude and frequency of electrical signals by oscilloscope. 4. To study the characteristics of RC circuits. 5. To study Brewster's law/Malus' law using laser light. 6. To study the diffraction of light by a grating. 7. To study the interference of light by Newton's ring apparatus.						

	8. To determine numerical aperture of optical fiber. 9. Determination of Planck constant.
Text and/or reference material	**SUGGESTED BOOKS**: 1) A Text Book on Practical Physics – K. G. Mazumdar and B. Ghosh 2) Practical Physics – Worsnop and Flint

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS51	**CHEMISTRY LABORATORY**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					
Course Outcomes	• CO1: To learn basic analytical techniques useful for engg applications. • CO2: Synthesis and characterization methods of few organic, inorganic and polymer compounds of industrial importance. • CO3: Learn chromatographic separation methods. • CO4: Applications of spectroscopic measurements.						
Topics Covered	1. Experiments based on pH metry: Determination of dissociation constant of weak acids by pH meter. 2. Experiments based on conductivity measurement: Determination of amount of HCl by conductometric titration with NaOH. 3. Estimation of metal ion: Estimation of Fe^{2+} by permangnomentry 4. Estimation of metal ion: Determ. of total hardness of water by EDTA titration. 5. Synthesis and characterization of inorganic complexes: e. g. $Mn(acac)_3$, $Fe(acac)_3$, cis-bis(glycinato)copper (II) monohydrate and their characterization by m. p. , FTIR etc. 6. Synthesis and charact. of organic compounds: e.g.Dibenzylideneacetone. 7. Synthesis of polymer: polymethylmethacrylate 8. Verification of Beer-Lamberts law and determination of amount of iron present in a supplied solution. 9. Chromatography: Separation of two amino acids by paper chromatography 10. Determination of saponification value of fat/ vegetable oil						

	Suggested Text Books: 1. Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall 2. Advanced Physical Chemistry Experiments: By Gurtu&Gurtu 3. Comprehensive Practical Organic Chemistry: Qualitative Analysis By V. K. Ahluwalia and S. Dhingra Suggested Reference Books: 1. Practical Chemistry By R.C. Bhattacharya 2. Selected experiments in Physical Chemistry By N. G. Mukherjee

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES51	**ENGINEERING GRAPHICS**	PCR	1	0	3	4	2.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	• CO1: Ability of mental visualization of different objects • CO2: Theoretical knowledge of orthographic projection to solve problems on one/two/three dimensional objects • CO3: Able to read/interpret industrial drawing and to communicate with relevant people
Topics Covered	Graphics as language of communication; technical drawing tools and their up-keep; types of lines; construction of geometrical figures; lettering and dimensioning. [6] Construction and use of scales; construction of curves of engineering importance such as curves of conic section; spirals, cycloids, involutes and different loci of points; use of equations for drawing some curves. [9] Descriptive geometry: necessity and importance of orthographic projection; horizontal and vertical reference planes; coordinate of points; orthographic projection of points and lines situated in different quadrants, viz. 1st, 2nd, 3rd and 4th quadrants; traces of lines. First angle and third angle projection of lines and planes; views from top, front and left (or right); true length and true inclination of lines with planes of projections; primary auxiliary projection of points, lines and planes; auxiliary plan and auxiliary elevation. [9] Projection of simple regular solids, viz. prisms, cubes, cylinders, pyramids, cones, tetrahedrons, spheres, hemi-spheres etc. [6] Section of solids; section by perpendicular planes; sectional views; true shapes of sections. [6] Dimensional techniques; international and national standards (ISO and BIS). [3] Freehand graphics. [3]
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… Engineering Drawing – N D Bhat 3)… Practical Geometry and Engineering Graphics – W Abbott

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES52	**Basic Electrical and Electronics Laboratory**	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	CO1: Learn to analyse the electric circuits using network theorems. CO2: Understand the characteristics of fluorescent lamp and compact fluorescent lamp. CO3: Analyze the behaviour of single phase and three phase AC circuits. CO4: Understand the application of electronics components, diode circuits as rectifier circuits and voltage regulators. CO5: Evaluate and study the performance of the transistor as a switch. CO6: Create inverting and non-inverting amplifier circuits using Op-Amp.
Labs Conducted.	1. Verification of the network theorems (DC). 2. Study of the characteristics of fluorescent and compact fluorescent lamp. 3. Analysis of the three phase system for star and delta connected load. 4. Study of the series and parallel R-L-C circuit. 5. Identify and understand the use of different electronic and electrical instruments, various electronic components. 6. Study of half-wave and full-wave (bridge) rectifier with and without capacitor filter circuit. Zener diode as a voltage regulator. 7. Study the performance of a transistor as a switch through NOT gate. 8. Realization of Inverting and Non-inverting amplifier using Op-Amp.
Text Books, and/or reference material	**TEXT BOOK** 1. Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru , J M Chuma, H U Ezea. 2. Experiments Manual for use with Electronic Principles (Engineering Technologies and the Trades) by Albert Paul Malvino Dr., David J. Bates, et al. **REFERENCE BOOKS** 1. Laboratory Courses in Electrical Engineering (5th Edition) by S. G. Tarnekar, P. K. Kharbanda, S. B. Bodhke, S. D. Naik, D. J. Dahigaonkar (S. Chand Publications). 2. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill. 3. Electronic Principles, by Albert Paul Malvino Dr. and David J. Bate.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES52	CO1	3	3	3	3	3	1	1	1	2	2	2	3
	CO2	3	3	2	3	3	3	1	1	2	2	2	3
	CO3	3	3	2	3	3	2	1	1	2	2	2	3
	CO4	3	3	3	3	3	1	1	1	2	2	2	3
	CO5	3	2	1	2	2	1	-	-	2	-	-	-
	CO6	3	2	2	2	3	-	-	-	2	-	-	-

	CO7	3	3	2	2	-	-	-	-	2	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS52	**DATA STRUCTURES AND ALGORITHMS LABORATORY**	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	CO1: Understanding the suitability and compatibility of array and linked list implementations for different application problems. CO2: Understanding the concept of abstract data types from real-life scenarios and their implementation in computing system. CO3: Identify, design and implementation of stack, queue, binary tree, and graph as applicable for given problem. CO4: Implementation of different searching and sorting techniques using appropriate data structures and perform efficiency analysis. CO5: Create efficient algorithms for real-life applications.						
Topics Covered	**List of Experiments:** 1. Application of arrays using dynamic memory allocation. 2. Implementation and Applications of linked lists. 3. Implementation of stack, and applications of stack. 4. Implementation of queue, applications of queue: Priority queue. 5. Implementation of Binary tree, Binary tree traversal: Preorder, Inorder and Postorder traversal. 6. Implementation of binary search tree and operations on it. 7. Implementation of linear search, binary search (recursive, non-recursive). 8. Implementation of different sorting algorithms. 9. Implementation of graph algorithms: Breadth first search, Depth first search. 10. Case Studies.						
Text Books, and/or reference material	**Text Books:** 1. S. Lipschutz, “Data Structures (Schaum’s Outline Series)”, McGraw Hill Education; First edition (2017). 2. E. Horowitz, S. Sahni, S. Anderson-Freed, “Fundamentals of Data Structures in C”, Universities Press; Second edition (2008). 3. E. Balagurusamy, "Programming in ANSI C", McGraw Hill Education India Private Limited, Seventh edition (2017). **Reference Books:** 1. B. S. Gottfried, "Programming with C", McGraw Hill Education, 4th Ed. (2018).						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS52	CO1	-	1	1	1	-	-	-	-	-	-	-	-
	CO2	-	1	1	3	-	-	-	-	-	-	-	-
	CO3	2	2	3	2	1	-	-	-	-	-	-	-
	CO4	2	2	2	1	1	-	-	-	-	-	-	-
	CO5	3	3	3	3	3	-	1	1	-	-	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXS51	**Extra Academic Activities**	PCR	**0**	**0**	**2**	**2**	**1**

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+EA

Course Outcomes	• CO1: Social Interaction through the medium of sports • CO2: Team building and self defence
Topics Covered	**YOGA** • Introduction of Yoga- Suryanamaskar. 1L • Sitting Posture / Asanas – Padmasana, Vajrasana, Ardha Kurmasana, Ustrasana, Janusirshasana, Gomukhasana, Bhadrasana. 7L • Mudra- Gyana Mudra, Chin Mudra. 1L • Laying Posture/ Asana-Pavana Mukhtasana, Uttana Padasana, Sarpasana, Bhujangasana (Cobra Pose), Eka Pada Salabhasana, Dhanurasana, Chakrasana, Viparitkarani, Ardha Halasana (Half Plough Pose), Naukasana (Boat Posture), Shavasana (Relaxing Pose) , Makarasana. 7L • Meditation-Om Chant. 1L • Standing Posture / Asana-Tadasana (Mountain Pose), Vrikshana (Tree Pose), Ardha Chandrasana, Padahastasana, Ardha Chakrasana (Half Wheel Posture). 5L • Pranayama-Deep Breathing, Anulom Vilom, Shitali, Bhramari. 5L • Kriya- Kapalbhati 1L **TAEKWONDO** • Introduction About Taekwondo- Meaning Of Taekwondo, Korean Language Of Dress, Fighting Area, Punch, Block, Kicks Etc. 1L • Stance- Ready Stance, Walking Stance, Front Stance, Back Stance. 2L • Punch Technique- Front Fist Punch, Double Fist Punch, With Stance Etc. Blocks- Upper Blocks, Middle Block, Side Block, Suto Etc. 4L • Foot Technique- Standing Kick, Front Kick, Doliyo, Back Kick Etc. 6L • Poomsae (Forms)- Jang, Yi Jang. 6L • Self Defense Technique- Self Defense from Arms, Fist and Punch. 4L

	• Sparring (Kyorugi)- One Step Sparring 2L • Combination Technique- Combined Kick And Punch. 2L • Project Work 1L

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS51	CO1	-	-	-	-	-	2	-	-	2	-	-	1
	CO2	-	-	-	-	-	-	-	2	3	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Third Semister

CSC 301 Discrete Mathematics 3-1-0 4Credits 4Hours

<table>
<tr><td colspan="8">Department of Computer Science and Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSC 301</td><td>Discrete Mathematics</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="3"></td><td colspan="5">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● CO1: Remember the basic terms, definitions and concepts of mathematics.
● CO2: Students will be able to understand the key concepts of discrete mathematics such as functional mapping, mathematical logic, counting principles, generating functions, algebraic structures and graph theory.
● CO3: Students will be able to apply the learned concepts to solve various problems.
● CO4: Students will be able to differentiate or relate the various ideas with respect to problems.
● CO5: Students will be able to judge the formulas and ideas to be applicable to a problem.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Set Theory: Definition of Sets, Venn Diagrams, complements, cartesian products, power sets, counting principle, cardinality and countability (Countable and Uncountable sets), proofs of some general identities on sets, pigeonhole principle. 3L
Relation: Definition, types of relation (reflexive, symmetric, transitive, antisymmetric, Equivalence, partial ordering relations), composition of relations, domain and range of a relation, pictorial representation of relation, properties of relation, Partial Order, Lattice, Hasse Diagram. 6L
Function: Definition and types of function, composition of functions, recursively defined functions, Surjection, Injection, Bijection, Composition of Function, Asymptotic notations: big-Oh, Theta, big-Omega. 4L
Propositional logic: Proposition logic, basic logic, logical connectives, truth tables, tautologies, contradiction, normal forms (conjunctive and disjunctive), modus ponens and modus tollens, validity, predicate logic, universal and existential quantification. Notion of proof: proof by implication, converse, inverse, contrapositive, negation, and contradiction, direct proof, proof by using truth table, Proof by Well ordering principle. 6L
Combinatorics: Mathematical induction, recursive mathematical definitions, basics of counting, permutations, combinations, inclusion-exclusion, recurrence relations (nth order recurrence relation with constant coefficients, Homogeneous recurrence relations), generating function (closed form expression, properties of G.F., solution of recurrence relation using G.F, solution of combinatorial problem using G.F.) 8L
Algebraic Structure: Binary composition and its properties definition of algebraic structure; Semi group, Monoid, Groups, Abelian Group, properties of groups, Permutation Groups, Sub Group, Cyclic Group. 6L
Graphs: Graph terminology, types of graph, connected graphs, components of graph, Euler graph, Hamiltonian path and circuits, Degree Sequence, Radius, Diameter,</td></tr>
</table>

	Center of a graph, Graph coloring, Chromatic number. Planarity of a graph : K(3,3) and K(5). Clique, Independent set, bipartite graph, Tree: Definition, types of tree (rooted, binary), properties of trees. 9L
Text Books, and/or reference material	**Text Books:** 1. C. L. Liu, Elements of Discrete Mathematics, Tata McGraw Hill 2. Norman L. Biggs, Discrete Mathematics, Oxford 3. Douglas B. West, Introduction to Graph Theory, Prentice Hall, India **Reference Books:** 1. Ronald L. Graham, Donald E. Knuth and O. Patashnik, Concrete Mathematics, Pearson Education

CSC302 Digital Logic Design 3-1-0 4Credits 4Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CS 302	Digital Logic Design	PCR	3	1	0	4	4
Pre-requisites:		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	At the completion of this course students will be able to: ● CO1: Realize the various logic gates and and laws Boolean algebra. Analyse different types of digital electronic circuit using various mapping and logical tools. ● CO2: Design and analyses the various combinational circuits. ● CO3: Design and analyses the various sequential circuits ● CO4: Design and analyse combinational and sequential logic circuits through HDL models. ● CO5: Synthesis the various logic using ASM charts						
Topics Covered	**UNIT-I**: **Switching Circuits,** Various number system and their conversions: Arithmetic of these number systems, Complements, Data Representation: Binary numbers, binary codes, fixed point representation, floating point representation, Code and their conversions, Addition and Subtraction on Codes, Error Detection codes (Hamming code etc), representation of signed binary number in Fixed and Floating Points. 5L **UNIT-II**: **Boolean algebra**, logic gates, and switching functions, truth tables and switching expressions, minimization of completely and incompletely specified switching functions, Karnaugh map and Quine-McCluskey method, multiple output minimization, representation and manipulation of functions using BDDs, two-level and multi-level logic circuit synthesis. 10L **UNIT-III**: **Combinational logic circuits**: Realization of Boolean functions using NAND/NOR Gates, Decoders, multiplexers. Logic design using ROMs, PLAs and FPGAs. Case Studies. 8L **UNIT-IV**: **Sequential circuits:** Clocks, flip-flops, latches, counters and shift registers, finite-state machine model, synthesis of synchronous sequential circuits, minimization						

	and state assignment, asynchronous sequential circuit synthesis. 12L **UNIT-V**: **ASM charts**: Representation of sequential circuits using ASM charts, synthesis of output and next state functions, data path control path partition-based Design. 7L
Text Books, and/or reference material	**Text Books:** 1. Digital Logic Design, M. Morris Mano, Michael D Cilleti, PHI **Reference Books:** 1. Digital Principles & Application, 5th Edition, Leach & Malvino, McGraw Hill Company. 2. Modern Digital Electronics, 2nd Edition, R.P. Jain. Tata Mc Graw Hill Company Limited. **Others:**

CSC303 Algorithm Design and Analysis- I 3-1-0 4 Credits 4 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC303	Algorithm Design and Analysis- I	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Data Structures and Algorithms (CSC02), Computer Programming (CSC01)		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	After completing the course, students will be able to: ● CO1: Understand the fundamental concepts of data structures and algorithms as well as their design paradigms. ● CO2: Apply different algorithmic ideas efficiently to solve new problems. ● CO3: Efficiently analyze the time complexities of the data structures and algorithms. ● CO4: Evaluate/recognize the state-of -the-art about the data structures and algorithms. ● CO5: Create algorithmic solutions for real-life applications.						
Topics Covered	**Introduction and basic concepts:** Algorithm, Asymptotic notations (big-Oh, big-Omega, big-Theta, small-oh) and their significance, introduction to RAM model of computation, complexity (Time Complexity, Space Complexity) analysis of algorithms, worst case and average case. Solving Recurrences – Substitution method, Recurrence tree method and Master Method. (5L) **Amortized complexity analysis:** aggregate analysis, accounting method and potential method. Examples: storage allocation problem, binary counting problem. (3L) **Sorting:** Comparison-based sorting: quick sort, merge sort, and their worst and average case analysis. Sorting in linear time: Radix sort, Count Sort. (4L)						

	Heaps: Heap, applications of heaps: priority queue and heap sort, etc. (3L) **Lower bound:** Lower bound for a problem. Computing the lower bound for sorting (comparison based sorting) and computing the lower bound for computing convex hull using the lower bound for sorting problem. (2L) **Search trees:** Binary search tree, Balanced binary search tree, AVL tree, Red Black tree, M-way tree, M-way search tree, B tree, B+ Tree. (8L) **Hashing:** Hash functions, Collision, Collision resolution techniques: linear probing, quadratic probing, double hashing, chaining, Rehashing. Hash Function for Hierarchical Memory Model. (4L) **Divide and Conquer Problem:** Multiplication of two n-bit integers, Strassen's Matrix Multiplication problem, Closest pair of points, linear time median finding algorithm, Convex hull and its computation. (5L) **Greedy Algorithm:** Greedy algorithms and their correctness proof: Interval scheduling problem, Interval partitioning problem, Minimizing the Lateness of Intervals problem, Fractional Knapsack Problem. (4L) **Dynamic Programming:** Matrix Chain Multiplication, 0-1 Knapsack Problem, Longest Common Subsequence Problem. (4L)
Text Books, and/or reference material	**Text Books:** 1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, Introduction to Algorithms, by Prentice Hall. 2. Kleinberg and Eva Tardos. Algorithm Design. Addison-Wesley 2005 ISBN-13: 978-0321295354. 3. E. Horowitz, S. Sahni, S. Anderson-Freed, "Fundamentals of Data Structures in C", Universities Press; Second edition (2008). 4. A. V. Aho, J. D. Ullman and J. E. Hopcroft, "Data Structures and Algorithms", Addition Wesley. **Reference Books/Lecture Notes:** 1. Knuth, Donald E. The Art of Computer Programming. 3rd ed. Vols 1&2. Reading, MA: Addison-Wesley, 1997. ISBN: 0201896834. ISBN: 0201896842. ISBN: 0201896850. 2. Michael T. Goodrich and Roberto Tamassia, Algorithm Design: Foundations, Analysis, and Internet Examples, Second Edition, Wiley, 2006. 3. Sanjoy Dasgupta, Christos H. Papadimitriou and Umesh V. Vazirani, Algorithms, Tata McGraw-Hill, 2008. 4. Y. Langsam, M. J. Augenstein and A. N. Tanenbaum, "Data Structures using C and C++", Pearson, 2006. 5. R. F. Gilberg and B. A. Forouzan, "Data Structures: A pseudocode approach with C", 2nd Edition, CENGAGE Learning.

CSC 304 Object Oriented Programming 3-1-0 4 Credits 4Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC 304	Object Oriented Programming	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))
Introduction to Computing (CSC01), Data Structures and Algorithms (CSC303)	**[CA: 15%, MT: 25%, ET: 60%]**

Course Outcomes	CO1: Apply Object oriented approach to design software CO2: Implement programs using classes and objects CO3: Specify the forms of inheritance and use them in programs CO4: Analyze polymorphic behavior of objects CO5: Design and write programs using an object oriented language CO6: Introduce Templates and Exception Handling
Topics Covered	**Course Introduction-** Concepts of Object Oriented Programming, Procedural approach, Limitation of Procedural Language, Object concept (2L) **Object Oriented Terminologies**- Class concept, ADT, encapsulation, Cardinality, Data hiding, Inheritance, Polymorphism, Advantages of OOPs, Advantages of OOPs, difference between Procedural and Object Oriented Language, Evolution of C++ (4 L) **Basic Input/Output in C++ -** The 1st C++ Program (temperature conversion), compilation, Input stream and output stream, Advantages of cin a cout over pritnf and scanf (3L) **Basic C++ features -** Literals, Constants, Manipulators, Assertions, Enumerated Data Types, Scope resolution operator (5L) **Pointers & References in C++**- Basic operations on pointers, Array of pointers, pointer to an array, self referential structures, References in C++ , use of references (7 L) **Dynamic memory allocation/deallocation** - Use of new and delete operator, multi-dimensional array allocation, Examples (5L) **Constructor and Destructor**, Various examples of constructors, Constructor Salient Features, Destructors,, Examples (2L) **Functions in C++; Overloading**- function call, Macros, and it's limitations, Inline function, Function Overloading, Constructor Overloading, Examples, Function with Default arguments, Various Examples of Default arguments (5L) **Writing C++ Classes**- Class, C++ class vs Structure, This pointer, Memory Layout of C++ program, Static member of class. Static Member Functions, Static Object, Examples (5L) **C++ Constants Revisited** - Storage Allocation, Constants and References, Constant member data and Functions, Constants Objects, Examples (2L) **Friend Function & Operator Overloading -** Friend Functions, Use of friend functions, friends as bridges, Various examples, Operator Overloading, examples, advantages of friend functions during overloading (6L) **Templates in C++**, Generic function and classes, examples, syntax of a template, Template class (5L) **Inheritance in C++**, Derive class, Parameterized constructor in derive class, Protector Specifier, Examples of different types of inheritance, Virtual Base Class, Up casting. Polymorphism and virtual function, Function call finding, Virtual Functions, Examples.
Text Books, and/or reference material	Text Books: 1. Adam Drosdek, "DATA STRUCUTRES AND ALGORITHMS IN C++" , Brooks/Cole Thomson Learning 2. Bjarne Stroustrup "The C++ Programming Language", Pearson Education **3. E. Balaguruswamy, "Object Oriented Programming with C++", Tata**

	McGraw Hill Reference Books: 1. Bruce Eckel, "Thinking in C++", Prentice Hall 2. S. B. Lippman, J. Lajoie, B. E. Moo, "C++ Primer", Addison-Wesley Professional **3. Bjarne Stroustrup, "Programming: Principles and Practice Using C++", Addison-Wesley Professional** 4. Effective C++: 50 Specific Ways to Improve Your Programs and Design by Scott Meyers, 1997 5. More Effective C++ by Scott Meyers, 2002 Others: NPTEL course link by Prof. Partha Pratim Das - https://onlinecourses-archive.nptel.ac.in/noc19_cs10/preview

CSS 351 Digital Logic Design Laboratory 0-0-3 2Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS351	Digital Logic Design Laboratory	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA [CA: 60%, ET(Laboratory assignment + Viva Voce): 40%]					
Course Outcomes		● CO1: Understand basic gate operations. ● CO2: Realise the boolean function using basic gates in both SOP/POS form. ● CO3 :Realize different combinational circuits with basic gates. ● CO4: Understand the basic structure of different digital components- multiplexer, decoder, encoder etc. ● CO5: Verification of state table of different flip flop using NAND/NOR gate.					
Topics Covered		1. Introduction to digital logic laboratory, specifications of IC, study of the data sheet, concept of Vcc, ground and verification of the truth tables. 2. Implementation of a given Boolean function using logic gates in both SOP and POS forms. 3. Verify DE Morgan's law. Verify the Universal logic gates (NAND, NOR). 4. Implement NAND based logic circuit for any Boolean expression. 5. Implement Half Adder. Design and verify Full adder using Half Adder. Implement the combinational circuit to realize both Adder and Subtractor together. 6. Implement Multiplier, Comparator and code converter. 7. Implementation and verification of Decoder, Multiplexer, Encoder and Priority Encoder. 8. Implement and verify Ripple Carry Adder, Carry Look Ahead Adder and BCD Adder. 9. Verification of state tables of RS, JK, T and D flip-flops using NAND & NOR gates. 10. Design, and verify the 4-bit counter/ mini project.					

Text Books, and/or reference material	**Text Books:** 1. Digital Logic Design, M. Morris Mano, Michael D Cilleti, PHI **Reference Books:** **Others:** 1. Laboratory Manual.

CSS 352 Algorithm Design Laboratory 0-0-3 2Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS 352	Algorithm Design Laboratory	PEL	0	0	3	3	2
Pre-requisites			Course Assessment methods (Continuous (CT) and end assessment (EA))				
Data Structure and Algorithms (CSC02), Data Structures and Algorithms Laboratory (CSS52), Design and analysis of Algorithm I (CSC303)							

Course Outcomes	After completion of this course, the students will be able to: ● CO1: Identify the essence of theory into implementation. ● CO2: Interpret the theory efficiently through coding. ● CO3: Verify the theory experimentally. ● CO4: Explain the behavior of an algorithm efficiently. CO5: Compare the efficiency of different algorithms.
Topics Covered	**Assignment 1:** Implementation of **e**xponential versus polynomial running time solutions **Assignment 2:** Implementation of Heaps and their applications **Assignment 3:** Implementation of Search Trees **Assignment 4:** Implementation of Hashing techniques **Assignment 5:** Problems based on Linear time sorting algorithms **Assignment 6:** Problems using Divide and Conquer algorithms **Assignment 7:** Problems using Greedy algorithms **Assignment 8:** Problems using Dynamic Programming algorithms
Text Books, and/or reference material	**Text Books:** 1. T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, Introduction to Algorithms, by Prentice Hall India. 2. J. Kleinberg and Eva Tardo, Algorithm Design by Pearson Education (Indian edition). **Reference Books:** 1. Michael T. Goodrich and Roberto Tamassia, Algorithm Design: Foundations, Analysis, and Internet Examples, Second Edition, Wiley, 2006. 2. S. Dasgupta, C. Papadimitriou and U. Vazirani, Algorithms, by Tata McGraw-Hill. **Others:** The Algorithm Design Manual 2nd ed. 2008 Edition by Steven S S. Skiena, Springer.

CSS 353 Object Oriented Programming Laboratory 0-0-3 2Credits 3Hours

<table>
<tr><td colspan="8">Department of Computer Science and Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSS353</td><td>Object Oriented Programming Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">CT+EA [CA: 60%, ET(Laboratory assignment + Viva Voce): 40%]</td></tr>
<tr><td colspan="2">Introduction to Computing (CSC01), Data Structures and Algorithms (CSC303)</td><td colspan="6">CT+EA [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Apply the basic object oriented concepts in problem solving
CO2: Apply the concepts of function & operator overloading
CO3: Design and develop template libraries
CO4: Understand and solve problems involving Inheritance & Composition</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Assignment 1: Design codes using OOL syntax; use of manipulators, dynamic allocation, multi-dimensional array writing application like addition, subtraction, multiplication, finding factorial of a large numbers etc.
Assignment 2: Develop codes involving binary and text files involving string manipulation, graph processing, etc.
Assignment 3: Design class library for implementing matrix, complex number, string, stack, queue, linked list, heap, binary search tree, polynomial, etc.
Assignment 4: Develop class library to implement application like hashing, huffman code, expression evaluation using the libraries developed in assignment 3
Assignment 5: Enhance the class libraries in assignment 3&4 implementing function overloading
Assignment 6: Enhance the class libraries in assignment 3&4 implementing operator overloading
Assignment 7: Develop codes using inheritance
Assignment 8: Design and develop template classes
Assignment 9: Implement exception handling in some existing template classes</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Bruce Eckel, “Thinking in C++”, Prentice Hall
2. S. B. Lippman, J. Lajoie, B. E. Moo, “C++ Primer”, Addison-Wesley Professional
3. Bjarne Stroustrup, “Programming: Principles and Practice Using C++”, Addison-Wesley Professional
4. Effective C++: 50 Specific Ways to Improve Your Programs and Design by Scott Meyers, 1997
5. More Effective C++ by Scott Meyers, 2002
Reference Books:
Others: NPTEL course link by Prof. Partha Pratim Das - https://onlinecourses-archive.nptel.ac.in/noc19_cs10/preview</td></tr>
</table>

FOURTH SEMESTER

CSC401 Computer Organization and Architecture 3-1-0 4Credits 4Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC-401	Computer Organization and Architecture	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
Digital Logic Design (CSC302)		CT+EA **[CA: 15%, MT: 25%, ET: 60%]**					
Course Outcomes	CO1: Analyse the various parts of a modern computer functional units, bus structure, addressing modes and Computer arithmetic. CO2: Identify the process involved in executing an instruction and fetching the word from memory. CO3: Design the hardwired and micro-programmed control units and implementation of interrupts. CO4: Understand the memory hierarchy and design a memory system. CO5: Understand Pipelined execution and instruction scheduling.						
Topics Covered	**UNIT-I**: Introduction: Evolution of computers, Basic Structure of Computers: Basic Operational Concepts, GPR based and stack based organisation. Bus Structures, Performance Measurement: Processor Clock, Basic Performance Equation, Clock Rate, Machine Instructions and Programs: Memory Location and Addresses, Memory Operations, Instructions and Instruction Sequencing, Addressing Modes, Assembly Language, Basic Input and Output Operations, Encoding of Machine Instructions (Huffman encoding etc) [12 L] **UNIT-II**: Fundamental concepts of the processing Unit: Fetching and Storing words, Register Transfer, Execution of instruction, Arithmetic Operations:Addition and Subtraction of Signed Numbers, Design of Fast Adders, Combinational and Sequential ALU, ALU expansion strategies, Design of Multipliers and Dividers, Wallace tree and Booth's Multipliers, Floating Point Numbers (IEEE754), Floating Point Operations, Multiplication of Positive Numbers, Signed Operand Multiplication (Booth's Multiplication etc.), Fast Multiplication, Integer Division. [10 L] **UNIT-III**: Computer Organization and Design (Datapath and control path): Instruction codes, computer registers, computer instructions, timing & control, instruction cycle, memory reference instructions, Hard-wired Control, Micro programmed Control: Micro instruction, Microprogram sequencing, Input/output Organization: Accessing I/O Devices, Interrupts – Interrupt Hardware, Enabling and Disabling Interrupts, Handling Multiple Devices, Controlling Device Requests, Exceptions, Direct Memory Access, Buses, Interface Circuits, Standard I/O Interfaces – PCI Bus, SCSI Bus, Bus Arbitration schemes, USB. (Brief overview of 8085/8086 microprocessor) [12 L] **UNIT-IV**: Memory System: Basic Concepts, Semiconductor RAM Memories, Read Only Memories, Speed, Size, and Cost, Cache Memories – Mapping Functions,						

	Replacement Algorithms, page mode access, interleaved access. Performance Considerations, Virtual Memories, Secondary Storage [12 L] **UNIT-V**: Basic concepts of pipelining, the instruction pipeline – pipeline hazards – instruction level parallelism – reduced instruction set –Computer principles – RISC versus CISC. Introduction to GPP, ASIP and ASIC etc. [10 L]
Text Books, and/or reference material	**Text Books:** 1.David A Patterson, John L Hennessy, "Computer Organization and Design", (The Hardware/Software Interface) Morgan Kaufmann. 2.Carl Hamacher, Zvonko Vranesic, Safwat Zaky: Computer Organization, 5th Edition, Tata McGraw Hill **Reference Books:** **1. William Stallings, "Computer Organization and Architecture".** 2. Nicholas P Carter, "Computer Architecture & Organisation". **Others:**

CSC 402 Theory of Computation 3-1-0 4Credits 4Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC402	Theory of Computation	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
Discrete Mathematics (CSC 301)		CT+EA **[CA: 15%, MT: 25%, ET: 60%]**					
Course Outcomes	CO1 : Explain the concept of regular languages through regular expressions and finite automata CO2 : Describe context-free languages and context free grammars CO3 : Design grammars and automata for various languages CO4 : Examine the power of Turing machines and design TM for simple problems CO5 : Analyse the concept of undecidability in the context of Turing machine design						
Topics Covered	1. Regular sets and Regular Expression , Non-deterministic and deterministic finite automata and their equivalence , Minimization of deterministic finite automata , Regular expressions to Finite Automata **L10** 2. Finite Automata with outputs. **L2** 3. Properties of Regular Sets: Pumping Lemma, Closure Properties, and Decision algorithms. **L5** 4. Context Free Grammars. Derivations. Ambiguity in grammars**. L3** 5. Chomsky hierarchy of languages and grammars. Regular grammars. **L3** 6. Normal Forms for Context free grammars. CNF and GNF. Closure properties of context free languages, Pumping lemma for context free languages. Decision Properties **L10** 7. Pushdown automata **L3** 8. Turing machines. Unrestricted Grammars. Properties of recursive and r.e.languages, Undecidability. **L6**						

Text Books, and/or reference material	**Text Books:** **1. Introduction to Automata Theory, Languages and Computation by J.E.Hopcroft, Rajiv Motwani and J.M.Ullman. Pearson Education.** **2. Introduction to Languages and Theory of Computation By John C. Martin McGraw Hill Education** **Reference Books:** **1. Elements of the Theory of Computation By Harry R. Lewis and Christos H. Papadimitriou Prentice Hall of India.** **2. Theory of Automata and Formal Languages By Anand Sharma University Science Press** **Others:**

CSC403 Operating Systems 3-1-0 4Credits 4Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC403	Operating Systems	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
Computer Organization and Architecture (CSC401), Introduction to Computing (CSC01), Data Structures and Algorithms (CSC303)		**[CA: 15%, MT: 25%, ET: 60%]**					
Course Outcomes		● CO1: Understanding functional architecture of an operating system ● CO2: Understanding process control algorithms, deadlocks and multi-threading in OS ● CO3: Develop application programs using UNIX system calls. ● CO4: Design and solve control & data access synchronization problems ● CO5: Understanding virtual memory organization and management in OS ● CO6: Understand standard FAT & UNIX file system					
Topics Covered		**Introductory Concepts:** Introduction to Operating System as a whole, memory, CPU(registers and ALU), Evolution of Operating System-types of OS(advantages and drawbacks), Performance measurement metrics (5L) **Process Data Structures and State transitions:** Process management, Basic Definitions, Process table, PCB(process control block), PTE(process table entry), Process states, Transition diagram, context of process-user level, kernel-level and process Level (4 L) **Process Control:** Process creation, Parent and Child processes, System calls--fork(), exit(), wait(), kill(), Signal handling, Process scheduling strategies-FCFS, SPN, SRT,					

	Round Robin, HRRN, Fair share scheduling (6 L) **Multi-threading:** Threads in OS, thread vs process, ULT & KLT, Applications of threads, Use of POSIX threads library (4 L) **Process synchronization** - Race condition, Critical section, Process Sync Solution using Algorithmic approach (Lamport bakery Algorithm), Creating shared memory using POSIX library (3 L) **Semaphore**- Binary and Counting semaphore, P() and V() operations, Solving Classical problem using semaphores- Sleeping barber, Producer-consumer, Reader-writer, Dining philosophers's problem, Posix library for semaphores (7 L) **Monitors** - Solving Classical problems using monitors (4 L) **Deadlocks** - Necessary and sufficient conditions for deadlocks, approaches to deal with deadlocks, Deadlock Prevention, Avoidance (Banker's algorithm) and Detection (3 L) **Memory organization & management** - Virtual memory organization, Pure Paging, Pure Segmentation, Combined Paging-Segmentation, Inverted PMT, Page fault handling algorithms, Working set theory (7 L) **File management**- Directory structure, Storage of files on disks, contiguous and non-contiguous file allocation strategies, Internal and external fragmentation, FAT & Inode Structure, Free Space management, Disk scheduling strategies (6 L) **I/O management concepts** (2 L)
Text Books, and/or reference material	**Text Books:** 1. "Operating System Concepts", Silberschatz and Galvin 2. "Operating Systems: Internals and Design Principles" by William Stalling 3. "Operating Systems: A Concept-Based Approach" by D M Dhamdhere **Reference Books:** 1. "Operating System: A Design-oriented Approach" by Charles Crowley 2. "Operating Systems: A Modern Perspective" by Gary J Nutt 3. "Design of the Unix Operating Systems" by Maurice Bach 4. "MODERN OPERATING SYSTEMS" by Andrew S Tanenbaum **Others:** ● https://nptel.ac.in/courses/106/106/106106144/# Course "Introduction to Operating Systems" by PROF. CHESTER REBERIO, IIT Madras ● https://nptel.ac.in/courses/106105214/ Course "Operating System Fundamentals" by Prof. Santunu Chattopadhyay, IIT Kharagpur

CSE 404 Database Management Systems 3-1-0 4Credits 4Hours

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC 404	Database Management System	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
Programming knowledge, Data Structures and		CT+EA **[CA: 15%, MT: 25%, ET: 60%]**					

Algorithms	
Course Outcomes	CO 1: Understand the basic concepts and appreciate the applications of database systems CO 2: Comprehend the fundamentals of design principles for logical design of relational databases CO 3: Apply the query writing skill and its subsequent optimization CO 4: Discuss the basic issues of transaction processing and concurrency control
Topics Covered	**Introduction :** Concept & Overview of DBMS, Applications, Data Models, Database Languages, Database Administrator, Database Users, Three Schema architecture of DBMS. **(4 L)** **Entity-Relationship Model:** Basic concepts, Design Issues, Mapping Constraints, Keys, Entity-Relationship Diagram, Weak Entity Sets, Extended E-R features. **(5L)** **Relational Model:** Structure of relational Databases, Relational Algebra, Relational Calculus, Extended Relational Algebra Operations, Views, Modifications of the Database. **(7L)** **SQL and Integrity Constraints:** Concept of DDL, DML, DCL. Basic Structure, Set operations, Aggregate Functions, Null Values, Domain Constraints, Referential Integrity Constraints, assertions, views, Nested Subqueries, Database security application development using SQL, Stored procedures and triggers. **(7L)** **Index Structures:** Necessity of index structures, Types of Single-Level Index (primary, secondary, clustering), Multilevel Indexes, Dynamic Multilevel Indexes using B tree and B+ tree . **(4L)** **Normalization:** Functional Dependency, Anomalies in a Database, The normalization process: Conversion to first normal form, Conversion to second normal form, Conversion to third normal form and BCNF, Fourth Normal form and fifth normal form, normalization and database design, Denormalization, Loss-less join decomposition, Dependency preservation. **(8L)** **Transaction processing:** Introduction of transaction processing, advantages and disadvantages of transaction processing system, online transaction processing system, serializability and recoverability, view serializability. **(5L)** **Concurrency Control:** Serializability: Enforcing, Serializability by Locks, Locking Systems With Several, Lock Modes, Architecture for a Locking Scheduler Managing Hierarchies of Database Elements, Concurrency Control by Timestamps, Concurrency Control by Validation. **(5L)** **Database recovery management:** Deferred database modification Vs. Immediate database modification, Check point technique. **(3L)** **Query Optimization:** Heuristics in Query Optimization, Converting Query Tree to Query Evaluation Plan, **(4L)** **Distributed Database (DDB):** Introduction of DDB, DDBMS architectures, Homogeneous and Heterogeneous databases, Distributed data storage, Advantages of Data Distribution, Disadvantages of Data Distribution Distributed transactions, Commit protocols, Data Replication, Data Fragmentation. Distributed database transparency features. **(4L)**
Text Books, and/or reference material	**Text Books:** 1. "An Introduction to Database Systems", C. J Date, Pearson Education. 2. "DatabaseSystem Concepts", Abraham Silberschatz, Henry F. Korth and S. Sudarshan, McGraw-Hill. 3. "Distributed Databases Principles & Systems", Stefano Ceri and Giuseppe Pelagatti, McGraw-Hill International Editions. **Reference Books:**

	1. "Fundamentals of Database Systems", Ramez Elmasri and Shamkant B. Navathe, Addison-Wesley. **Others:** https://onlinecourses-archive.nptel.ac.in/noc18_cs15/preview

CSS451 Computer Organization Laboratory 0-0-3 2Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS451	Computer Organization Laboratory	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Digital Logic Design (CSC302), Digital Logic Design laboratory (CSS351)		CT+EA [CA: 60%, ET(Laboratory assignment + Viva Voce): 40%]					
Course Outcomes	CO1: Understand the basic structure of digital computer CO2: Understand the synchronous / asynchronous logic CO3: Perform different operations with flip-flop. CO4: Understand arithmetic and control unit operation CO5: Understand the basic concepts of Memory						
Topics Covered	1. Introduction to Verilog HDL and Implementation of basic logic gates using Verilog. 2. Familiarization of Assembly language programming 3. Implementation of combinational circuits using Verilog. 4. Implementation of sequential circuits using Verilog 5. Implementation of Booth's Multiplier circuit.. 6. Synthesis of simple data path and Controllers, Processor Design 7. Implementation of Random Access Memory (RAM) to perform both R/W operation 8. Mini project.						
Text Books, and/or reference material	**Text Books:** 1. David A Patterson, John L Hennessy, "Computer Organization and Design", (The Hardware/Software Interface) Morgan Kaufmann. 2. Carl Hamacher, Zvonko Vranesic, Safwat Zaky: Computer Organization, 5th Edition, Tata McGraw Hill **Reference Books:** **1. William Stallings, "Computer Organization and Architecture".** **2. Nicholas P. Carter, "Computer Architecture & Organisation".** **Others: Laboratory Manual**						

CSS452 Operating Systems Laboratory 0-0-3 2Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hour	

		(PEL)				s	
CSS452	**Operating Systems Laboratory**	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Introduction to Computing (CSC01), Data Structures and Algorithms (CSC303)							
Course Outcomes		CO1: Analyze the different system calls related to process control CO2: Devise programs to test data access synchronization problems CO3: Design and develop applications using user level thread library CO4: Apply file system concepts					
Topics Covered		**Assignment 1**: Getting a feel of race conditions through read/write operations by multiple process (run the same program in four terminals simultaneously) on a single binary file **Assignment 2**: Design application where the parent process uses fork system call to create multiple child processes in the different given hierarchy and displaying and storing the process hierarchy in a separate file **Assignment 3**: Design application where parent sync with several child process using fork & wait system call to solve a perticular task (searching, prime number generation, etc.) like parallely also try to understand and change process priorities using system calls **Assignment 4**: Implement signal handling among parent child processes **Assignment 5**: Design multithreaded application using POSIX thread library **Assignment 6**: Create shared memory to be used among a set of concurrent processes using POSIX library **Assignment 7**: Implement semaphores (named) and solve data access sync problems like (producer/consumer) using multiple processes **Assignment 8**: Implement semaphores (unnamed) and solve data access sync problems like (producer/consumer) using multiple threads **Assignment 9**: Use other IPC mechanisms like message queues, named pipe					
Text Books, and/or reference material		**Text Books: "**Beginning Linux Programming", 4th Edition by Richard Stones, Neil Matthew, Wiley Publishing, Inc. **Reference Books: "**Advanced Programming in the UNIX environment*"*, 3rd Edition, W. Richard Stevens and Stephen A. Rago, Addison-Wesley, 2013 **Others:**					

CSS453 Database Management System Laboratory 0-0-3 2Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS453	Database Management System	PCR	0	0	3	3	2

	Laboratory						
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Programming knowledge, Data structure knowledge		CT(Continuous Laboratory Assessment) and EA(Labtest and Viva)					
Course Outcomes	CO1: Understand, appreciate and effectively explain the underlying concepts of database technologies. CO2: Design and implement a database schema for a given problem-domain. CO3: Populate and query a database using SQL DML/DDL commands. CO4: Programming PL/SQL including stored procedures, stored functions, cursors, packages						
Topics Covered	**Structured Query Language (SQL):** 1. Creating Database Creating a Database Creating a Table Specifying Relational Data Types Specifying Constraints Creating Indexes 2. Table and Record Handling INSERT statement Using SELECT and INSERT together DELETE, UPDATE, TRUNCATE statements DROP, ALTER statements 3. Retrieving Data from a Database The SELECT statement Using the WHERE clause Using Logical Operators in the WHERE clause Using IN, BETWEEN, LIKE , ORDER BY, GROUP BY and HAVING Clause Using Aggregate Functions Combining Tables Using JOINS Subqueries 4. Database Management Creating Views Creating Column Aliases Creating Database Users Using GRANT and REVOKE **PL / SQL:** Decision-control in PL / SQL, Cursors in PL / SQL, Stored Procedures. **Case Studies:** Real-life case studies.						
Text Books, and/or reference material	**Text Books:** SQL, PL/SQL the Programming Language of Oracle by Ivan Bayross**,** PHI, 2010. **Reference Books:** SQL The Complete Reference, Groff James, 3rd Edition, Tata McGraw-Hill Education, India.						

FIFTH SEMESTER

CSC501 Compiler Design **3-1-0** **4Credits** **4Hours**

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC501	Compiler Design	PCR	3	1	0	4	4
Pre-requisites Theory of Computing/ Theory of Automata		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		● CO1: Idea of the difference between Compiler and other various Translators, Phases of a Compiler and Bootstrapping. ● CO2: Understand Lexical Analyzer, Transition Diagram of different tokens, Reserved Word Strategy. ● CO3: Idea of Syntax Analyzer, Ambiguity, Parse Tree, Top down and Bottom Up Parser. ● CO4: Concept of Semantic Analyzer, Semantic Actions, Intermediate Code, Virtual Machine. Lexical and Grammatical Errors. ● CO5: Idea of Code Optimization, Criterion of Optimization, Different Local and Global Optimization Techniques. ● CO6: Idea of Code Generation, Instruction Costs, Code Generation Algorithm, Run Time Store Management.					
Topics Covered		Idea of the difference between Compiler and other various Translators, Phases of a Compiler and Bootstrapping. (5L) Understand Lexical Analyzer, Transition Diagram of different tokens, Reserved Word Strategy. (5L) Idea of Syntax Analyzer, Ambiguity, Parse Tree, Top Down and Bottom Up Parser. (6L) Concept of Semantic Analyzer, Semantic Actions, Intermediate Code, Virtual Machine. Lexical and Grammatical Errors. (7L) Idea of Code Optimization, Criterion of Optimization, Different Local and Global Optimization Techniques. (7L) Idea of Code Generation, Instruction Costs, Code Generation Algorithm, Run Time Store Management. (7L) Symbol Table Design, Fixed Length and Variable Length Entry, Symbol Table Actions, Different Searches, Hash Table Organization, Different Deletions of Symbols, Linked List and Tree Representation. (5L)					
Text Books, and/or reference material		**Text Books:** 1. Principles of Compiler Design – Alfred V. Aho & Jefrey D. Ullman, Pearson Education. **Reference Books:** 1.Compiler Design in C – Holub, Prentice Hall.					

CSC 502 Data Communication and Computer Networks 3-1-0 4Credits 4Hours

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSC 502</td><td>Data Communication and Computer Networks</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))</td></tr>
<tr><td colspan="2">Data Structures and Algorithms, Operating system concepts</td><td colspan="5">CT+EA [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">CO1: Understand the basic taxonomy and terminology of the computer networking and enumerate the layers of OSI model and TCP/IP model
CO2: Comprehend the fundamentals of Physical layer, and will apply them in real time applications
CO3: Identify data link layer concepts, design issues, and protocols
CO4: Classify the routing protocols and analyze how to assign the IP addresses for the given network
CO5: Acquire knowledge of Application layer and Presentation layer paradigms and protocols</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Overview of Data Communication and Networking: Introduction; Data communications: components, data representation (ASCII,ISO etc.), direction of data flow (simplex, half duplex and full duplex); network criteria, physical structure (type of connection, topology), categories of network (LAN, MAN,WAN); Internet: brief history, Protocols and standards; Reference models: OSI reference model, TCP/IP reference model, their comparative study. [4L]
Physical Level: Overview of data (analog & digital), signal(analog & digital), transmission (analog & digital) & transmission media (guided & unguided); Circuit switching: time division & space division switch, TDM bus; Telephone Network. [6L]
Data link Layer: Types of errors, framing (character and bit stuffing), error detection & correction methods; Flow control; Protocols: Stop & wait ARQ, Go-Back- N ARQ, Selective repeat ARQ, HDLC; Medium Access sublayer: Point to Point Protocol, LCP, NCP, Token Ring; Reservation, Polling, Multiple access protocols: Pure ALOHA, Slotted ALOHA, CSMA, CSMA/CD, CSMA/CA, Traditional Ethernet, Fast Ethernet. [12L]
Network layer: Internetworking & devices: Repeaters, Hubs, Bridges, Switches, Router, Gateway; Addressing : IP addressing, subnetting; Routing : techniques, static vs. dynamic routing , Unicast Routing Protocols: RIP, OSPF, BGP; Other Protocols: ARP, IP, ICMP, IPV6, Congestion Control: Open Loop, Closed Loop choke packets; Quality of service: techniques to improve QoS: Leaky bucket algorithm, Token bucket algorithm. [14L]
Transport layer: Process to Process delivery; Socket address, UDP; TCP. [4L]
Application Layer: Introduction to DNS, SMTP, SNMP, FTP, HTTP & WWW. [4L]
Security: Cryptography (Public, Private Key based), Digital Signature, Firewalls.</td></tr>
</table>

	[4L] **Modern topics:** ATM, DSL technology, Introduction to blue-tooth. [4L] **Queuing Theory:** Introduction to Queuing Theory and Delay Analysis for networks.[4L]
Text Books, and/or reference material	**Text Books:** 1.B. A. Forouzan – "Data Communications and Networking (3rd Ed.) " – TMH 2. A. S. Tanenbaum – "Computer Networks (4th Ed.)" – Pearson Education/PHI **Reference Books:** 3. Comer – "Internetworking with TCP/IP, vol. 1, 2, 3(4th Ed.)" – Pearson Education/PHI.

CSC 503 Embedded Systems 3-1-0 4 Credits 4 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC503	Embedded Systems	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Computer Organization and Architecture (CSC401)		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		• CO1: Understand the Building Blocks of Embedded Systems • CO2 : Learn to implement circuits using FPGAs and HDL programming • CO3: Learn the working of microcontrollers in building embedded systems. • CO4: Understand the importance of power in the design process. • CO5: Understand the concepts and constraints of realtime systems. • CO6: Learn the techniques of synthesizing hardware design from HDL.					
Topics Covered		UNIT-1 Introduction to embedded System, Modular approach to embedded system design using six-box approach: Input devices, output devices, embedded computer, communication block, host and storage elements, and power supply., Processor, General Purpose and ASICs Processor, Designing a single purpose processor, Optimization Issues. 6L UNIT-2 Introduction to FPGA, Behavioral synthesis on FPGA using VHDL/Verilog. 4L UNIT-3 Microcontroller based embedded system Design, Salient feature of modern microcontroller, Arduino Uno, Serial Communication and Timer, Controller Design using Arduino. 5L UNIT-4 Sensors and Signals, Discretization of signals and A/D Converter, Quantization Noise, SNR and A/D converter, 5L UNIT-5 Power Aware Embedded System, SD and DD Algorithm, Parallel operations and VLIW, Code efficiency, DSP Application and address generation Unit. 6L					

	UNIT-6 Real time operating system, RMS Algorithm, EDF Algorithm and resource constraint issue, Priority inversion and Priority inheritance 5L UNIT-7 Modelling and specification, FSM and state chart, state mate semantics, Program state machine, SDL, Data flow model 5L UNIT-8 Hardware synthesis, Scheduling, Digital camera design, Digital camera-iterative design, HW-SW partitioning, Optimization, Simulation, Formal verification 6L
Text Books, and/or reference material	Text Books: 1. Mazidi and Mazidi, Microcontroller and Embedded Systems, Pearson Education. 2. Peter Marwedel, Embedded System Design, Kluwer. 3. Wayne Wolf, Computers as Components: Principles of Embedded Computing Systems Design, Morgan-Kaufmann. 4. Frank Vahid and Tony Givargis, Embedded System Design: A Unified Hardware/Software Introduction, John Wiley. Reference Books: 1. R. Kapadia, 8051 Microcontroller and Embedded Systems, Jaico. 2. Peatman,J.B., "Design with PIC Micro Controllers"PearsonEducation,3rdEdition, 2004. 3. Furber,S., "ARM System on Chip Architecture" Addison Wesley trade Computer Publication, 2000.

CSC504 Algorithm Design and Analysis- II 3-1-0 4 Credits 4 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC504	Algorithm Design and Analysis- II	PCR	3	1	0	4	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Algorithm Design and Analysis- I (CSC303)		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	After completing the course, students will be able to: ● CO1: Understand some advanced concept of data structures and algorithms. ● CO2: Understand algorithms through its design paradigms. ● CO3: Efficiently analyze the time complexity of the data structures and algorithms. ● CO4: Recognize the state-of -the-art about the data structures and algorithms. ● CO5: Create efficient solutions to more complex real-life problems.						

Topics Covered	**Introduction.** (1L) **Some Advanced Data Structures:** Augmented Data Structures, Count-min-Sketch, Tries and Suffix Trees, KD-Tree, Range Minimum Queries, Splay Trees, Fusion Trees and Euler Tour Trees. (9L) **Disjoint Set Forests,** Overview of Fibonacci heap and Binomial heap. (2L) **Graph Algorithms:** Depth First Search, Breadth First Search, Dijkstra's Single Source Shortest Path, All Pair Shortest Path, Bellman Ford, Minimum Spanning Tree (Prim's and Kruskal's algorithm), Strongly Connected Components. (7L) **Randomized Algorithm**: Las Vegas and Monte Carlo; Randomized Quick Sort algorithm and Min Cut problem. (3L) **Reducibility between problems and NP-completeness:** Different class of Problems (P, NP, NP-Hard, NP-Complete), Discussion of different NP-complete problems like satisfiability, clique, vertex cover, independent set, Hamiltonian cycle, set cover, dominating set problem. (6L) **Approximation Algorithm:** Approximation ratio for maximization problem and minimization problem, Constant ratio approximation algorithms for metric travelling salesperson problem (TSP) and vertex cover problem, log n ratio approximation algorithm for Set Cover problem. (6L) **Backtracking Method, Branch and Bound Method.** (2L) **Learning Algorithm:** Overview of Multiplicative Weight Update with its analysis. (1L) **Maximum Flow:** Flow Networks and the Ford-Fulkerson method. Application of flow network: bipartite matching. (3L) **String Matching Algorithms:** Rabin-Karp and Knuth-Morris-Pratt. (2L)
Text Books, and/or referenc e material	**Text Books:** 1..T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, Introduction to Algorithms, by Prentice Hall. 2. 1. A. V. Aho, J. D. Ullman and J. E. Hopcroft, “Data Structures and Algorithms”, Addition Wesley. 3. Kleinberg and Eva Tardos. Algorithm Design. Addison-Wesley 2005 ISBN-13: 978-0321295354. **Reference Books/Lecture Notes:** 1. Tim Roughgarden, Algorithms Illuminated (Part 1-4), Soundlikeyourself Publishing, LLC; Illustrated edition (August 5, 2018). 2. Michael T. Goodrich and Roberto Tamassia, Design and Analysis of Algorithms, Wiley. 3. Robert Sedgewick and Kevin Wayne, Algorithms (4th Edition), Addison-Wesley. 4. Keith Schwarz and Kevin Tan, CS166: Advanced Data Structures (Stanford). 2. Knuth, Donald E. The Art of Computer Programming. 3rd ed. Vols 1&2. Reading, MA: Addison-Wesley, 1997. ISBN: 0201896834. ISBN: 0201896842. ISBN: 0201896850. 6. Juraj Hromkovič, Algorithmics for Hard Problems: Introduction to Combinatorial Optimization, Randomization, Approximation, and Heuristics, Second Edition, Springer-Verlag, 2004.

CSS 551 Compiler Laboratory 0-0-3 2Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS551	Compiler laboratory	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Compiler Design Theory of Computation CSC402		CT(Continuous Assessment) and EA(Labtest and Viva)					
Course Outcomes	CO1 : To apply the concept of regular expressions in the identification of tokens in a lexical analyser CO2 : To explore the use of program generating softwares like LEX CO3 : To generate context -free grammar to represent the syntax of the language CO4 : To use compiler generators like YACC CO5: To use syntax directed translation to generate intermediate code.						
Topics Covered	1. Handle tokens in an input using LEX generated program 2. Describe class of tokens using regular expressions in LEX 3. Use context free grammars with YACC to describe simple syntactical structures. 4. Remove ambiguity in if-then-elst\e constructs using YACC's inbuilt features. 5. Use syntax directed translation in YACC to generate simple intermediate code.						
Text Books, and/or reference material	**Text Books:** 1. Lex - A Lexical Analyzer Generator ***M. E. Lesk and E. Schmidt*** Online Manual 2. Yacc: Yet Another Compiler-Compiler ***Stephen C. Johnson*** Online Manual 3. Lex & Yacc *John R. Levine, Tony Mason, Doug Brown* , O'Reilly & Associates **Reference Books:** **1. Compilers: Principles, Techniques, and Tools** **By Alfred V. Aho, Ravi Sethi, Jeffrey D. Ullman. Addison-Wesley Pub Co**						

CSS 552 Embedded System Design Laboratory 3-0-0 2 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS 552	Embedded Systems Laboratory	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
CSS 451 Computer Organization Laboratory		CT+EA [CT: 60%, EA(Laboratory assignment + Viva Voce): 40%]					
Course Outcomes	After the course the students are expected to be able to CO1: Learn the working of microcontroller.						

	CO2 : Understand the Building Blocks of Embedded Systems CO3: Learn to implement circuits using FPGAs and HDL programming. CO4 : Learn to solve problems using Arduino/Raspberry Pi CO5: Know the characteristics ARM processor and use it in designing embedded systems.
Topics Covered	List of Experiments: 1. Familiarization with 8051 microcontroller based programming. 2. Interfacing of 8051 Microcontroller with ADC and DAC/LCD Display/Traffic signal Processing etc. 3. Simulating simple circuits using Verilog/VHDL and FPGA kits. 4. LED blink for different amounts of time using Arduino (with/without using delay () function). 5. Controlling the LED blinking using a Potentiometer (Read potentiometer). 6. Interfacing Arduino with simple LED Matrix. 7. Sensing temperature using Raspberry Pi. 8. Familiarization with ARM DEVELOPMENT KIT microcontroller using embedded C program. 9. Develop and verify the interfacing LED and PWM with ARM DEVELOPMENT KIT microcontroller using embedded C program 10. Develop and verify the interfacing of real time clock and serial port with ARM DEVELOPMENT KIT microcontroller using embedded C program. 11. Verify the Interrupt performance characteristics of ARM and FPGA by using embedded C program
Text Books, and/or reference material	**Text Books:** 1. Peatman,J.B., "Design with PIC Micro Controllers"PearsonEducation,3rdEdition, 2004. 2. Programming Arduino: Getting Started with Sketches Book by Simon Monk 3. R. Kapadia, 8051 Microcontroller and Embedded Systems, Jaico.

CSE5XX System Software 3-0-0 3 Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE5XX	System Software	PEL	3	0	0	3	3
Pre-requisites: Programming Language Paradigms, Theory of Computing, Computer Architecture, Operating Systems, Compilers		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
		CT+EA [CA=15%, MT=25%, ET=60%]					
Course Outcomes	CO1: To introduce the students to the collection of programs and procedures which constitute the system software of a computer platform. CO2: To allow the students to understand & acknowledge the main objectives,						

	problems faced and programming techniques used by a system programmer in designing and implementing system software. CO3: To emphasise on conceptual framework in which the system software is developed and used rather than a broad overview of programs which belong to the system software running on a particular computer platform. CO4: To enable the students to deduce the logical relationship between the software components of any software system. CO5: To enable students to understand the mechanism of Integration of different System Software components.
Topics Covered	Part I: The Methodology ● The fundamental objective of this part is to develop a concept of a System. Concept is to be built upon both Mathematical construction (Algebraic and Logic Systems) as well as around construction based on Abstract Machines. [3L] ● Programs and documents that are part of System Software are to be defined. [1L] ● A structuring of System Software Components are to be defined and built. ○ Vertical Structuring: Components of the system software are layered on a hierarchy of levels. The hardware system is taken as the first level of this hierarchy. The interface relationship between the components of the system software vertical hierarchy is then established. [2L] ○ Horizontal Structuring: Each level of the system software vertical hierarchy is discussed as a horizontal structure. The elements of this horizontal structure (formal definitions will also be given) are specific software components of the system software organized as software systems. [2L] ● The specific problems posed by the interaction between the software system components of a horizontal level of the system software hierarchy are discussed and illustrated. The problems raised by the **reliability, efficiency, convenience**, and evolution of a system software are introduced and illustrated. [2L] Part II: Programming Support Environment: ● of a System Software is to be discussed as the collection of tools offered by a computer platform to computer users to help them use the computer to develop programs that solve their problems. [2L] ● Detailed discussions on Topics like: Language, Translators, Interpreters, Mechanism of target machine code generation; proper emphasis on distinguishing between Compilers, Assemblers, Linker/Loaders, and Interpreters will be there. Interfacing users with the Operating System environment as tolls from the support environment is to be discussed. [6L] ● Case study of JVM, GNU GCC implementation of the Linux Assembler, Linker and Loader will be dealt with in detail, introducing implementation of symbol tables. [8L] Part III: Execution Support Environment: ● A software system that manages computer resources of the computer platform and the processes running on the computer platform will be introduced and illustrated by the operating system. [3L] ● The components of the operating system itself are layered on the levels of a hierarchy. [2L]

	● The mechanism of a system call (system function call) will be discussed as a tool for implementing this hierarchy relation. [2L] ● The following layers of an operating system will be discussed with a practical illustration with the Linux kernel, with mechanisms of designing system programs developed with and for the support of: [10L] ○ Interrupt System ⇔ designing interrupt handlers. ○ Process Management System ⇔ designing schedulers. ○ Memory Management System ⇔ designing page-fault exception handlers ○ Input/Output Management System ⇔ designing device drivers ○ Information Management System (File System) ⇔ examining ext2/ext3/ext4.
Text Books, and/or reference material	**Text Books:** 1. System Software and Software Systems: Systems Methodology for Software, Tudor Rus, World Scientific Press, 1993 2. System Software: An Introduction to Systems Programming, leyland L. Beck, 1996 3. System Programming with C and Unix, Adam Hoover, Adison Wesley 2010. **Reference Books:** 1. Understanding the Linux Kernel, Daniel P. Bovet, Marco Cesati, O'Reilly Pub Date:November 2005 Available online at: http://johnchukwuma.com/training/UnderstandingTheLinuxKernel3rdEdition.pdf

CSE5XX Graph Theory 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 5XX	Graph Theory	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
Discrete Mathematics and Data Structures		CT: 15%, MT: 25%, EA: 60%					
Course Outcomes	CO1: **Understand** the basic concept of graph and its properties CO2: **Apply** the basic properties of graph theory to prove different CO3: **Discuss** about chromatic characteristics and planar graph CO4: Students can explore knowledge of graph theory to solve the technology driven and research oriented problems. CO4: **Solve** various graph theory problems CO5: **Use** a combination of theoretical knowledge and mathematical thinking to solve various computer science applications						
Topics Covered	**Preliminaries:** Graphs, isomorphism, automorphism, components, sub-graphs, degree, operations on graphs, radius, diameter, bipartite graph, Operations on graph: deletion of vertex/edge, fusion, union, intersection, ring sum, decomposition, join, Cartesian product, complement. Self-complementary graphs, circuits [8L]						

	Connected graphs and shortest paths: Walks, trails, paths, connected graphs, distance, cut-vertices, cut-edges, connectivity: edge and vertex connectivity, relationship between edge and vertex connectivity, k-connected graph, Menger's theorem, separable graph, blocks, block-cut vertex tree, block tree, cut vertex tree,1-isomorphism, 2-isomorphism, topological ordering [8L] **Trees:** Characterizations, number of trees, minimum spanning trees, Distance between spanning tree of a connected graph, eccentricity, Centre(s) of trees and connected graph, diameter of tree and connected graph , nullity of tree, labelled graph [3L] **Planarity:** Planar graph, Kuratowski's theorem , Euler's formula, Detection of planarity , duality, uniqueness of duality, Homomorphism: subdivision, merging, planarity detection using homeomorphism graphs, five color and four color problem [5L] **Covering, Independent sets, Dominating Set, Matching:** Basic concepts, vertex and edge covering, minimal covering, independent set, maximal independent set, relationship between covering and independent set, theorems, dominating set, MDS, CDS, matching in bipartite graphs, perfect matching, maximal matching, minimum matching, Hall's theorem [6L] **Factorization:** Factor, 1-factor, 2-factor Tutte's theorem [3L] **Vertex coloring:** Chromatic number and cliques, greedy coloring algorithm, Brook's theorem, chromatic partition, Uniquely colourable graph [3L] **Edge coloring:** Gupta-Vizing theorem, color edge, equitable edge-coloring [2L] **Line Graph:** Properties and proof [2L] **Eulerian graphs:** Characterization, Arbitrarily traceable graph, Fleury's algorithm [2L]
Text Books, and/or reference material	**Text Books:** **1** Douglas B. West. Introduction to Graph Theory. Pearson Education, Second Edition 2. R. Deistel. Graph Theory. Springer- Verlag NewYork 1997 3. R.J. Wilson and J.J. Watkins. Graphs : An Introductory Approach. John Wiley and Sons Inc **Reference Books:** 1. N. Deo. Graph Theory; With Applications to Engineering and Computer Science. PHI 2. S. Pirzada. An Introduction to Graph Theory. Orient Blackswan

CSE5XX Advanced Computer Architecture 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 5XX	Advanced Computer Architecture	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
Digital Electronics,		CT+EA [CA=15%, MT=25%, ET=60%]					

Computer Organisation	
Course Outcomes	● CO1: To know about the classes of computers, and new trends and developments in computer architecture ● CO2: To acquire knowledge about the various architectural concepts that may be applied to optimize and enhance the classical Von Neumann architecture into high performance computing systems. ● CO3: To learn the basic design procedure for different levels of parallelism. ● CO4: To learn the design issues relating to the architectural options.
Topics Covered	OVERVIEW OF VON NEUMANN ARCHITECTURE: Instruction set architecture; The Arithmetic and Logic Unit, The Control Unit, Memory and I/O devices and their interfacing to the CPU; Measuring and reporting performance; CISC and RISC processors. (4) PIPELINING: Pipelining fundamentals, Linear and Nonlinear Pipeline Processors, Arithmetic and instruction pipelining, Pipeline hazards, Techniques for overcoming or reducing the effects of various hazards, superscalar and super pipelined and VLIW architectures. (8) INSTRUCTION –LEVEL PARALLELISM (ILP): Concepts and challenges of ILP; Compiler Techniques for exposing ILP; Branch costs reductions - Static and Dynamic predictions; Hardware-based speculation. (8) MULTIPROCESSORS ARCHITECTURES: Introduction; Taxonomy of parallel architectures, Centralized shared-memory architecture: synchronization, memory consistency, interconnection networks. Distributed shared-memory architecture. (8) MEMORY HIERARCHY DESIGN: Introduction; Memory technology and optimizations, Virtual memory, Cache memory, Cache performance; Cache Optimizations, Cache coherence, Cache coherence protocols – snoop based and directory based protocols, Advanced optimizations of cache performance. (10) INTERCONNECTION NETWORKS: Topology, Different interconnection Networks, Routing Mechanism. (4)
Text Books, and/or reference material	**Text Books:** 1. Computer Architecture, A Quantitative Approach – John L. Hennessey and David A. Patterson; 4th edition, Morgan Kaufmann. 2. Advanced Computer Architecture Parallelism, Scalability, Programmability – Kai Hwang; Tata Mc-Graw Hill. **Reference Books:** 1. Computer architecture and parallel processing – Kai Hwang and FayéAlayé Briggs; McGraw-Hill. 2. Parallel Computer Architecture, a Hardware / Software Approach – David E. Culler, Jaswinder Pal Singh, Anoop Gupta; Morgan Kaufman. 3. John Paul Shen and Mikko H. Lipasti, Modern Processor Design: Fundamentals of Superscalar Processors, Tata McGraw-Hill. 4. M. J. Flynn, Computer Architecture: Pipelined and Parallel Processor Design, Narosa Publishing House. **Others:** NPTEL/MOOC Courses materials

CSE5XX Electronic Design Automation 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hour	

		(PEL)				s	
CSE5XX	Electronic Design Automation	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
Digital Electronics, Computer Organisation, Algorithm Analysis and Design.		CT + MT + EA					
Course Outcomes	CO1: To visit the various stages of the VLSI design cycle and appreciate the role of automation therein. CO2: To appreciate how High Level Synthesis converts an HDL code into an architecture level design. CO3: To discuss the algorithmic approach to physical design. CO4: To emphasize the importance to testability measures in the design.						
Topics Covered	VLSI Design cycle. Design styles. System packaging styles. Fabrication of VLSI devices. Design rules-overview. (L3) HLS: Scheduling in High Level Synthesis. ASAP and ALAP schedules. Time constrained and Resource constrained scheduling. (L4) HLS: Allocation and Binding. Datapath Architectures and Allocation tasks. (L4) Partitioning. Clustering techniques. Group Migration algorithms. (L4) Floorplanning. Constraint based Floorplanning. Rectangular Dualization. Hierarchical Tree based methods. Simulated Evolution approaches. Timing Driven floorplanning. (L5) Placement. Simulation based placement algorithms. Partitioning based placement algorithms. Cluster Growth. (L5) Global Routing. Maze Routing algorithms. Line probe algorithms. Shortest Path based algorithms. Steiner's Tree based algorithms. (L5) Detailed Routing. Channel Routing Algorithms. Switchbox Routing. Over-the-cell routing. Clock and Power Routing. (L4) Design for testability. Fault testing. Ad-hoc and structured DFT techniques. (L8)						
Text Books, and/or reference material	**Text Books:** 1. Algorithms for VLSI Physical Design Automation. N.A.Sherwani. Kluwer Academic Publishers. 2. High-Level Synthesis : Introduction to Chip and System Design. Gajski et. al. . Kluwer Academic Publishers. 3. Digital Systems Testing and Testable Design. Abramovici et.al. Jaico Publications **Reference Books** 1. VLSI Physical Design Automation. Sadiq M. Sait and Habib Youssef. Kluwer Academic Publishers. 2. Algorithms for VLSI Design Automation. Sabih H. Gerez. Wiley India. **3.** Essentials of Electronic Testing for Digital, Memory and Mixed Signal VLSI Circuits. Bushnell and Agrawal. Kluwer Academic Publishers**.**						

CSE5XX Digital Image Processing 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE5XX	Digital Image Processing	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
NIL		CT + MT + EA					
Course Outcomes	CO1: Acquire knowledge about image acquisition and camera basics CO2: To learn the basic algorithms on filtering, quality metrics, segmentation CO3: To learn about compression and color image processing, CO4: Development of image processing programs using ImageJ and Python						
Topics Covered	Introduction, Image acquisition process, image sensors, camera basics (4) Transform functions, Histogram, spatial and frequency filtering (8) Redundancy, compression models, coding methods (8) Point, Line, edge detection, thresholding, region based segmentation (6) Color models, color image processing, segmentation and compression using colors (8) Introduction to Image Processing using ImageJ and Python, Image databases (8)						
Text Books, and/or reference material	**Text Books:** 1. Digital Image Processing by Rafael C Gonzalez & Richard E Woods, 2. Fundamentals of Digital Image Processing by Anil K Jain **Reference Books:** Digital Image Processing by William K Pratt **Others:** NPTEL online course						

CSE5XX Game Theory and its Applications 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE5XX	Game Theory and its Applications	PEL	3	0	0	3	3
1. MAC 01: Mathematics - I 2. MAC 02: Mathematics - II 3. MAC 331 : MAC 01: Mathematics - III		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA)) CT:15%, MT:25%, EA:60%					

4. CSC 01: Introduction to Computing	

Course Outcomes	• CO1: Can have the efficiency to act in a strategic situation. • CO2: Can analyse the strategic interactions among agents. • CO3: Can understand modern state of the art in Game Theory • CO4: Will have the knowledge of related area where Game Theory can be applied
Topics Covered	**Introduction:** Motivation to the course (2) **Non-Coperative Game Theory:** Introduction to Game Theory, Extensive Form Games, Strategic Form Games, Dominat Strategy Equllibria, Pure Strategy Nash Equlibrium, Mixed Strategy Nash Equlibrium with examples.(8) **Mechanism Design without Money**: One sided and two sided matching with strict preferences, Voting theory, and Participatory democracy. (5) **Mechanism Design with Money:** Auction basics, sponsored search auctions, Revenue optimal auctions, VCG Mechanisms. Online auctions. (6) **Cooperative Game Theory**: Coalitional Games, The Core, and The Shapley Value. (4) **Repeated Games:** Introduction to repeated games and its Applications. (4) **Applications:** Incentive Study in - P2P Networks, Crowdsourcing (5) **Some Special Topics**: Fair Division, Price of Anarchy, Scoring rules, Learning in Auction, Synergies between Machine Learning & Game Theory. (8)
Text Books, and/or reference material	**Text Books:** **Reference Books:** **Others:**

CSE5XX Digital Systems Testing 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 5XX	Digital Systems Testing	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))
Digital Logic Design, Computer Organisation	CT + MT + EA

Course Outcomes	CO1: To explain and exemplify basic and advanced concepts of Testing of Digital Circuits. CO2: To understand fault modeling and test generation CO3 : To fully appreciate the need for testability measures in the design stage of circuits. CO4: To understand the use of built in testing measures for online testing.

	CO5: To appreciate the different testing strategies for memory based devices.
Topics Covered	Introduction to VLSI testing and verification. Logic and Event Driven Simulation. (L2) Fault Modeling. Single Stuck-at Fault model. Fault Collapsing. Fault Equivalence. Fault Domination. Checkpoint Theorem (L8) Fault Simulation. Serial, Parallel, Deductive and Concurrent. (L3) Test Generation. Boolean Difference Method. D-Algorithm. PODEM. FAN. (L8) Testability Analysis (L3) Design for Testability. Adhoc approaches. Scan based Design. Random Scan. Scan FF design. LSSD. Scan-Hold FF. (L8) Built-in Self Test. Pseudo-Random Pattern Generation. LFSR. (L8) Memory testing. (L2)
Text Books, and/or reference material	**Text Books:** 1. Essentials of Electronic Testing for Digital, Memory and Mixed Signal VLSI Circuits. Bushnell and Agrawal. Kluwer Academic Publishers. 2. Digital Systems Testing and Testable Design. Abramovici et.al. Jaico Publications **Reference Books:** **1.** VLSI Test Principles and Architectures. LT Wang et.al. Morgan Kaufman.

CSE5XX Advanced Database Systems 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE5XX	Advanced Database Management Systems	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))
Fundamental of DBMS, Data Structures	CT+EA [CA: 15%, MT: 25%, ET: 60%]
Course Outcomes	CO1: Acquire knowledge about the design and application view of DBMS CO2: Able to analyze query expression, specially importance of query optimization CO3: To learn about design, features and operations in the field of DDBMS, OODBMS and DW CO4: To learn the concept of using multimedia database as a real-life application
Topics Covered	**Unit-1:** Comparison between different databases: Significance of Databases, Database System Applications, Advantages and Disadvantages of different Database Management systems, Comparison between DBMS, RDBMS, Distributed and Centralized DB, Introduction of various types of index structures: Primary, Secondary, Multilevel, Dynamic multilevel (B-

	tree and B+- tree) (5 L) **Unit-2:** Normalization: Functional Dependency, Anomalies in a Database, The normalization process: Conversion to first normal form, Conversion to second normal form, Conversion to third normal form, The boyce-code normal form(BCNF), Fourth Normal form and fifth normal form, normalization and database design, Denormalization, Lossless join decomposition, Dependency preservation. (6L) **Unit-3:** Transaction processing: Introduction of transaction processing, advantages and disadvantages of transaction processing system, online transaction processing system, serializability and recoverability, view serializability, Transaction management in multi-database system, long duration transaction, high-performance transaction system. (5 L) **Unit-4:** Concurrency Control Serializability: Enforcing, Serializability by Locks, Locking Systems With Several, Lock Modes, Architecture for a Locking Scheduler Managing Hierarchies of Database Elements, Concurrency Control by Timestamps, Concurrency Control by Validation, Database recovery management. (5 L) **Unit-5:** Query Optimization: Algorithm for Executing Query Operations: External sorting, Select operation, Join operation, PROJECT and set operation, Aggregate operations, Outer join, Heuristics in Query Optimization, Semantic Query Optimization, Converting Query Tree to Query Evaluation Plan, multi-query optimization and application, Efficient and extensible algorithms for multi-query optimization. (5 L) **Unit-6:** Query Execution: Introduction to Physical-Query-Plan Operators, One-Pass Algorithms for Database, Operations, Nested-Loop Joins, Two-Pass Algorithms Based on Sorting, Two-Pass, Algorithms Based on Hashing, Index-Based Algorithms, Buffer Management, Parallel Algorithms for Relational Operations, Using Heuristics in Query Optimization, Basic Algorithms for Executing Query Operations. (5 L) **Unit-7:** Distributed Database (DDB): Introduction of DDB, DDBMS architectures, Homogeneous and Heterogeneous databases, Distributed data storage, Advantages of Data Distribution, Disadvantages of Data Distribution Distributed transactions, Commit protocols, Availability, Concurrency control & recovery in distributed databases, Directory systems, Data Replication, Data Fragmentation. Distributed database transparency features, distribution transparency. (5 L) **Unit–8:** Object Oriented DBMS(OODBMS): Overview of object: oriented paradigm, OODBMS architectural approaches, Object identity, procedures and encapsulation , Object oriented data model: relationship ,identifiers, Basic OODBMS terminology, Inheritance , Basic interface and class structure, Type hierarchies and inheritance, Type extents and persistent programming languages, OODBMS storage issues. (5 L)

	Unit –9: XML Query processing: XML query languages: XML-QL, Lorel, Quilt, XQL, XQuery, and Approaches for XML query processing, Query processing on relational structure and storage schema, XML database management system. (5 L) **Unit –10:** Data Warehousing: Overview of DW, Multidimensional Data Model, Dimension Modelling, OLAP Operations, Warehouse Schema (Star Schema, Snowflake Schema), Data Warehousing Architecture, Virtual Data, Metadata and Types of Metadata, OLAP Engine, Data Extraction, Data Cleaning, Loading, Refreshing. (8 L) **Unit-11:** Database application: Multimedia database, Video database management: storage management for video, video preprocessing for content representation and indexing. (2 L)
Text Books, and/or reference material	**Text Books:** 1. "An Introduction to Data Base Systems", C. J Date, Pearson Education. 2. "DatabaseSystem Concepts", Abraham Silberschatz, Henry F. Korth and S. Sudarshan, McGraw-Hill. 3. "Distributed Databases Principles & Systems", Stefano Ceri and Giuseppe Pelagatti, McGraw-Hill International Editions. **Reference Books:** 1. "Fundamentals of Database Systems", Ramez Elmasri and Shamkant B. Navathe, Addison-Wesley. **Others**

CSE5XX Randomized Algorithms 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the Course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE5XX	**Randomized Algorithms**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basics of Algorithms and Probability		CT+EA					

Course Outcomes	· CO1: To be able to model a problem using randomized algorithms, if it is necessary. · CO2: Comparing standard randomized algorithm with its non-randomized version through analysis. · CO3: Can learn tools and techniques for designing and analysing randomized algorithms.
Topics Covered	**Introduction:** Overview and Motivational Examples. (2) **Tools:** · Indicator Random Variable, Linearity of expectation; Markov inequality; Chebyshev's inequality; Chernoff bound; Union bound with examples to Randomized algorithm design. (12) · Coupon Collection and Occupancy Problems. (4) · Conditional Expectation and Martingales. (4) · Balls, Bins and Random Graphs. (4) · Markov Chains and Random Walks. (4) · Probabilistic Method. (6) **Applications:** · Sorting; Selection; Data Structure; Graph Problems. (6) · Metric Embeddings. (3) · Online Algorithms. (4) · Algorithms for Massive Data Set include Similarity Search. (4) · Other Modern Applications. (3)
Text Books, and/or reference material	**Text Books:** 1. Rajeev Motwani and Prabhakar Raghavan, Randomized Algorithms, 2nd Edition, Cambridge University press, Cambridge, MA, 1995. 2. Thomas H. Cormen, Charles Leiserson, Ronald Rivest, and Clifford Stein. Introduction to Algorithms. 3rd ed. MIT Press, 2009. ISBN: 9780262033848. 3. M. Mitzenmacher and E. Upfal, Probability and Computing: Randomized Algorithms and Probabilistic Analysis, Cambridge University Press. 4. J. Kleinberg and E. Tardos, Algorithm Design,Pearson. **Reference Book/Lecture Notes:** 1. D. Karger, 6.856J/18.416J: Randomized Algorithm (MIT Course), Spring 2019. 2. Siddharth Barman and Arindam Khan, E0 234: Introduction to Randomized Algorithms (IISc.), Spring 2021 (Several links of other courses are provided). 3. A. Goel, CME 309/CS 365: Randomized Algorithm (Stanford Course), Winter 2012-13. 4. G. Valiant, CS265/CME309: Randomized Algorithms and Probabilistic Analysis (Stanford University Course), Fall 2018. 5. Dimitri P. Bertsekas and John N. Tsitsiklis, Introduction to Probability, 2nd Edition, Athena Scientific, July 2008. 6. T. Roughgarden, CS261: A Second Course in Algorithms (Stanford University), 2016 and Randomized Algorithms: COMS 4995 (2019)

CSE XXX Object oriented system design 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSEXXX	**Object Oriented System Design**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basics of Algorithms and Probability		CT+EA					
Course Outcomes	CO1: Introduction of the fundamental concepts of Object Oriented System CO2: Understanding the concept of System Design Using Object Oriented Paradigm CO2: Understanding the concepts of UML CO4: Understanding Application Development and Quality management of Object Oriented System						
Topics Covered	**Introduction** Why object orientation, History and development of Object Oriented Programming language, concepts of object oriented programming language. Object, class, message passing, encapsulation, polymorphism, aggregation, threading, difference between OOP and other conventional programming-advantages and disadvantages. **(6H)** **Object Oriented Process Model:** Fountain Model, Iterative Water Model, RUP Model, Component Based model. **(6H)** **Object oriented analysis** Usecase diagram; Major and minor elements, Object, Class. Booch, Raumbagh, Codd Yordon, Jakobson Methods **(4H)** **Object oriented design** Relationships among objects, aggregation, links, relationships among classes association, aggregation, using, instantiation, meta-class, grouping constructs. **Fundamentals of Object Oriented design in UML (** Well-formed Rules and semantic guide of UML, Structural models – Use Case Description, Class Diagram, Object diagram, Role Concepts, interaction diagram: collaboration diagram, sequence diagram, UML Dynamic modelling concepts: state chart diagram, activity diagram, implementation diagram, UML extensibility- model constraints and comments, Note, Stereotype. **Analysis & Design of OOSE using UML [2H]** Analysis modelling using UML, Design modelling using UML, Tools support (Introduction to Rational Rose). **Object Oriented System Architecture [4H]** Model Driven Architecture, Domain Specific Modelling notation, Model integrated Computing for OOSE **Quality Evaluation of OOS:** CK metrics and methods, Lee Metrics, Quality analysis **(4H)**						

Text Books, and/or reference material	Rambaugh, James Michael, Blaha - "Object Oriented Modelling and Design" - Prentice Hall India/ Pearson Education References: 1. Ali Bahrami, "Object –Oriented System Development" - Mc Graw Hill. 2. Bruce, Foundations of Object Oriented Languages, PHI 3. UML Standards, V 2.5, OMG, 01-03-2015 or Latest.

CSE5XX Optimization Techniques 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE5XX	Optimization Techniques	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Engineering Mathematics, Discrete Mathematics		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	CO1: To understand the Basic principles of optimization. CO2: To able to formulate optimization problem mathematically. CO3: To know various solution methods in optimization Problems. CO4: Able to perform sensitivity analysis and post processing of optimal solutions. CO5: Able to explore a wide range of engineering optimization problems.						
Topics Covered	**Introduction to Optimization:** Development, mathematical problem formulation, engineering applications of optimization, classification of optimization problems. 2L **Classical Optimization of Single and Multi-variable:** Optimality criterion for single and multi-variable method, Region elimination methods, Gradient based methods for single variable and Multivariable, unidirectional search, direct search methods. 7L **Linear Programming Problem:** Linear programs formulation, preliminary theory and geometry of linear programs, basic feasible solution, different form of LPP; Graphical representation and solutions; Simplex method - variants of simplex method; Duality and its principles- interpretation of dual variables, dual simplex method, primal-dual method; Degeneracy in LPP; Sensitivity analysis; Transportation problems; Assignments problems. 15L **Network Analysis in Project Planning:** Basics of network models, PERT and CPM with activity times known and probabilistic. Various types of floats, Project crashing. Formulation of CPM as a linear programming problem. Resource leveling and resource scheduling. 6L **Decision Analysis and Game Theory:** Introduction, Decision-making environment, Decision under uncertainty; Theory of Games, Rules for Games, Mixed strategies, Bidding problems. 6L **Non-Linear Programming:** Introduction, examples of non-linear programming, types of non-linear programming, Constraint and Unconstrained optimization, methods of nonlinear programming. 6L						

Text Books, and/or reference material	**Text Books:** 1. S. S. Rao, Engineering Optimization: Theory and Practice, New Age International. 2. K. Deb, Optimization for Engineering Design, Prentice Hall of India. 3. A. Ravindran, K. M. Ragsdell and G. V. Reklaitis, Engineering Optimization: Methods and Applications, Wiley. 4. Hillier & Lieberman, Introduction to Operations Research, TMH. **Reference Books:** 1. S. M. Sinha, Mathematical Programming, Elsevier. 2. Handy Taha, Operations Research – An Introduction, Prentice Hall of India, New Delhi. 3. R. Fletcher, Practical Methods of Optimization, Wiley.

SIXTH SEMESTER

CSC 601 Software Engineering 3-1-0 4Credits 4Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC 601	Software Engineering	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
Course Outcomes	(a) Be successful professionals in the field with solid fundamental knowledge of software engineering. (b) Utilize and exhibit strong set of skills, while working as an individual and as part of a multidisciplinary team to develop and deliver quality software. (c) Apply their foundations in software engineering to adapt to readily changing environments using the appropriate theory, principles and processes. (d) Learning Object Oriented system Design methodologies. (e) Learning CASE Tools and their usage (f) Learning Project Management Skill						
Topics Covered	*Software Paradigm / Introduction:* Definition of Information System, software, software engineering paradigms, Software engineering in context of Business Process Engineering, Goal of Software Engineering, Quality focus. (2H) *Software Process Model:* Umbrella activities; Waterfall Model, Prototype model, Rapid Application Development Model, Evolutionary Approach in Process model (Spiral Model) (4H) *Requirement Engineering:* Requirements Engineering Tasks, Information Modelling (Entity Relationship Model, Extended ER Model), Functional Model (DFD, CFD), Behavioral Model (State Transition Diagram), Petri-net modelling, System Requirement Specification (SRS), Specification Language – Formal						

	Methods, Regular Expression, Decision Tree, Decision Table, SRS Standards (6H) *Design Principle and Basics:* Design level tasks, Problem partitioning, abstraction, top down & bottom up design strategies, refinement techniques, Minor Design principles, Control Hierarchy (Structured Chart), constraint design (Warnier –Orr). (2H) *Design Language basics:* Unified Modelling Language – Building Blocks, Well-formedness rule; Use case, structural diagram introduction - Class Diagram, Object Diagram, Sequence diagram, collaboration diagram. (6H) *Modular Design:* Concept of module and Modular design, Functional independency, Cohesion, Coupling, measuring cohesion and coupling, Model Driven Architecture. (4H) *Architecture Basic:* Software architecture, Functional and extra-functional properties, families of related system, Architectural styles: Data-centric, data-flow, call and Return, layered, enterprise. (2H) *Project Management*: LOClFunction Point Analysis PERT Chart estimationl Different cost estimation: Delphi-empirical-COCOMO estimation. (2H) *Coding Techniques & Standard guidelines*: Rules/guidelines for standard Coding l Gunning Fog Index for documentation. (2H) *Testing strategy 1*– Introduction to Software Testingl Software Testing Terminology and Methodologyl Verification and Validationl Static Testing: Inspections, Structured Walkthroughs, Technical Reviews l Dynamic Testing : Black-Box Testing Techniques: Boundary Value Analysis (BVA), Equivalence Class Testing, State Table-Based Testing, Decision Table-Based Testing, Cause-Effect Graphing Based Testing, Error Guessing l Dynamic Testing : White-Box Testing Techniques: Need of White-Box Testing, Logic coverage Criteria, Basis Path Testing, Graph Matrices, Loop Testing, Data Flow Testing. (6H) *Testing strategy 2*- Validation Activities: Unit Validation Testing, Integration Testing, Function Testing, System Testing, Acceptance Testing lRegression Testing: Progressive vs Regressive Testing, Regression Testability. (2H) *Software & Metrics:* Software Measurement & metrics, Direct and indirect metrics, Size oriented metrics, Function oriented Metrics, Complexity Metrics – McCabe Complexity, McClure Complexity, and Halstead Software Science. (4H)
Text Books, and/or reference material	**Text Books:** R. S. Pressman -"Software Engineering – Practitioner's Approach"- McGraw Hill International I. Somerville – "Software Engineering", Addison-Wesley **Reference Books:** Rajib Mal - "Fundamental of Software Engineering", PHI **Others:** Unified Modelling Language, Object Management Group, http://www.omg.org/spec/UML/

CSC602 Artificial Intelligence and Machine Learning 3-1-0 4Credits 4Hours

<table>
<tr><td colspan="8">Department of Computer Science and Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSC502</td><td>Artificial Intelligence and Machine Learning</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))</td></tr>
<tr><td colspan="2">Basic Concepts of Probability and Statistics, Knowledge of Algorithm analysis</td><td colspan="6">CE+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Identify problems where artificial intelligence (AI) techniques are applicable
• CO2: Understand to apply search strategies to solve the problems.
• CO3: Principal models used in machine learning and Apply them in machine learning to appropriate problems
• CO4: Formulate valid solutions for problems involving uncertain inputs or outcomes by using decision making techniques.
• CO5: Understanding different supevised and unsupervised learning methods.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to Artificial Intelligence (AI): What is Intelligence, Reasoning and Planning, Learning and Adaptation, and interaction with the real world, A brief history of AI, Application areas of AI, State of the art. (2)
Problem solving by search: Problem types, Illustrative search problems; Search Space, Search tree; BFS, DFS, UCS; Greedy search, Local search; Hill climbing; Heuristics; A* search; Admissibility and consistency of heuristics, Game trees; Minimax search; Alpha-beta pruning. (7)
Knowledge Representation: Propositional, predicate logic, first order logic, resolution and unification; logic programming. (6)
Reasoning under Uncertainty: Conditonal independence representation, exact inference through variable elimination, and approximate inference through sampling. (5)
Machine Learning:
(i) Supervised Learning: Regression and classification problems, simple linear regression, multiple linear regression, ridge regression, logistic regression, k-nearest neighbour, naïve Bayes classifier, linear discriminant analysis, support vector machine, decision trees, bias-variance trade-off, cross-validation methods such as leave-one-out (LOO) cross-validation, k-folds cross validation, multi-layer perceptron, feed-forward neural network. (12)
(ii) Unsupervised Learning: Clustering algorithms, k-means/k-medoid, hierarchical clustering, top-down, bottom-up: single-linkage, multiple-linkage, dimensionality reduction, principal component analysis. (10)</td></tr>
<tr><td>Text Books, and/or reference</td><td colspan="7">Text Books:
1.Artificial intelligence : A Modern Approach- Stuart Russell, Peter Norvig, Prentice Hall, Fourth edition, 2020
2. Tom M. Mitchell, “Machine Learning”, McGraw Hill Education, International</td></tr>
</table>

material	Edition, 2010 **Reference Books:** 1. Elaine Rich, Kevin Knight and Shivashankar B Nair, "Artificial Intelligence", Tata McGraw Hill, 3rd Edition 2017. 2. Ethem Alpaydin, "Introduction to Machine Learning", Third Edition, , MIT Press, 2014

CSS 651 Data Communication and Computer Networks Laboratory 0-0-3 2Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS 651	Data Communication and Computer Networks Laboratory	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Operating System Laboratory		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Course Outcomes							
Topics Covered		Assignment 1 : Socket Programming for TCP client server (Iterative server) (3 hours) Assignment 2 : Socket Programming for TCP client server (Concurrent Server) (3 hours) Assignment 3 : Socket programming for UDP client (3 hours) Assignment 4 : Usage of select() system call (3 hours) Assignment 5 : FTP implementation (6 hours) Assignment 6 : Two player game (Tic Tac Toe) implementation (6 hours) Assignment 7 : Implementation of simplified Chat server (3 hours) Assignment 8 : RPC (Remote Procedure Call) implementation (3 hours)					
Text Books, and/or reference material		**Text Books:** 1. Richard Stevens, Unix Network Programming, Volume 1 and 2, Addison-Wesley Professional **Reference Books:** 1. Neil matthew and Richard Stones, Beginning Linux Programming, Wrox Publishers, 4th Edition. **Others:**					

CSS 652 Software Engineering Laboratory 0-0-3 2Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	

CSS652	Software Engineering Laboratory		0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Course Outcomes							
Topics Covered	1) Control Flow Graph based problems (Tool: C++/Java Language Compiler) 2) ERD / DFD related problems (Tool: StarUML ER Extension or Other OpenSource Tools) 3) UML based Design problems (Tool: Rational Rose/StarUML) 4) Software Testing related Problems (Tool: Junit) - Implementation Program on Java and testing using Junit. Suggested List of Applications:1. Student Marks Analysing System, 2. online Ticket Reservation System, 3. Payroll System, 4. Course Registration System, 5. Expert Systems, 6. ATM Systems, 7. Stock Maintenance						
Text Books, and/or reference material	**References:** 1. Frances E. Allen, "Control flow analysis", Proceedings of a symposium on Compiler optimization archive, ACM SIGPlan Notices, Pages 1 – 19, 1970 2. Unified Modelling Language, Object Management Group, http://www.omg.org/spec/UML/ 3. JUnit User Guide, https://junit.org/junit5/docs/current/user-guide/						

CSS 653 Artificial Intelligence and Machine Learning Laboratory 0-0-3 2Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the Course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS653	Artificial Intelligence and Machine Learning Laboratory	PCR	0	0	0	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NA		CT+EA [CT: 60%, EA(Laboratory assignment + Viva Voce): 40%]					

Course Outcomes	● CO1: Design and develop solutions for informed and uninformed search problems in AI. ● CO2: Demonstrate and enrich knowledge to select and apply AI tools to synthesize information and develop models within constraints of application area. ● CO3: Effectively use the various machine learning tools and understand and implement the procedures for machine learning algorithms. ● CO4: Design Python programs for various machine learning algorithms and apply appropriate datasets to the Machine Learning algorithms
Topics Covered	● Study of PROLOG programming language to implement the following: Simple arithmatic, Factorial of a given numbe, Depth First Search (DFS), Breadth First Search for Tic-Tac-Toe problem, 8-puzzle problem using Best First Search, A * algorithm. Hill climbing algorithm, Water Jug problem, N-Queen problem, Monkey Banana problem, Simple chatbot application. ● Basic machine learning tools and techniques (Basic programming in Python, Google Sheets basic formulae and operations, Data Visualization, NumPy, Pandas) ● Data Preprocessing (Handling missing data; Handling imbalanced classes: introduction to SMOTE algorithm; Feature selection; Noise removal; Data preprocessing of sensor data; Frequency domain tools; Fourier transform) ● Fundamental Concepts on ML (exploration of online data repositories for machine learning – UCI, OpenML, Kaggle etc.; sklearn or related libraries: training, testing, evaluation; performance metrics; similarity computation; cross-validation, overfitting and underfitting; dimensionality reduction) ● Machine Learning techniques - I (linear and logistic regression; Introduction to classification; KNN; Naïve Bayes; Decision Trees; Random Forests) ● Machine Learning techniques – II (Hidden Markov Model; Support Vector Machine; Clustering techniques) ● Case study on real-life problems on classification or regression.
Text Books, and/or reference material	**Text Books:** 1. Jure Leskovec, Anand Rajaraman, Jeffrey David Ullman: Mining of Massive Dataset, Cambridge University Press/ Dreamtech Press (India) 2. lvan Bratko, Prolog programming for artificial intelligence, Addison-Wesley publishing company. 3. T. Roughgarden, CS 168: The Modern Algorithmic Toolbox (Stanford University), 2017 with Gregory Valiant.

CSE 6XX Web Technologies 3-0-0 3 Credits 3 Hours

<table>
<tr><td colspan="8">Department of Computer Science and Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSE 6XX</td><td>Internet and Web Technology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="2">Programming Fundamentals, Data Structure and Algorithms, Operating Systems, Data networks (may be carried out simultaneously)</td><td colspan="6">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● CO1: Understanding the fundamental concepts of Internet Structure and Protocols.
● CO2: Using TCP/IP protocols and Internet programming using SOCKET API.
● CO3: Understanding HTTP protocol and Structures of Web Programming.
● CO4: Designing and developing Web applications with security enhancement.
● CO5: Understanding Semantic Web and Applying Web Analytics over Semantic Web.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">INTERNET TECHNOLOGY:
Brief review of Data Networking; data transmission, links and MACs, Forwarding and Routing, TCP-IP layered network concepts. (3L)
Internet specific issues like scalability, inter-operability (1L)
Internet Structures – logical and physical grouping with sub-netting and super netting. (3L)
Review of TCP-IP protocols – processing, performance and variations. (3L)
Security Implementations - secured IP, Transport Layer security. (3L)
Quality of Service Issues and their Application in Internet. (2L)
SOCKET PROGRAMMING: Introduction to SOCKET API; Client programming; Server programming – sequential, concurrent and multi-threaded; P2P application Programming. (4L)
HTTP: Requests and Responses - Message Formats, Headers and Fields; TCP Keep-alive and pipe-lining concepts; Server Architecture, Performance and Deployment. (3L)
WEB PROGRAMMING: Document Object Model; Client side scripting fundamentals: Server Side Scripting and Programming – Data base connectivity, session management and security enhancement; Introduction to Web Application Development Platforms – JavaEE, Dzango. (7L)
XML: DTD and Schema; Visualisation using XSLT; Web Application using XML; Service Oriented Architecture and Web services based application development and deployment; Xquery and SOA based application development platforms. (6L)
SEMANTIC WEB: General Concept of Semantic Web and linked Data; RDF based relation description; Web Ontology concepts and use; Putting XML, RDF and Ontology together to develop semantic web applications; Capturing Information</td></tr>
</table>

	from semantic web pages; Data analytics over semantic and linked Web. (7L)
Text Books, and/or reference material	**Text Books:** 1. B. A. Forouzan, "TCP/IP Protocol Suite", 4th Edition, 2010, McGrawHIll Publishers. 2. P. Deitel, H. Deitel, A Deitel, "Internet and World Wide Web – How to Program", Pearson. 3. G. Antoniou, P. Groth, F. Harmelen and R. Hoekstra, "A Semantic Web Primer" Prentice Hall India. **Reference Books:** 1. D. E. Comer and D L Stevens, "Internetworking with TCP/IP vol.II", Pearson.

CSE 6XX Mobile Computing 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 6XX	Mobile Computing	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Computer Networks		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		● CO1: Introduce the basics of Wireless Networks. ● CO2: Preparing the right background to take up research works in emerging wireless technologies and Internet of Things. ● CO3: To introduce the scopes of using sensing, edge computing, Machine learning mechanisms in pervasive cyber physical systems. ● CO4: Able to understand the innovation opportunity in IoT application segments. ● CO5: Hands-on experience on Wireless Networks & Mobile Computing.					
Topics Covered		**Module 1:** Physical Layer **(6 L)** Bit transmission over Wireless, Vary Much different from Wired Network. **Module 2:** Mac Layer **(8 L)** Access in Shared Medium, Difference between Wired MAC & Wireless MAC, Different Type of MACs (a) Random MAC (b) Scheduled MAC, Examples of MAC Implementation (WiFi Protocol --802.11, Bluetooth Protocol--805.15). **Module 3:** Network Layer **(8 L)** Reactive Routing, Proactive Routing, DSR Principle, AODV Principle, Location Aware Routing. Adhoc Network, Delay Tolerant Network, Opportunistic Network Introduction, Architecture & Applications, Routing Algorithms – Epidemic, Prophet, Spray & Wait, Spray & Focus, Maxprop Simulation Tool - ONE Simulator. **Module 4:** Transport Layer **(8 L)** Wireless TCP and rationale, Difference between Wired TCP and Wireless TCP, QoS Measurement of Wireless Networks. **Module 5:** Modelling **(8 L)** Mathematical Modelling of Network Functionalities - Combining them to derived					

	overall performance. **Module 6:** Case Study: Implementation of opportunistic Networks in Challenged Network scenarios **(4 L)** (a) Connection Mechanism (b) Sync - Transferring the information in Collaborative manner (c) Offline Dashboard (Information Summarization) (d)security
Text Books, and/or reference material	**Text Books:** 1. "Mobile Communication", by Jochen Schiller (PEARSON EDUCATION LIMITED). 2. "Wireless Networking" A kumar, D. manjunath, J. Kuri, Elsevier, 2008. 3. "Wireless Communication", T. S. Rappaport, Pearson, latest edition. **Reference Books:** **Research Papers:** 1. IEEE Infocom Tutorials slides by Prof. Nitin Vaidya. **Others:** Tools: ● Sniffer Tool (Wireshark) ● Simulation Tools: OMNET, ONE, NS3

CSE 6XX Internet of Things (IoT) 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 6XX	Internet of Things(IoT)	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
		CT: 15%, MT: 25%, ET: 60%					
Course Outcomes	CO1: Understand the concepts of Internet of Things CO2: Preparing the right background to take up research works in emerging wireless technologies and Internet of Things. CO3: To introduce the scopes of using sensing, edge computing, Machine learning mechanisms in pervasive cyber physical systems. CO4: Able to understand the innovation opportunity in IoT application segments.						
Topics Covered	**Module 1: Introduction to IoT and Sensing** (3 Hours) Introduction to IoT, Sensing, Edge computing, Data processing, Learning. **Module 2: Sensing Layer** (4 Hours) Different type of sensors, working principle of some sensors like Ultrasonic sensor, Thermal Sensors, Infrared Sensors, Pollutant Sensors, Temp, IMU Sensor etc. **Module 3: Play with Sensors & Microcontroller/Microcomputer** (4 Hours) Open source hardware, Play with Sensors using Arduino Programming, Local data processing using Raspberry Pi/Uddo Neo, Play with different Network Modules (Bluetooth, WiFi, GSM/GPRS) **Module 4: Wireless Networks Present and Future** (10 Hours) Concept of TCP/IP protocol Stack, 802.11 Protocol (WiFi Network), LoRa Network, Acoustic Communication, Socket Programming, Wireshark Tool, **Module 5: IoT Protocols (4 Hours)**						

	HTTP, QUIC, CoAP, MQTT **Module 6: Performance and Security in IoT (4 Hours)** **Module 7: Case Study of IoT Based Applications** (14 Hours) Case Study 1: **(activity Identification)** Human Activity using Ultra sonic Sensors/Thermal Sensors, Case Study 2: **(Environment Monitoring)** Pollution Monitoring and Forecasting in Indoor and Outdoor, Case Study 3: **(Road Transportation System)** (a)Important PoIs using GPS trails, (b)Context Aware Speed Profiling from Mobile Phone Sensors, (c)My Smartphone Can Monitor My Street-lights Case Study 4: **(Challenged Networks)** offline Crisis Mapper Design using ChatBot, IoT Protocol Stack Development using Acoustic Communication Case Study 5: **(Agriculture Monitoring):** Smart Farming using MQTT Protocol through Cost-effective Heterogeneous Sensors
Text Books, and/or reference material	**Text Books** **1.** "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman (CRC Press) 2. "Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti (Universities Press) **Reference Books:** **Others:**

CSE 6XX Optical Networks 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 6XX	Optical Networks	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
Basic Concepts of Computer Networks, and Algorithms		CT: 15%, MT: 25%, ET: 60%					
Course Outcomes	CO1: Identify and illustrate the main differences between optical networking and traditional networking, different problems in optical networks. CO2: Comprehend the routing and wavelength assignment (RWA), virtual topology design, wavelength rerouting, Traffic grooming in WDM optical network design. CO3: Understanding of the wavelength convertible network. CO4: Concept and analyze the benefit of various survivability strategies CO5: Comprehend the multicast routing in optical networks						
Topics Covered	1. **Fundamentals and Different Problems**: Optical fiber principles, Optical transmission system, Wavelength Division Multiplexing (WDM), optical networking evolution, Optical Network Architectures, Different issues in wavelength routed networks. (06L) 2. **Routing and Wavelength Assignment (RWA) algorithms**: ILP formulation of the RWA problem, Route Selection algorithms – Fixed Routing, Fixed Alternate						

	Routing, Exhaust Routing, Least Congested Path Routing, Limited alternate Routing. Wavelength Selection algorithms. Joint wavelength-Route selection algorithm. (07L) 3. **Wavelength Convertible Networks**: Need for Wavelength Converters, Wavelength convertible Switch Architecture, Routing in Convertible Networks, Performance Evaluation of Convertible networks, Network with Sparse Wavelength Conversion, Converter Placement problem. (06L) 4. **Wavelength Rerouting Algorithm**: Benefits of wavelength rerouting, Issues in wavelength rerouting, Rerouting algorithm. (04L) 5. **Virtual Topology Design**: Physical and Virtual topology, Traffic routing over virtual topology, Limitations on virtual topology, Virtual topology problem formulation, Virtual topology design heuristics. (06L) 6. **Traffic Grooming:** Basic concepts, Grooming node architecture, ILP formulation of the traffic grooming problem, Different heuristics (MST, MRU, TGCP, etc) for the traffic grooming problem. (06L) 7. **Optical Multicast Routing**: Multicast routing problem, architecture of Light spliting node and MI node, Network with full splitting and sparse splitting, Multicast Tree generation algorithms – Source based, Steiner based and Virtual source based tree generation algorithms. (07L)
Text Books, and/or reference material	**Text Books:** **1. WDM OPTICAL NETWORKS Concepts, Design and algorithms by C. Siva Ram Murthy and Mohan Gurusamy (PHI)** **2. OPTICAL NETWORKS by Biswanath Mukherjee (TMH)** **Reference Books:** **1. Optical Networks: A Practical Perspective (3rd Edition) by R. Ramaswami, K. Sivarajan, G. Sasaki (Morgan Kaufmann Publishers)**

CSE 6XX Distributed Systems 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 6XX	Distributed Systems	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
Operating systems. Computer Networks		CT + MT + EA					
Course Outcomes	CO1: To explain the paradigm of distributed computing.. CO2: To explore various existing and possible architectures of distributed systems. CO3: To properly appreciate the issues that arise in distributed systems and explore solutions for the problems. CO4: To fully appreciate the advantages to be obtained from a distributed environment wrt fault tolerance, load sharing etc.						
Topics Covered	Introduction to Distributed Systems. Motivations. Design Issues. (L3) Clocks in a Distributed System. Synchronization Issues. Logical Clocks. Causal relationships. Vector Clocks. (L3)						

	Distributed State Detection. Global State. Consistent Cut. Global State recording algorithm (L2) Termination Detection. Credit based algorithm. Diffusion Computation based algorithm. (L2) Distributed Mutual Exclusion. Token based and non-token based algorithms. (L4) Deadlocks in Distributed Systems. Resource allocation Models. Deadlock Prevention. Deadlock Avoidance – Safe states. Deadlock detection and Correction. Phantom Deadlocks. Centralized, Distributed and Hierarchical deadlock detection algorithms (L5) Fault recovery. Classes of Faults. Backward and Forward recovery. Log based recovery. Checkpoints. Shadow paging. (L5) Fault Tolerance. Data Replication. Quorum Algorithms. Distributed Commit Protocols. 2-phase commit. 3-phase commit. Election Algorithms. Bully algorithm. Ring topology algorithm. (L8) Byzantine faults and Agreement Protocols (L2) Distributed File systems. Mechanisms. Stateful and Stateless servers. Scalability. Naming and Name Servers. (L4) Distributed Scheduling. Load Balancing. Load Estimation. Stability. Process Migration. Remote Procedure Calls. Transparency. Binding. (L4)
Text Books, and/or reference material	**Text Books:** 1. Advanced Concepts in Operating Systems. Singhal and Sivaratri. McGraw Hill. **Refenence Books:** 1. Operating Systems : A Concept Based Approach. Dhamdhere. McGraw Hill. 2. Distributed Operating Systems : Concepts and Design. P.K.Sinha. Prentice Hall. 3. Distributed Operating Systems. A.Tanenbaum. Pearson Education. 4. Distributed Systems : Concepts and Design. Coulouris et.al. Pearson Education

CSE 6XX Semantic Web Technology 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE6XX	Semantic Web	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
Data structure, DBMS, Web Technology, Basic Computer Logic		CT + MT + EA					
Course Outcomes		CO1: Students can write their own semantic web page by using publicly available vocabulary. CO2: Students can publish their data in Open Data format, such that the other people can discover it easily. CO3: Students can able to develop semantic web application. CO4: Students will get exposure in this topic for further higher studies and research.					

Topics Covered	Principles of Linked Data, Introduction, A Layered Approach. (3) Naming Things with URIs, Making URIs Dereferenceable. (3) The Semantic Web (SW) vision: What is SW? The difference between Current web and SW, SW technologies, the Layered approach. (5) The XML Language, Structuring, Namespaces, Addressing and Querying XML Documents. (5) Resource Description Framework, RDF syntax, RDF Schema (RDFS). (7) Construction RDF and RDFS: Different syntax implementation, How to Store into server, Construction of RDFS. (5) SPARQL: Query Language: Syntax and Query processing. (2) Web Ontology Language OWL: OWL Syntax and Intuitive Semantics, OWL Species. (4) Description Logics, Model-Theoretic Semantics of OWL. (4) Ontology Engineering: Introduction, Constructing Ontologies, Reusing existing Ontologies. (2) Protégé tools. (2)
Text Books, and/or reference material	**Text Books:** 1. Semantic Web Primer: second edition by Grigoris Antoniou and Frank van Harmelen 2. Foundations of Semantic Web Technologies by Hitzler Pascal **Reference Books:** 1. Ontological Engineering by Asunción Gómez-Pérez, Mariano Fernández-López, and Oscar Corcho 2. Linked Data: Evolving the Web into a Global Data Space by Tom Heath and Christian Bizer **Others:** Harald Sack semantic web videos

CSE 6XX Multimedia Information Systems 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 6XX	Multimedia Information Systems	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
Knowledge of data structures databases and compression techniques		CT+EA **[CA: 15%, MT: 25%, ET: 60%]**					
Course Outcomes	CO1: In depth understanding of media characteristics and resource requirement. CO2: Organizing multimedia content, physical storage and retrieval of multimedia data, Content-based Search and retrieval, creating and delivering networked and multimedia presentations, securing multimedia content and current research directions in this area. CO3: Understanding networking of multimedia data and how technology can help us access, deliver, browse, search, enrich and share multimediacontent.						

	CO4: Understanding of multimedia database storage and retrieval
Topics Covered	Overview of multimedia system: Textual information codes (Morse, ASCII, EBCDIC), audio, video and graphics, RTF, TIFF, RIFF (3) Video and Animation: Capturing Graphics and Images Computer Assisted Graphics and Image Processing; Reconstructing Images; Graphics and Image Output Options. Basics; Television Systems; Digitalization of Video Signals; Digital Television; Basic Concepts; Virtual Reality, Video signal representation, Computer Video Format, Computer- Based animation, Animation Languages, Methods of controlling Animation, Display of Animation, Transmission of Animation (10) Information representation, media synchronisation, SAS factors, relative and absolute temporal specifications, networking delays, Skew, Jitter, end to end delay factors, latency time for stored and captured objects (6) Data Compression : Storage Space requirement, Coding Requirements Source, Entropy Coding Lossy Sequential DCT- based Mode, Expanded Lossy DCT-based Mode, JPEG and MPEG (8) Data transmission techniques like simplex, duplex, baseband vs. broadband, synchronous transmission vs. asynchronous transmission, synchronization parameters. (5) Content-based Search and retrieval, creating and delivering networked and multimedia presentations, storage, manipulation, and retrieval of multimedia data residing across global computer networks, multimedia databases, indexing, retrieval by similarity (10)
Text Books, and/or reference material	Multimedia Information Networking, Nalin K.Sharda, Prentice Hall India. Multimedia: Computing, Communications and Applications, Ralf Steinmetz and Klara Nahrstedt, Pearson Education Asia Multimedia Communications, Applications, Networks, Protocols and Standards, Fred Halsall, Pearson Education Asia Multimedia Systems, John F. Koegel Buford, Pearson Education Asia Reference Books: Subrahmanian and Jajodia, Multimedia Database Systems, Springer V.S. Subrahmanian, Principles of Multimedia Database Systems, Morgan Kaufmann Publishers, 1998.

CSE6XX Cloud Computing 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE6XX	Cloud Computing						
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					

Course Outcomes	(a) Explain the core concepts of the cloud computing paradigm: paradigm shift, the characteristics, advantages and challenges various models and services (b) Apply fundamental concepts in cloud infrastructures to understand the tradeoffs in power, efficiency and cost, and then study how to leverage and manage single and multiple datacenters to build and deploy cloud applications that are resilient, elastic and cost-efficient. (c) Learning of system, network and storage virtualization and outline their role in enabling the cloud computing system model. (d) Analyze the performance, scalability, and availability of the underlying cloud technologies and software. (e) Identify security and privacy issues in cloud computing (f) Explain recent research results in cloud computing and identify their pros and cons.
Topics Covered	**Introduction to Services Oriented Computing -** Service Oriented Software, Web Applications Paradigm. **Services Oriented Architecture -** SOA and Web Services Fundamentals, SOA and Service-Orientation, SOA - Planning and Analysis, SOA - Technology and Design, SOA Reference model (OASIS), SOA standard S3, Business Process and SOA, Software as a Service (SaaS) **Web Services -** Introduction to Web Services, Web Service Jargon – Publishing, Discovery and Binding, Web Service Technologies – WSDL, SOAP, UDDI, Issues and Challenges – MANET, CLOUD, DTN,Formal, Representation of Services **Cloud Computing Basics-** Overview, Applications, Intranets and the Cloud. Organization and Cloud Computing- Benefits, Limitations, Security Concerns. **Cloud Infrastructure -** Data center, Virtualization, Clients, Security, Network, Services and Delivery Models (SaaS, PaaS, IaaS). Case study like Amazon EC2, Microsoft Azure etc. Deployment types (Private, Public, Hybrid) **Software as a Service (Saas)-** Understanding the Multitenant Nature of SaaS Solutions, Understanding SOA. **Platform as a Service (PaaS)-** IT Evolution Leading to the Cloud, Benefits of Paas Solutions, Disadvantages of Paas Solutions. **Infrastructure as a Service (Iaas)-**Understanding IaaS, Improving Performance through Load Balancing, System and Storage Redundancy, Utilizing Cloud-Based NAS Devices, Advantages, Server Types. **Virtualization-**Understanding Virtualization, History, Server Virtualization, Data Storage Virtualization. **Securing the Cloud-** General Security Advantages of Cloud-Based Solutions, Introducing Business Continuity and Disaster Recovery. Disaster Recovery-Understanding the Threats. **Migrating to the Cloud-**Cloud Services for Individuals, Cloud Services Aimed at the Mid-Market, Enterprise-Class Cloud Offerings, and Migration. **Designing Cloud Based Solutions-**System Requirements, Design Is a Give-and-Take Process. Coding Cloud Based Applications-Creating a Simple Yahoo Pipe, Using Google App Engine and creating a Windows Azure Application. Application Scalability-Load-Balancing Process, Designing for Scalability, Capacity Planning Versus Scalability, Scalability and Diminishing Returns and Performance Tuning.

Text Books, and/or reference material	**Text Books:** Cloud Computing : A Practical Approach by Anthony T. Velte Toby J. Velte, Robert Elsenpeter, The McGraw-Hill Publisher. Cloud Computing: SaaS, PaaS, IaaS, Virtualization and more. by Dr. Kris Jamsa, Jones & Bartlett Publisher **Reference Books:** Cloud Computing Bible by Barrie Sosinsky, Published by Wiley Publishing. Cloud Computing for Dummies by Judith Hurwitz, Robin Bloor, Marcia Kaufman, and Dr. Fern Halper, Wiley Publishing. Cloud Computing Theory And Practice Danc.Marinercus, Elsevier.

CSE6XX Big Data Modelling and Management 3-0-0 3Credits 3Hours

Department of Computer Science & Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 6XX	Big Data Modelling and Management	PEL	3	0	0	3	3
Pre-Requisite: Database Management System		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	• CO1: Understand the necessity of Big Data Infrastructure Plan in Information System Design • CO2: Recognize different types of data elements – structural issues, characterization issues, modelling issues • CO3: Identify the frequent data operations required for various types of data • CO4: Apply techniques to handle streaming data						
Topics Covered	**Introduction**: Big data attributes and Definitions, Data Variety – Structured, Semi-structured and Unstructured, Defining Big Data from 3Vs to 3^2Vs - Data Domain, Business Intelligent (BI) Domain, Statistics Domain, Introduction of big data platforms: Hadoop, HDFS, MapReduce, Spark, Google File System (GFS) and HDFS. **(4)** **Database Techniques for Big Data:** Big data management - Data ingestion, Data storage, Data quality, Data operations, Data scalability and security; Big data management services - Data cleansing, Data integration; Storage models - Block-based storage, File-based storage, Object-based storage; Data Models - Navigational Data Models, Relational Data Models, XML, Canonical Data Model, NoSQL Movement, NoSQL Solutions for Big Data Management. **(6)** **NoSQL Data Models**: Key-Value Stores, Column-Based Stores, Graph-Based Stores, Document-Based Stores. **(6)** **Operation On NoSQL Databases:** CRUD operations – Creating, Updating, Accessing and Deleting Data; Query – Non-DBMS Vs DBMS Approaches, Declarative Query Language (DQL), Hive Query Language (HQL), Cassandra Query Language (CQL), Spark SQL, Query for Document Store data, MapReduce functionality; Transaction Management – Isolation Levels and Isolation Strategies, BASE Theorem, CAP Theorem. **(8)**						

	Modelling Streaming Data: Data stream and data model versus data format, Use cases of stream processing, Data streaming systems - Data harvesting, Data processing, Data analytics; Importance and implications of streaming data, streaming data solutions, Exploring streaming sensor data, Analyzing the streaming data. **(4)** **Resource Management in Big Data Processing Systems:** Types of Resource Management – CPU, Storage, Network, Big Data Processing Systems and Platforms, Big data and Cloud Resources - Single-Resource Management, Multi-resource Management. **(4)** **System Optimization for Big Data Processing:** Basic Framework of the Hadoop Ecosystem, Parallel Computation Framework: MapReduce; Job Scheduling of Hadoop, Performance Optimization of HDFS, Performance Optimization of HBase, Performance Enhancement of Hadoop System. **(4)** **Security and Privacy in Big Data:** Secure Queries Over Encrypted Big Data - Threat Model and Attack Model, Secure Query Scheme in Clouds, Security Definition of Index-Based Secure Query Techniques, Implementations of Index-Based Secure Query Techniques; Privacy on Correlated Big Data **(4)**
Text Books, and/or reference material	**Text Books:** 1. Big Data Principles and Paradigms, Rajkumar Buyya; Rodrigo N Calheiros; Amir Vahid Dastjerdi, Elsevier/Morgan Kaufmann, Cambridge, MA. 2. Hands-On Big Data Modelling, James Lee, Tao Wei, Suresh Kumar Mukhiya, Packt Publishing. ISBN: 9781788620901.

CSE6XX Complex Network Theory 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 6XX	Complex Network Theory	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
Probability, Calculus, Linear Algebra, Graph Theory							
Course Outcomes	CO1: A broad conceptual introduction to the modern theory and applications of network science CO2: Understand structure of communities in different networks like social networks. CO3: Understand random walk and its real-world applications like page ranking algorithm. CO4: Application of linear algebra and probability to real-world complex network problems CO5: Cultivate reading of research papers and articles						
Topics Covered	· **Introduction to Network Science (2 L)** · **Graph Theory:** revision of basic concepts **(2 L)** · **Properties of Complex networks**: Degree distribution, associativity,						

	clustering coefficient**(5L)** · **Random Networks**: Poisson's distribution, giant component and its emergence, generating function, component size distribution **(8L)** · **Bipartite networks**: unipartite projection, giant component condition **(5L)** · **Centrality measures**: degree centrality, closeness centrality, betweenness centrality, eigen vector centrality, Peron Frobenius theorem **(5 L)** · **Spectral Graph Theory**: eigen values and eigen vectors, spectrum of a graph, spectrum of a clique, eigen values and eigen vectors of special matrices like triangular and diagonal matrices, Markov matrix, trace of a matrix, physical interpretation of principal eigen vector, spectral coverage, significance of 2nd eigen vector, Motifs, Frobenius norms, dimension reduction **(5L)** . **Network Models:** Erdos Renii graph, power law distribution in small world network, scale free networks **(4L)** · **Random walks on graphs and its applications:** random walks and Markov chain, transitional probability, stationery state, hitting time, commute time, cover time, mixing rate, stochastic matrix, page rank algorithm, page rank ++, HITS (Hypertext induced topic selection) algorithm by Klienberg, HITS on citation networks, bibliographic coupling, SALSA (The stochastic approach to Link Structure analysis and TKC effects) **(10L)** . **Community detection algorithms:** what is a community, core community, Wu-Huberman Algorithm, Radicchi's Algorithm, community detection algorithms based on shortest path betweenness and random walk betweenness **(6 L)**
	Text Books: ● " The structure and dynamics of networks" by Newman, Barabasi, Watts, Princeton University Press ● "Networks: An Introduction" by Mark Newmann, Oxford University Press ● "Network Science" by Barabasi, Cambridge University Press **Reference Books:** ● "Network Science" Theory and Applications by Ted G Lewis, Wiley **Others:** ● http://www.infocobuild.com/education/audio-video-courses/computer-science/complex-network-theory-iit-kharagpur.html (Video Lecture) by Dr. Animesh Mukherjee

CSE6XX Pattern Recognition 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE6XX	Pattern Recognition	PEL	3	0	0	3	3
Pre-requisites Artificial Intelligence, Data Mining, DBMS, Object Oriented Programming		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA)) CT, MT and ET					

Course Outcomes	CO1: Idea about Pattern and Pattern Class, Design of a Pattern Recognition System CO2: Idea of Instar, Outstar, Groups of Instar and Outstar, Different types of Memories. CO3: Concept of Feedforward, Feedback and Competitive Learning Network CO4: Concept of Complex PR Tasks: RBF, RBF Network for Pattern Classification CO5 : Idea of Temporal Pattern Recognition: Concepts
Topics Covered	Pattern and Pattern Class: Design of a Pattern Recognition System, Syntactic and Decision Theoretic Approach, Bayesian Decision Theory, Continuous Features, Error, Risk and Loss [4L] Parametric and Non Parametric Methods: Histogram Method – Kernel Based Methods – K - Nearest Neighbor Method -- Probabilistic Neural Network base on Parzon Window – PNN Learning. [3L} Basics of ANN: Instar, Outstar, Groups of Instar and Outstar, Different types of Memories. [3L] PR Tasks: PR Problems, Different PR Tasks by FF, FB and Competitive Learning Network, Pattern Clustering, Feature Mapping Problem, Different Feature Mapping Network, Self Organizing Network. [4L] FF ANN: Pattern Association Network, Hebb's Law, Pattern Classification Network. [3L] FB ANN: Pattern Association, Pattern Storage, Pattern Environment Storage, Auto association , Hopfield Network, Capacity and Energy of a Hopfield Network, State Transition Diagram, Stochastic Network and Boltzmann Machine. 5L] Competitive Learning Network: Pattern Storage, Pattern Clustering Network, Minimal Learning, Malsburg Learning and Leaky Learning [4L] Complex PR Tasks: RBF, RBF Network for Pattern Classification, Advantages of RBF over MLFF ANN, CPN Network [3L] Single and Multilayer Network: Gradient Descent Procedure, Newton's Algorithm, Fixed Increment Learning, Variable Increment Learning, Support Vector Machine(SVM), Multilayer Neural Networks, Unsupervised Learning. [5L] Temporal Pattern Recognition: Concepts, Problems in temporal sequence, Architecture for temporal PR Tasks, Avalanche Structure, Jordon Network, Fully Connected Recurrent Network, Difference between Avalanche Network and Jordon Network. [4L] Similarity Measures: Mahalanabis Distance, Properties of Metrics, Minkowski Metric, Manhattan / City Block / L1 norm, Euclidean Distance L2 Norm, Maximum Value Distance L∞ Norm, Hamming Distance L1 norm. [4L]
Text Books, and/or reference material	**Text Books:** 1. Pattern Classification – Duda, Hart & Stork – J. Wiley & Sons. 2. Artificial Neural Networks – B. Yegnanarayana – PHI **Reference Books:** 1. Neural Networks for Pattern Recognition – C.M. Bishop – Oxford **Others: Nil**

CSE6XX Data Warehousing and Data Mining 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering				
Course	Title of the	Program Core	Total Number of contact hours	Credit

Code	course	(PCR) / Electives (PEL)	Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE6XX	Data Warehousing and Data Mining	PEL	3	0	0	3	3
Pre-requisites Artificial Intelligence, DBMS, Object Oriented Programming		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA)) CT, MT and ET					
Course Outcomes	CO1: Understanding the Concept of Data Warehousing and Data Mining CO2: Association Rules: Item set, Support, Confidence CO3: Classification – Pattern: Labelled Pattern, Decision Trees CO4: To understand the SVM, Generalization Error CO5: To understand the different types of Clustering Methods CO6: To understand the detection of different types of outliers and outlier detection.						
Topics Covered	Data Warehousing: Multidimensional Data Model, Dimension Modelling, OLAP Operations, Slicing and Dicing, Warehouse Schema, Star Schema, Snowflake Schema, Advantages and Disadvantages of Snowflake Schema, Data Warehousing Architecture, Virtual Data Warehouse, Advantages and Disadvantages of Virtual Data Warehouse, Metadata, Types of Metadata, OLAP Engine, Different Options for OLAP Engine, Data Extraction, Data Cleaning, Loading, Refreshing. [4L] Data Mining: Different Definitions of Data Mining, KDD vs. Data Mining, Stages of KDD , DBMS vs. DM, AI vs. DM, Classifications of Data Mining, Stages of KDD, DM Techniques , Discovery Driven Tasks, Classification, Frequent Episodes, Discovery of Association Rules , Clustering, Deviation Detection, Mining Problems, Applications of DM, Other Mining Problems. [4L] Association Rules: Item set, Support, Confidence, Problem Decomposition, Frequent Item Set, Maximal Frequent Set, Border Set, Applications of Data Mining, Spotting Fraudulent Behaviour, Astronomy etc., Association Rules, Informal a priori Algorithm for Learning Association Rules, Finding Frequent Sets and Association Rules, Formal a priori Algorithm for Association Rule. [5L] Classification – Pattern: Labelled Pattern, Approaches of Classification, Evaluation of Classifiers, Normalized Confusion Matrix, Accuracy, Precision, Recall and F – score, Cross Validation Technique, Classification Techniques. [4L] Decision Trees: Inductive Learning, ID3 Program, Algorithm for Building Decision Trees , Advantages of Decision Trees for Classification Purpose, Development of Decision Trees for Different Training Data Sets, Rule Extraction from Pattern Set, Covering the instances, Extraction of rules, Instance Space, Covering Algorithm. [4L] Bayesian Belief Nets (DAG): K nearest Neighbour, ANN, Learning in ANN, Perceptron as a model of neuron, Single and multiplayer Perceptron for classification and knowledge representation, Back propagation Network, Supervised, Reinforcement and Unsupervised Learning. [4L] Classification (Complex): Support Vector Machine (SVM), Generalization Error, SVM to find out the best classification, Margin. [3L] Clustering: Partitioned and Hierarchical Clustering, k means Clustering, Fast k Means						

	Clustering, Fuzzy K means Clustering, Hierarchical Clustering, Agglomerative and Divisive Hierarchical Clustering, Single Linkage, Complete Linkage and Average Linkage Clustering. [4L] Clustering (Complex): Outlier Detection, Outlier vs. Cluster, Types of Outliers, Outlier Detection Methodologies, Supervised, Unsupervised and Semi supervised detection , Statistical Approaches, Parametric and Non Parametric Methods, Proximity Based Methods, Clustering Based Methods. [4L] Temporal and Spatial Data Mining: Temporal Data Mining, Tasks involved, Temporal Association Rules, Sequence Mining, Episode Discovery, Spatial Mining, Tasks involved , Spatial Clustering. [3L] Web Mining: Web Mining Techniques, Web Content Mining, Web Structure Mining, Web Usage Mining, Text Mining. [3L]
Text Books, and/or reference material	**Text Books:** 1. Data Mining Techniques – Arun K Pujari – Universities Press 2. Data Mining – Vikram Pudi, P. Radha Krishna – Oxford University Press **Reference Books:** 1. Data Mining – J. Han, M. Kamber, J. Pei -- Elesvier 2. Data Mining – Hand, Mannila and Smith – PHI **Others:**

CSE 6XX Soft Computing 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 6XX	Soft Computing	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
Introduction to computing, Data Structures and Analysis of Algorithms		**[CA: 15%, MT: 25%, ET: 60%]**					

Course Outcomes	
Topics Covered	**Module I**: Introduction (6 hours) Introduction and different definitions of Soft Computing, Basic tools/members of Soft Computing: Fuzzy Logic, Neural Network and Evolutionary Computing **Module II: Fuzzy Logic** (10 hours) **Fuzzy Logic-I:** Crisp Sets, Fuzzy sets, Fuzzy membership functions, Basic operations on fuzzy sets, Fuzzy relations and Composition of fuzzy relations. **Fuzzy Logic –II (Fuzzy Rules and Approximate Reasoning):** Fuzzy if-then rules: M-A and TSK Rules, Fuzzification, Compositional rule of Inference/Approximate Reasoning, Defuzzification, Applications: Pattern Recognition, Fuzzy c-means Clustering and Control. **Module III: Neural Networks** (10 hours) **Neural Networks-1 (Introduction & Architecture):** Introduction to neural

	networks: Artificial Neuron and its model, Activation functions, Neural network architecture, learning algorithms/rules, Training and testing. **Neural Networks-II:** Perceptron model: single layer and multilayer perceptron (MLP), Error back propagation, Radial basis function network (RBFN), Self-organizing map network (SOMN), Recurrent neural network, Applications of ANN. **Module IV: Evolutionary Computing (**12 hours**)** **Genetic Algorithm–I:** Evolutionary Computing, Basic concepts and working principle of simple GA (SGA), Genetic Operators: Selection, Crossover and Mutation, flow chart of SGA, Chromosome Encoding & Decoding, Population Initialization, Objective/fitness Function, variable length Chromosome, Applications: Travelling Salesman Problem (TSP). **Genetic Algorithm–II (Multi-objective Genetic Algorithm (MOGA)):** Conflicting objectives, Objective space and variable space, Domination, Pareto front, Pareto Set, NSGA-II: Non-dominated Sorting, Crowding distance operator, Applications Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Local Search and Memetic algorithm **Module V: Hybridization of different Soft Computing Tools** (4 hours)
Text Books, and/or reference material	**Text Books:** 1. S. Rajsekharanand and Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications", Prentice Hall of India. 2. N. P. Padhy, "Artificial Intelligence and Intelligent Systems", Oxford University Press. 3. G. Klir and B. Yuan, "Fuzzy sets and Fuzzy logic", Prentice Hall of India. 4. K. H. Lee., "First Course on Fuzzy Theory and Applications", Springer-Verlag. 5. G. J. Klir and T. A. Folger: Fuzzy Sets, Uncertainty, and Information, PH. 6. J. Yen and R. Langari, "Fuzzy Logic, Intelligence, Control and Information", Pearson Education. 7. D. Goldberg: Introduction to Genetic Algorithm. **Reference Books:** 1. Siman Haykin, "Neural Networks", Prentice Hall of India. 2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications", Wiley India. 3. Kumar Satish, "Neural Networks", Tata Mc. Graw Hill. 4. B. Yegnanarayana , "Artificial Neural Networks" 5. A. Konar, "Computational Intelligence", Springer. 6. Y. H. Pao: Adaptive Pattern Recognition and Neural Networks, Addison-Wesley. **Others:**

CSE 6XX Knowledge Management 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 6XX	Knowledge Management	PEL	3	0	0	3	3

Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	CO1: Understand Knowledge and its creation, acquisition, dissemination, use and re-use. CO2: Understand KM systems and its application in knowledge generation and knowledge transfer CO3: Understand knowledge codification and system development, testing and deployment of KM systems. CO4: To evaluate effectiveness of KM System, draw inference from data, data mining for knowledge extraction, understand role of KM Systems and Applications in institutes and organizations.						
Topics Covered	KM concepts: Use of KM, KM System Life Cycle, aligning KM and business strategy (6L) Knowledge Types, KM System Life Cycle models (5L) Knowledge codification and system development, testing and deployment, Knowledge transfer and knowledge sharing (7L) KM systems: Analysis, design and development of KM System (5L) KM tools: inferences from data, data mining and knowledge portals (6L) Evaluation of KM effectiveness: Tools and metrics, Case studies on KM Systems and Applications (7L) KM experiences from Indian companies, KM innovation and Learning organization, The future of KM (6L)						
Text Books, and/or reference material	**Text Books:** 1. Elias.M. Awad & Hassan M. Ghaziri – "Knowledge Management" Pearson Education. 2. Knowledge Management in Theory and Practice - 2nd edition by Kimiz Dalkir. **Reference Books:** 1. Guus Schreiber, Hans Akkermans, Anjo Anjewierden, Robert de Hoog, Nigel Shadbolt, Walter Van de Velde and Bob Wielinga, "Knowledge Engineering and Management", Universities Press. 2. C.W. Holsapple, "Handbooks on Knowledge Management", International Handbooks on Information Systems, Vol 1 and 2. Others: This course follows the structure of NPTEL Course on Knowledge Management by Prof. KBL Srivastava, IIT Kharagpur, link: https://nptel.ac.in/courses/110105076						

CSE 6XX Ethics, Society, and Computer Science 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE6XX	Ethics, Society, and Computer Science	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))
Basic knowledge of programming and AI/ML	CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**
Course Outcomes	● CO1: To understand professional and ethical responsibilities, including those defined in the ACM/IEEE Professional Code of Ethics. ● CO2: To ensure fairness, accountability, and transparency while working on machine learning, artificial intelligence and related fields. ● CO3: To appreciate the threats to privacy posed by modern data aggregation and data processing techniques. ● CO4: To design technologies incorporating ethical considerations from the specification provided.
Topics Covered	**Introduction:** What is Ethics?, Ethics and Computer Science, Social consensus on unethical practices by computer professionals, Conventional issues, Emerging issues in the age of data driven (AI/ML based) decision making, History and Evolution of ethics with advances in computer science and engineering. (4L) **Ethics in Data collection and aggregation:** Basic mechanism of data driven (AI/ML based) decision making, Data aggregation and decision making, Data Ownership, Collection and collation of digital imprints of users, Data stealing and data broking, Informed consent, Data repurposing, Privacy, Anonymity, Data validity, Establishing data protection framework with legal backing, Concept of differential privacy, GPDR (10L) **Algorithmic Fairness:** Discriminatory impact of imperfect decisions, Case study: Facial recognition software, Criminal justice using big data, recidivism models for sentencing guidelines, predictive policing, Trust in AI/ML based decision making, Algorithmic fairness, Notions of fairness, Parity based and preference based notions, Fairness and accuracy, Identifying and mitigating inherent bias in data and/or machine learning algorithms, Proper choice of representative sample, Making training data fair, Designing fairness aware classifiers, Algorithmic audit, Challenges, Audit based on user survey, Sock puppet audit, Audit based on scrapping/crawling. (12L) **Transparency and Explainability:** Black-box phenomenon and trust, Unpredictability, Explanation/Reasoning, Right to explanation, Explainability and accuracy trade off, Transparency and interpretability, DARPA XAI, ML model explainability, Linear model explainability, Nonlinear model explainability, Neural networks explainability, LIME package, SHAP values, What-if tool. (5L) **AI Ethics:** Moral issues in autonomous and intelligent systems, Narrow (or Weak) AI and General (or Strong) AI, Weaponization of AI, Moral issues in autonomous robots, Robot ethics, Moral issues in self-driving cars, Moral Machine Quiz. (5L) **Personalization:** Personalized recommendation, search and newsfeed, Intellectual isolation associated with personalization, Objective search results, Personalized advertisement, Cross-domain tracking. (3L) **Code of Ethics:** Ethical standards by international professional societies, IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems, ACM Code of Ethics and Professional Conduct. (3L)
Text Books, and/or reference material	**Text Books:** 1. D J Patil, Hilary Mason, Mike Loukides, “Ethics and Data Science”, O'Reilly Media, Inc.; 1st edition (July, 2018). 2. P. Singer, “Practical Ethics”, Cambridge University Press, 3rd edition (Feb. 2011) **Reference Books:** 1. Cathy O'Neil, “Weapons of Math Destruction: How Big Data Increases Inequality

	and Threatens Democracy", Crown; 1st edition (September 6, 2016). 2. John C. Havens, "Heartificial Intelligence: Embracing Our Humanity to Maximize Machines", TarcherPerigee; (February 2, 2016). 3. Wendell Wallach, Colin Allen, "Moral Machines: Teaching Robots Right from Wrong", Oxford University Press; 1st edition (June 3, 2010). 4. Garry Kasparov, "Deep Thinking: Where Machine Intelligence Ends and Human Creativity Begins", PublicAffairs; 1st edition (May 2, 2017).

CSE 6XX Computational Intelligence 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE6XX	Computational Intelligence	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
Introduction to Computing, Data Structures, and Analysis of Algorithms		CE+EA					
Course Outcomes	• CO1: To familiarize with the real life problems which cannot be solved by exact algorithms and formulate them by mapping different soft computing techniques • CO2: To familiarize with the ideas of fuzzy sets, fuzzy logic and fuzzy inference • CO3: To familiarize with different architectures and learning algorithms of neural networks • CO4: To familiarize with different evolutionary computing techniques and their applications in optimization problems • CO5: To introduce different tools to use computational intelligence techniques to design algorithms and systems that can predict, recognize, and make decisions						
Topics Covered	**Introduction to Computational Intelligence** (6L) Introduction and different definitions of Computational Intelligence, Basic tools/members of Computational Intelligence, Requirement of Computational Intelligence, Characteristics of Computational Intelligence, Applications of Computational Intelligence **Fuzzy logic** (10L) Introduction to fuzzy logic; Fuzzy sets and membership functions; Operations on fuzzy sets; Fuzzy relations, Composition of fuzzy relations, Fuzzy rules, propositions, implications and inferences; Fuzzification; Defuzzification; Fuzzy Clustering and control **Artificial Neural Network (ANN)** (10L) Introduction to ANN: Biological neurons and its working, Artificial neuron and its						

	model, Activation functions, Neural network architecture and learning algorithms/rules, Training and testing. Perceptron model, single layer and multilayer perceptron (MLP), Error back propagation, Radial basis function network (RBFN), Self-organizing map network (SOMN), Recurrent neural network, Applications of ANN. **Evolutionary Computing** (12L) Introduction to evolutionary computing: Concept of genetics, fitness, evolution and evolutionary computing Genetic Algorithm: Basic concepts and working principle of simple GA (SGA); Genetic Operators: Selection, Crossover and Mutation, Chromosome Encoding & Decoding, fitness Function, Solving Travelling Salesman Problem using SGA using GAs. Introduction to Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Local Search and Memetic algorithm. Multi-objective Optimization: Multi-objective optimization problems (MOOPs) and their challenges; Multi-objective evolutionary algorithm (MOEA): Non-Pareto based approach (SPEA2) and Pareto-based approach (NSGA II); Some applications **Hybridized System** (4L) Genetic Algorithms–Fuzzy Logic, Genetic Algorithms–Neural Networks, Neural Networks–Fuzzy Logic **Applications of computational intelligence** techniques to solve some real life problems
Text Books, and/or reference material	**Text Books** 1. S. Rajsekharanand and Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications", Prentice Hall of India. 2. A. Konar, "Computational Intelligence", Springer. 3. G. Klir and B. Yuan, "Fuzzy sets and Fuzzy logic", Prentice Hall of India. 4. K. H. Lee., "First Course on Fuzzy Theory and Applications", Springer-Verlag. 5. G. J. Klir and T. A. Folger: Fuzzy Sets, Uncertainty, and Information, PH. 6. D. E. Goldberg, "Genetic Algorithms in Search, Optimization and Machine learning", Second Edition, Addison Wesley, 2007. 7. Melanie Mitchell, "An Introduction to Genetic Algorithms", MIT Press, 2000. 8. D. K. Pratihar, "Soft Computing", Narosa, 2008. 9. Nikola K. Kasabov, "Foundations of Neural Networks, Fuzzy Systems, and Knowledge Engineering, MIT Press, 1998. **Reference Books** 1. Satish Kumar, "Neural Networks - A Classroom Approach", Tata McGraw-Hill, 2004. 2. Simon Haykin, "Neural Networks and Learning Machines", 3rd Edition, Prentice Hall of India, 2011. 3. Kumar Satish, "Neural Networks", Tata Mc. Graw Hill. 4. B. Yegnanarayana, "Artificial Neural Networks" 5. Y. H. Pao: Adaptive Pattern Recognition and Neural Networks, Addison-Wesley. 6. J. Yen and R. Langari, "Fuzzy Logic, Intelligence, Control and Information", Pearson Education. 7. Timothy J. Rose, "Fuzzy Logic with Engineering Applications", Third

	Edition, John Wiley, 2010. 8. Ahmed M. Ibrahim, "Fuzzy Logic for Embedded Systems Applications", Elsevier Press, 2004. 9. J.-S. R. Jang, C.-T. Sun, and E. Mizutani, "Neuro-Fuzzy and soft Computing", PHI Learning, 2009. 10. R. A. Aliev, R. R. Aliev , Soft Computing and its Applications, World Scientific Publishing Co. Pte. Ltd., 2001.

CSE 6XX Mathematics for AI and ML 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE6XX	Mathematics for AI and ML	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Mathematical foundations, Basic optimization concepts, AI, ML		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	CO1: Understand the fundamental mathematics required for ML development. CO2: Able to understand the tensor basics for AI and ML CO3: Understand the importance of linear algebra for AI and ML algorithms. CO4: Grasp probability theory and statistics to model uncertainties in AI. CO5: Utilize optimization techniques and apply multivariable calculus for improving AI algorithms.						
Topics Covered	**Linear Algebra**: Linear systems, Overdetermined and Underdetermined Systems, Solving Linear Equations, Vector Space and Subspaces, Orthogonality and projections, Linear Independence, Basis and Dimensions, Ranks, Matrix Decompositions, Eigenvalues and Eigen Vectors, Singular Value Decompositions, Linear Transformations. 10L **Vector Calculus:** Differentiation and Gradients of Vectors, Gradient of Matrices, Backpropagation and Automatic Differentiation, Higher-order Derivatives, Linearization and Multivariate Taylor Series. 4L **Tensor Basics:** Scalar, Vector, Matrix, and Tensor; Tensor Unfolding/Matricization; Tensor Products and Norms; Representation Learning via Tensors. - Canonical Polyadic Decomposition (CPD); Tucker Decomposition (TuckerD); Tensor Train Decomposition. 4L **Probability and Distributions:** Construction of a Probability Space, Discrete and Continuous Probabilities, Bayes' Theorem, Gaussian Distribution, Exponential Family, Change of Variables, Expectation, Variance, and Covariance. 4L **Optimization for ML:** Basics of optimization, Convex objective function, Gradient descent search, Properties of optimization in ML, computing derivatives with respect to vectors, optimization for numerical, binary and multiclass targets, coordinate descent. 4L **Advanced optimization solutions:** challenges in Gradient-Based optimization, Adjusting First-order derivatives for descent, Newton method, Newton methods in ML, Non differential optimization functions. 4L						

	Machine Learning Problems: Data, Models, and Learning, Parameter Estimation, Model fitting, Probabilistic Modelling and Inference, Directed Graphical Models. Linear Regression, Dimensionality Reduction with Principal Component Analysis, Density Estimation with Gaussian Mixture Models, Classification with Support Vector Machines, Basics of Neural Networks and Deep Learning Models. 12L
Text Books, and/or reference material	Books: 1. G. Strang, Introduction to Linear Algebra, 5th Ed., Wellesley - Cambridge Press, 2016. 2. G. Strang, Linear Algebra and Learning from Data, Wellesley - Cambridge Press, 2019. 3. H. Nelson, Essential Math for AI, 1st Ed., O'Reilly Media, Inc., 2023. 4. G. Favier, Matrices and Tensors with Signal Processing, ISTE Ltd and John Wiley & Sons, Inc., 2021

CSE 6XX Parallel Algorithms 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 6XX	Parallel Algorithms	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
C Programming, Data Structures and Algorithms, Design and Analysis of Algorithms I, II, Discrete Mathematics		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		• CO1: Remember the basic terms, definitions and concepts of parallel computing. • CO2: Students will be able to understand the key concepts of PRAM and Network model algorithms and complexities • CO3: Students will be able to apply the learned concepts to solve various problems. • CO4: Students will be able to differentiate or relate the various ideas with respect to problems. • CO5: Students will be able to judge the ideas to be applicable to a problem.					
Topics Covered		1. Parallel Programming Models: Shared-memory model (PRAM, MIMD, SIMD), network model (line, ring, mesh, hypercube), performance measurement of parallel algorithms. (5L) 2. Algorithms for PRAM Models: Balancing, divide and conquer, parallel prefix computation – work optimal and non-work optimal algorithms, pointer jumping, symmetry breaking, list ranking – deterministic and randomised algorithms, selection – maximal selection and general selection (deterministic and work-optimal randomised algorithms), merging – odd-even merging, a work-optimal algorithm, sorting – merge sort, a randomised algorithm,					

	Preparata's algorithm, Reischuk's randomised algorithm; searching, graph algorithms, string algorithms. (20L) 3. Algorithms for Network Models: Matrix algorithms, sorting, graph algorithms, routing, relationship with PRAM models. (10L) 4. Parallel Complexity: Lower bounds for PRAM models, the complexity class NC, P-completeness. (7L)
Text Books, and/or reference material	• Joseph F Jájá, *An Introduction to Parallel Algorithms*, Addison-Wesley, 1992. • Michael J Quinn, *Parallel Computing: Theory and Practice*, second edition, McGraw Hill, 1994/2002. • Michael J Quinn, *Parallel Programming in C with MPI and OpenMP*, first edition, McGraw Hill, 2004/2003. • Ananth Grama, Anshul Gupta, George Karypis and Vipin Kumar, *Introduction to Parallel Computing*, second edition, Addison-Wesley/Pearson, 1994/2003. • Russ Miller and Laurence Boxer, *Algorithms: Sequential and Parallel — A Unified Approach*, third edition, Cengage, 2013. • Fayez Gebali, *Algorithms and Parallel Computing*, Wiley, 2011. Seyed H Roosta, *Parallel Processing and Parallel Algorithms: Theory and Computation*, Springer, 2000.

CSE 6XX Logic for Computer Science 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 6XX	Logic for Computer Science	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Discrete Mathematics, Formal Languages and Automata Theory/Theory of Computation		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					

Course Outcomes	• CO1: Remember the basic terms, definitions and concepts of first and second order logic. • CO2: Students will be able to understand the key concepts of logic for computer science and applications. • CO3: Students will be able to apply the learned concepts to solve various problems. • CO4: Students will be able to differentiate or relate the various ideas with respect to problems related to this course. • CO5:Students will be able to judge the ideas to be applicable to a problem.
Topics Covered	Introduction to First Order Logic, Syntax and semantics of first order logic. (4L) Proof procedures – Hilbert system, natural deduction and sequent calculus, resolution methods, soundness and completeness. (6L) Prenex normal form and Skolemization. (2L) Compactness, Lowenheim Skolem theorem, Herbrand's theorem, undecidability

	and incompleteness. (8L) Peano and Presburger arithmetics, incompleteness of first order number theory. (6L) Introduction to Second Order Logic, Monadic second order logic: syntax, semantics, truth, definability, relationship between logic and languages. (8L) Introduction to Modal and Temporal Logic with applications. (8L)
Text Books, and/or reference material	1. C. L. Chang and R. C. T Lee: Symbolic Logic and Mechanical Theorem Proving, Academic Press, New York and London, 1973. 2. H. Enderton: A Mathematical Introduction to Logic, Academic Press, London, 1972. 3. M.Fitting: First-order Logic and Automated TheoremProving, Springer, Berlin, 1990. 4. H.Gallier: Logic for ComputerScience, JohnWileyandSons, NewYork, 1987. 5. G.E. Hughes and M.J. Cresswell: A New Introduction to Modal Logic Symbolic Logic, Routledge, 1996. 6. E. Mendelson: Introduction to Mathematical Logic, Van Northand, London, 1979. 7. A. Nerode and R.A. Shore: Logic for Applications, Springer, Berlin, 1993. 8. V. Sperschneider and G. Antonio: Logic: A Foundation for Computer Science, Addison-Wesley, California, 1991. 9. I.S. Torsun: Foundations of Intelligent Knowledge-Based Systems, Academic Press, New York, 1995. 10. L. Zhongwan: Mathematical Logic for Computer Science, World Scientific, Singapore, 1989. 11. B.Khoussainov and A.Nerode: Automata Theory and its Applications, Springer, 2001. 12. E. Gradel, W. Thomas and T. Wilke (Eds.): Automata, Logics, and Infinite Games, LNCS 2500, Springer, 2002. 13. D. Perrin and J.-E. Pin: Infinite Words: Automata, Semigroups, Logic and Games, Elsevier, 2004. 14. P. Blackburn, M. de Rijke and Y . V enema: Modal Logic, Cambridge University Press, 2001.

CSE 6XX Computational Number Theory 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE6XX	Computational Number Theory	XXX	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
Basic knowledge of Abstract Algebra, Algorithm Analysis and Design		CE+EA					
Course Outcomes	• CO1: Understanding the fundamentals of Number Theory • CO2: Building the mathematical foundation of Cryptography, Cryptanalysis						

	• CO3: Application of Group and Extension Group • CO4: Analyzation of basic Cryptographic application.
Topics Covered	Introduction: Outline of the course, Finite Field, Extension of Finite Field, Algorithms on Finite Field and Extension Field – Fast Multiplication, Fast Exponentiation, GCD, Chinese Remainder Theorem, polynomial congruences and Hensel lifting, orders and primitive roots, quadratic residues. (8) Representation of Finite Field: Polynomial basis, Primitive elements, Normal basis, Optimal normal basis, Irreducible polynomials, root and factorization, polynomials over finite fields, Extension Field Algorithm. (6) Elliptic Curve: Representation of Elliptic Curve, Projective Plane, Jacobian Plane, Elliptic Curve operation over Finite Field and Extension Field, Point counting, Cardinality (Trace). (6) Pairing: Functions, Divisors, Weil Pairing, Tate Pairing, Twists, Carves with Twists of Degree 2, Applications of Pairing. (6) Prime Factorization and Index Calculation Methods: Pollard rho method, p-1 method, Dixon's Method, Sieve Methods. (3) Secret Sharing Methods: Access class, additive secret sharing, Threshold Secret Sharing (Shamir's Secret Sharing), Operations on shared secret. (3) Applications: Notion of Asymmetric Encryption, Zero-Knowledge Proofs, Functional Encryption and Multiparty Computation. (4)
Text Books, and/or reference material	1. Abhijit Das, Computational Number Theory, CRC Press 2. Darrel Hankerson, Alfred J. Menezes, Scott Vanstone, Guide to Elliptic Curve Cryptography, Springer 3. Lawrence C. Washington, Elliptic Curves: Number Theory and Cryptography, CRC Press 4. Abhijit Das, C. E. Veni Madhavan, Public-key Cryptography: Theory and Practice, Pearson 5. Paul J. McCarthy, Algebraic Extensions of Fields

CSE6XX Advanced Algorithms 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE6XX	Advanced Algorithms	PEL	3	0	0	42	3
Pre-requisites CSC 303, CSC 403		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
		CT 15%, MT 25%, and EA 60%					
Course Outcomes	CO1. Can have the efficiency in the complexity analysis of the algorithms. CO2. Detecting and applying the algorithmic structures in many different fields of engineering. CO3. Will have the knowledge for state of the art development in the field of algorithms. CO4. Can have the proficiency of coding and comparing different algorithms.						
Topics Covered	**Revisit:** Different Complexity analysis and Algorithm's correctness by Loop-Invariant techniques. (2)						

	Data Structures: van Emde Boas Trees, Dynamic graphs, Bloom filters, Hashing (Open addressing). (5) **Randomized Algorithm-** Las Vegas and Monte Carlo algorithms, Essential mathematical tools for Randomized algorithms: Linearity of expectation, Markov inequality, Chebyshev's inequality, Chernoff bound, and Union bound with examples to Randomized algorithm design. Examples and analysis of: Hiring Assistant Problem, Randomized selection, Skip list. (4) **Network Flow -** Flow networks, Augmenting paths, Ford- Fulkerson Algorithm, Edmonds - Karp algorithm, Max flow min-cut theorem, Push-relabel algorithm, Maximum bipartite matching, Some applications of network flow. (5) **Linear Programming:** Introduction, algorithms, and its applications, Linear programming duality (4) **Parallel Algorithms** – Multithreaded Algorithms: Multithreaded matrix multiplication, Multithreaded merge sort. (3) **Online Algorithms:** Overview, Online scheduling and online Steiner tree, Online Bipartite matching, Online learning and multiplicative weights algorithm. (5) **NP- Completeness** - Reduction revisited; NP-Completeness proof of different problems: CLIQUE, VERTEX COVER, INDEPENDENT SET, SET COVER. (4) **Approximation Algorithms** - Constant factor approximation algorithm: VERTEX COVER and TSP; Christofides algorithm on TSP with 1.5 approximation factor; SET-COVER problem with log n factor approximation algorithm; PTAS and FPTAS, Linear programs and approximation algorithms. (7) **Semidefinite Programming:** Introduction with the problem: The Maximum Cut Problem and Semidefinite Programming. (2) **Overview of some Special Topics:** Communication complexity, Spectral graph theory, Compressive sensing (1).
Text Books, and/or reference material	**Text Books:** **1. Rajeev Motwani and Prabhakar Raghavan, Randomized Algorithms, 2nd** Edition, Cambridge University press, Cambridge, MA, 1995. 2. Thomas H. Cormen, Charles Leiserson, Ronald Rivest, and Clifford Stein. Introduction to Algorithms. 3rd ed. MIT Press, 2009, ISBN: 9780262033848. 3. S. G. Akl, The Design and Analysis of Parallel Algorithms, Prentice-Hall, 1989. 4. M. J. Quinn, Designing Efficient Algorithms for Parallel Computers, McGraw Hill Higher Education, 1987, ISBN: 978-0070510715. 5. J. Kleinberg and E. Tardos, Algorithm Design, Pearson. 6. D. V. Williamson and D. B. Shmoys, The Design of Approximation Algorithms, Cambridge University Press. 7. S. Arora and B. barak, Computational Complexity: A Modern Approach, Cambridge University Press. **Reference Books:** 1. Dimitri P. Bertsekas and John N. Tsitsiklis, Introduction to Probability, 2nd Edition, Athena Scientific, July 2008. 2. M. Mitzenmacher and E. Upfal, Probability and Compuitng: Randomized Algorithms and Probabilistic Analysis, Cambridge University Press. 3. T. Roughgarden, CS261: A Second Course in Algorithms (Stanford University), 2016. 4. T. Roughgarden, CS168: Modern Algorithmic Toolbox (Stanford University), 2017. **Others:** *NMEICT video on:* *Design of Algorithms(http://www.nmeict.iitkgp.ac.in/Home/videoLink/10/3gp)*

SEVENTH SEMESTER

CSC 701 Data Science 3-1-0 4Credits 4Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC 701	**Data Science**	PEL	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basics of Regression, Matrix Arithmetic, Probability		CT+EA [CA: 15%, MT: 25%, ET: 60%]					

Course Outcomes	After successful completion of this course, students will be able to	Bloom Level
	CO1: Understand the concept of basic data science and demonstrate proficiency with statistical analysis of data.	L1, L2
	CO2: Students can choose appropriately from a wider range of exploratory and inferential methods for analyzing data, and can interpret the results contextually.	L3, L4
	CO3: Students can carry out standard data visualization and formal inference procedures and can comment on the results..	L4
	CO4: Students understand what a model is, can use a given model and validate the model.	L5,L6

Topics Covered
● Introduction to Data Science: What is data science? Importance and applications of data science, Roles and responsibilities of a data scientist, data science in business, Data Analysis, Data Visualization (2L) ● Descriptive statistics: Sample, Population, Measure of Central Tendency, Measure of Dispersion (4L) ● Probability and Distribution: Basic Probability, Joint, marginal and conditional distributions, product moments, correlation and regression, independence of random variables, Normal Distribution, t-distribution, chi-square distribution (4L) ● Inferential statistics: Estimating Population parameters, Null Hypothesis, Alternate Hypothesis, confidence intervals, hypothesis testing (4L) ● Data Collection and Cleaning: Surveys and Questionnaires, Web Scrapping, APIs and Databases, Handling Missing values, Outlier detection, Data Normalization, Feature Selection (4L)

	• Exploratory Data Analysis: Data Visualization, Bar Graph, Line Graph, Scatter plot, Histogram, Checking data distribution, Correlation coefficient, Heatmap (4L) • Regression Analysis: Fundamentals of regression analysis, assumption of regression analysis, Standard error of the estimate, accuracy, validity of the regression model, dealing with categorical data, Evaluation Metric (5L) • Classification: Introduction, Logistic regression, model building and evaluation, Evaluation Metric (3L) • Clustering and Dimensionality Reduction: K-means clustering, Hierarchical clustering, Principal Component Analysis (4L) • Natural Language Processing: Tokenization, Stemming, Lemmatization, vector representation of words, Bag of words, Word2Vec (2L) • Deep Learning and Time Series Analysis: Introduction to Neural Network, Building Deep Neural Network, CNN concept, Introduction to Time Series Analysis (4L) • Ethics and Data Privacy: Importance of ethical considerations in data science. Handling sensitive data responsibly (2L)

CSS 751 Data Science Laboratory 0-0-3 2Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS751	Data Science Lab	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
Algorithms, Data Science		CT+EA (Assignment, Weekly Demonstration & Presentation, Viva)					

Course Outcomes	After successful completion of this course, students will be able to	Bloom Level
	• CO1: Perform the quantitative and qualitative analysis of the data.	L2, L3
	• CO2: Understand the basic trends and distributions, outliers in one variable plot, and correlations in two variables of numerical data.	L3, L5
	• CO3: Apply regression analysis, analyze the obtained result, and asses the model output for a dataset.	L4, L5
	• CO4: To create a machine learning model for business applications.	L6

Topics Covered	Students may use either Python or R language for the following experiments. 1) Explore the features of Jupyter Notebook, NumPy, SciPy, Statsmodels, Pandas, QGIS and R studio. Overview of required libraries for importing data, explanatory data analysis and data visualization. 2) Perform Matrix Operations, Calculate Eigen Values and Eigen vectors. 3) Determine Descriptive Statistics and apply various measures- range, IQR, deviation, variance

	4) Make a graphical Summary of the data: histogram, pi plot, box plot, bar graph, scatter plot, detect outliers, remove outliers 5) Implement supervised and unsupervised models 6) Implement regression techniques with suitable datasets, and observe the standard error, p-value, R-square values. 7) Implement classification problems using suitable datasets 8) Utilize a dataset to perform univariate, bivariate and multivariate data analysis. 9) Implement neural network models for regression and classification problems. 10) Implement Convolutional Neural Network for image classification using a standard dataset available in public domain. 11) Implement problems on natural language processing - Part of Speech tagging, N-gram & smoothening and Chunking using suitable libraries.
Text/Reference Books	1. Python for Data Analysis- Data Wrangling with Pandas, NumPy and IPython- Wes McKinney, Oreilly Publication 2. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Third Edition

CSS 752 Internet Technologies Laboratory 0-0-3 2Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS752	Internet Technologies Lab	XXX	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
Knowledge of Database, Networking, Algorithms, Data Science, Software Engineering		CT+EA (Assignment, Weekly Demonstration & Presentation, Viva)					
Course Outcomes	• CO1: Understand project management towards system design • CO2: Realize different concepts of different software architectures (layered, client-server, event-based, microkernel, microservice, broker based, enterprise, workflow etc.) towards system design • CO2: Understanding the use of modern technologies to design frontend, backend, database, interfaces (with external software, Hardware prototyping platform or micro-computer), debugging, version control related to system design • CO4: Understanding concepts of system verification and validation						
Topics Covered	A small group/team of students should design and develop system prototypes that involves design of frontend, handling backend database, analytics, scalability, authentication, and fault tolerance. They should be able to apply the basic concepts of algorithms, database design, networking, operating system and software engineering concepts in designing the system. Some representative problems are as following: • Develop an online MCQ-Based Exam Platform that can be used for conducting online exams with following features: user login from different terminals from different physical machines, user registration and authentication, user-friendly						

	interface with time to submit, answered-question tags, a fault-tolerant multithreaded server processing module for student performance analysis, etc. (Architecture: Client-server based) • Develop a File Sharing Platform which enables users to upload/download (Large ~GB) files to a central local cloud like multithreaded server with following features: file sharing polices (like who could access/update/modify which file), Visualization of availability/status, handling abruptly terminated, server failures and load balancing, performance analysis, etc. (Architecture: Event-driven) • Develop an online Ticketing platform where event-executors can sell tickets for concerts, theaters, and sporting events and audience/users can purchase tickets with following features: user login from different terminals from different physical machines, user registration and authentication, user-friendly interface Visualization, design dynamic pricing policies, handling server faults, analytics, etc. (Architecture: Micro-service based/Event-Driven based and Software Interface Design) • Develop an online Multi-player game platform which allows game creators to load simple multi-player games like Tic-Tac-Toe, Crossword puzzle, Quizing games, word-formation, etc. with following features: user login from different terminals from different physical machines, APIs to upload the suitable game information, rules, wining conditions, etc. design credit/scoring policies, visualizations, enable multi-user team formation, game analytics, etc. (Architecture: Micro-service based/Event-Driven based and Software Interface Design) • Develop an online reservation platform, (hotel rooms/bus seats/railway berths booking system), where rooms/seats are offered based on user requests with following features: user login from different terminals from different physical machines, user registration and authentication, user-friendly interface Visualization, design dynamic pricing policies, handling server faults, analytics, etc. • Develop an online application software for handing Departmental activities like managing UG/PG related activities with provisions for approval of HOD/faculty members of the department, project allocation management, etc. (Architecture: Workflow based and Software Interface Design) • Develop a smart building monitoring system with the following features: aggregating multiple sensor inputs, data validations, fault detection, alert generation, user registration & authentication, visualization, analytics, etc. (Architecture: Event-Driven based, Hardware prototyping platform or micro-computer and Software Interface Design) **The system prototypes are expected to use following technologies for implementation:** • **Architecture Fundamentals:** UML, Model-driven Architecture, Zachman Framework, i* Framework, Business Process Modelling Notations (BPMN) etc. • **Frontend** – HTML, HMTL5, CSS3, JavaScript, jQuery, xQuery etc. • **Backend** – Node.js, Angular 2, PHP, BPMN/BPEL Tools, REST API based tools etc. • **Database** – MySQL, PostgreSQL, MongoDB, XML etc. • **Debugging/Version Control** – GIT, Subversion, Debuggers (Xdebug, Firedebug), etc.

	• **Hardware Prototyping Platform**: Arduino, Raspberry Pi
Text Books, and/or reference material	1. Philip Ackermann, "Full Stack Web Development: The Comprehensive Guide", SAP Press. 2. Chris Northwood, "Full Stack Developer: Your Essential Guide to the Everyday Skills Expected of a Modern Full Stack Web Developer", Apress. 3. Manu Sharma, "Full Stack Development with MongoDB: Covers Backend, Frontend, APIs, and Mobile App Development using PHP, NodeJS, ExpressJS, Python and React Native", BPB 4. https://nptel.ac.in/courses/106106156 Prof. Gaurav Raina, Tanmai Gopal Introduction to Modern Application Development, IIT Madras 5. https://onlinecourses.nptel.ac.in/noc20_cs52/preview Prof. Aamod Sane, Prof. Abhijat Vichare, Prof. Madhavan Mukund, Modern Application Development Persistent Computing Institute, Persistent Computing Institute, Chennai Mathematical Institute.

CSE 7XX Wireless sensor & Adhoc networks 3-0-0 3Credits 3Hours

Department of Computer Science & Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 7XX	Wireless sensor & Adhoc networks	PEL	3	0	0	3	3
Pre-Requisite: Data Communication and Computer Networks		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	• CO1: To understand the WSN node Architecture and Network Architecture • CO2:To identify the Wireless Sensor Network Platforms • CO3: Explain fundamental principles of Ad-hoc Networks • CO4: Discuss a comprehensive understanding of Ad-hoc network protocols						
Topics Covered	**Introduction**: Introduction to Wireless Sensor Networks (WSNs), Motivation, Performance Requirement, Diverse applications, Ad-hoc Wireless Networks Introduction, Issues in Ad-hoc Wireless Networks, Ad-hoc Wireless Internet; MAC Protocols for Ad-hoc Wireless Networks: Introduction, Issues in Designing a MAC Protocol, Design Goals of MAC Protocols, Classificationof MAC protocols (4) **Wireless Sensor Network Architecture:** Hardware components, Energy consumption of sensor nodes, Motes, Sensor Devices, Types of Sensors, Sensor's specification, Operating systems and execution environments, Sensor network scenarios, Design principles for WSNs, Service interfaces of WSNs, Gateway concepts (3) **Localization and positioning:** Properties of localization and positioning procedures, Possible approaches (Proximity, Trilateration and triangulation, Scene analysis), Mathematical basics for the lateration problem, Single-hop localization, Positioning in multi-hop environments (5)						

	Topology control: Motivation and basic ideas, Controlling topology in flat networks – Power control, Hierarchical networks by dominating sets, Hierarchical networks by clustering, Combining hierarchical topologies and power control, Adaptive node activity (5) **Routing protocols:** Forwarding and routing, Energy-efficient unicast routing, Geographic and Random Routing, Clustering Algorithms in routing, Fault Tolerance in Wireless Sensor Networks, Routing Protocols for Ad-hoc Wireless Networks Introduction, Issues in Designing a Routing Protocol for Ad-hoc Wireless Networks; Classification of Routing Protocols; Table Driven Routing Protocols; On-Demand Routing Protocols, Hybrid Routing Protocols, Hierarchical Routing Protocols and Power-Aware Routing Protocols. (12) **Transport layer and Quality of Service (QoS):** Coverage and deployment, Reliable data transport, Single packet delivery, Block delivery, Congestion control and rate control, Energy Management in Ad-hoc Wireless Networks, Classification of Energy Management Schemes, Battery Management Schemes, Transmission Management Schemes, System Power Management Schemes. (10) **Security in Ad-hoc Wireless Networks:** Issues and Challenges in Security Provisioning, Network Security Attacks, Key Management and Secure Touting Ad-hoc Wireless Networks. (3)
Text Books, and/or reference material	**Text Books:** 1. H. Karl and A. Willig, *Protocols and Architectures for Wireless Sensor Networks*, Wiley Publishers , 2005 2. E. H. Callaway, Jr. E. H. Callaway, *Wireless Sensor Networks Architecture and Protocols:*, CRC Press , 2009 3. Ozan K. Tonguz and Gianguigi Ferrari: Ad-hoc Wireless Networks, John Wiley, 2007. 4. Xiuzhen Cheng, Xiao Hung, Ding-Zhu Du: Ad-hoc Wireless Networking, Kluwer Academic Publishers, 2004.

CSE 7XX Information Coding Theory 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE7XX	Information coding theory	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Probability and statistics, linear algebra, calculus.		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		● CO1: Understanding definition and measurement of information. ● CO2: Understanding source coding and Design and analysis of data compression techniques. ● CO3: Understanding Channel coding theory ● CO4: Design and analysis of Error correction coding					
Topics		Introduction, Mathematical Measure of Information, Average and Mutual					

Covered	Information and Entropy, Properties of Entropy, Discrete memoryless sources (DMS), Extension of DMS, Markov sources, Source coding theorem, Fixed length and variable length coding, Kraft inequality, Properties of prefix codes. (8L) Source Coding: Lossless entropy encoding, Huffman code, Huffman code applied on the symbols of extended sources, Shannon-Fano coding, efficiency calculations, Lempel-Ziv codes, arithmetic coding, Rate distortion Theory. (8L) Lossless and lossy predictive coding and decoding, Quantization, PCM, DM, ADM, DPCM. (6L) Channels and Channel Capacity: Discrete memoryless channel model, Binary symmetric channels and channel capacity, entropy rate and channel coding theorem, information capacity theorem. (6L) Error correction codes: Introduction, Basic concepts of linear algebra including group, ring, field, vector space etc. (3L) Block codes: Introduction, single parity check codes, product codes, repetition codes. (3L) Linear Codes: Definition, encoding and decoding of linear codes, generator matrix, error detection and correction, Perfect codes, Hamming codes. (5L) Cyclic codes: Definition, polynomials, encoding and decoding techniques, cyclic redundancy check. (3L)
Text Books, and/or reference material	**Text Books:** 1. Information Theory and Coding Hardcover by Norman Abramson, McGraw-Hill. 2. Elements of Information Theory (Wiley Series in Telecommunications and Signal Processing) by Thomas M. Cover, Joy A. Thomas, Wiley-Blackwell. 3. Error Control Coding by Shu Lin, Daniel J. Costello, Pearson. **Reference Books:** 1. Coding and Information Theory by Steven Roman, Springer-Verlag. 2. Error Control Coding by Peter Sweeney, John Wiley & Sons.

CSE 7XX CRYPTOGRAPHY AND CYBER SECURITY 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 7XX	CRYPTOGRAPHY AND CYBER SECURITY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	CO1: Acquire knowledge about various types of services, mechanisms and attacks. CO2: Analyze security different types symmetric key ciphers and asymmetric key ciphers CO3: Design schemes for providing integrity and authentication security services. CO4: Understand various cyber crimes and cyber security CO5: Analyze different techniques for providing cyber security						

Topics Covered	**UNIT –I Introduction to Cryptography 5L** Security Services and Mechanisms, Secret Key and Public Key Cryptography, Classical cipher: Substitution techniques, Transposition techniques, Steganography, Security threats, attacks, Notion of Perfect Secrecy. **UNIT –II Symmetric key Cryptography 9L** Algebraic Structures, Modular Arithmetic - Euclid's algorithm – Congruence and matrices, Block Cipher, DES, AES, Modes of Block Cipher, various Cryptanalytic attacks on Block Cipher, Stream Cipher:RC4, LFSR, attacks on stream cipher. **UNIT –III Asymmetric key Cryptography 9L** Background Mathematics: Primes, Primality Testing, Factorization, Euler's totient function, Fermat's and Euler's Theorem, Chinese Remainder Theorem, – Exponentiation, Discrete logarithmic Problem, Elliptic curve arithmetic; Cipher: RSA cryptosystem, Elgamal cryptosystem, Elliptic curve arithmetic, Elliptic curve cryptography **UNIT –IV Cryptographic Hash Functions and Digital Signatures 4L** Applications, Security of hash functions, Message Authentication Codes, HMAC, Digital signatures, Digital Signature Standards **UNIT –V Authentication Algorithms and Key Management 5L** Key Management, Diffie Hellman key exchange, Public Key Infrastructure, X.509 Certificates, Entity Authentication: Passwords, Challenge Response protocols, Biometrics, Kerberos **UNIT-VI Cyber Crimes and Cyber Security 10L** Cyber Crime and Information Security: classifications of Cyber Crimes, Password Cracking, Keyloggers, Spywares, SQL Injection, Session Hijacking and Spoofing, Phishing, Buffer Overflow, Electronic Mail Security, Web Security, IPSec, SSL, SET. Virus/Worms, Trojan, Spyware, Intrusion Detection and Prevention System, Firewall.
Text Books, and/or reference material	**Text Books:** 1. Stinson, "Cryptography, Theory & Practice", 3rd Ed., CRC 2. Forouzan, B. A., & Mukhopadhyay, D. Cryptography and network security (Sie). McGraw-Hill Education, 3. Stallings, "Cryptography & Network Security, Theory & Practice", 3rd Ed., Pearson, 2009. **Reference Books:** 1. Menezes, "Network Security & Cryptography", Cenegage Learning, 2011.

CSE 7XX Biometrics 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE7XX	Biometrics	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Basic Mathematics – Knowledge and ability		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					

to use calculus, probability, and statistics are essential.	
Course Outcomes	● CO1: Understanding biometrics systems and its different characteristics. ● CO2: Implementation of different biometrics systems including face, fingerprint, iris, palm, signature, EEG, etc. ● CO3: Apply the concept of unimodal and multimodal paradigms in biometrics systems. ● CO4: Analyze different feature extraction and learning techniques for biometrics systems. ● CO5: Design and develop real life biometrics systems.
Topics Covered	Biometrics Overview: Introduction, characteristics of biometric systems, biometric systems, biometric functionalities, biometrics system errors, design cycles of biometric systems, applications of biometric systems, security and privacy issues. [4L] Image Processing Techniques: What is image processing?, origin of image processing, fundamental steps in digital image processing, components of image processing system, image sensing and acquisition, image sampling and quantization, basic relationships between pixels. [6L] Filtering: Background, basic intensity transformation functions, histogram processing, fundamentals of spatial and frequency domain filtering, smoothing filters, sharpening filters, Discrete Fourier Transform, Fast Fourier Transform. [4L] Pattern Classification Techniques: Introduction, Bayesian decision theory, maximum likelihood and Bayesian parameter estimation, non-parametric techniques, linear discriminant functions, multilayer neural networks, non-metric methods. [6L] Fingerprint Recognition: Introduction, ridge pattern, fingerprint acquisition, feature extraction, matching, and fingerprint synthesis. [6L] Face Recognition: Introduction, image acquisition, and face detection, feature extraction, matching and advanced topics. [6L] Iris Recognition: Introduction, iris recognition systems, image acquisition, iris segmentation, iris normalization, iris encoding and matching, iris quality and performance evaluation. [4L] Multi-modal Biometric Systems: Introduction, sources of multiple evidence, acquisition and processing architecture, fusion levels. [2L] Other Biometrics: Signature, hand shape, ear, palmprint, etc. [4L]
Text Books, and/or reference material	**Text Books:** ● Anil K. Jain, Arun Ross, and Karthik Nandakumar, Introduction to Biometrics, Springer, 2011. ● J. L. Wayman, Anil K. Jain, D. Maltoni, D. Maio, Biometric Systems: Technology, Design and Performance Evaluation, Springer, 2005. ● R. M. Bolle, J. Connell, S. Pankanti, N. K. Ratha, A. W. Senior, Guide to Biometrics, Springer, 2004. ● Richard O. Duda, Peter E. Hart, David G. Stork, Pattern Classification, 2nd Edition, Wiley, 2000. ● R.C. Gonzalez and R. E. Woods, Digital Image Processing, Pearson, 2009. **Reference Books:** ● D. R. Kisku, P. Gupta and M. Tistarelli, Multibiometrics Systems: Modern Perspectives to Identity Verification, LAMBERT Publishing, 2012. ● D. R. Kisku, P. Gupta and J. K. Sing, Advances in Biometrics for Secure Human Authentication and Recognition, CRC Press, Taylor & Francis, 2013.

	● D. R. Kisku, P. Gupta and J. K. Sing, Design and Implementation of Healthcare Biometric Systems, IGI Global, 2019. ● M. Dawson, D. R. Kisku, P. Gupta, J. K. Sing and W. Li, Developing Next-Generation Countermeasures for Homeland Security Threat Prevention, IGI Global, 2016. **Others:** Online Biometrics Courses 1. https://nptel.ac.in/courses/106104119/ 2. https://www.mooc-list.com/tags/biometric

CSE7XX Hardware Security 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE7XX	Hardware Security	PEL	3	0	0	3	3
Pre-requisites: Foundation on Cryptography		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	At the completion of this course students will be able to: ● CO1: Understand different security threats on modern hardware design. ● CO2: Learn the various Hardware Security Primitives. ● CO3: Design and analyses the Side-channel Attacks and its impact on hardware security. ● CO4: Analyze different modelling attack on hardware and its prevention techniques. ● CO5: Understand different state-of-the-art defense techniques.						
Topics Covered	**UNIT-I**: **Preliminaries:** Algebra of Finite Fields, Basics of the Mathematical Theory of Public Key Cryptography, Basics of Digital Design on Field-programmable Gate Array (FPGA), Classification using Support Vector Machines (SVMs) (5L) **UNIT-II**: **Useful Hardware Security Primitives:** Cryptographic Hardware and their Implementation, Optimization of Cryptographic Hardware on FPGA, Physically Unclonable Functions (PUFs), PUF Implementations, PUF Quality Evaluation, Design Techniques to Increase PUF Response Quality (5L) **UNIT-III Side-channel Attacks on Cryptographic Hardware**: Basic Idea, Current-measurement based Side-channel Attacks (Case Study: Kocher's Attack on DES), Design Techniques to Prevent Side-channel Attacks, Improved Side-channel Attack Algorithms (Template Attack, etc.), Cache Attacks. (8L) **UNIT-IV**: **Testability and Verification of Cryptographic Hardware:** Fault-tolerance of Cryptographic Hardware, Fault Attacks, Verification of Finite-field Arithmetic Circuits (12L) **UNIT-V**: **Modern IC Design and Manufacturing Practices and Their Implications:** Hardware Intellectual Property (IP) Piracy and IC Piracy, Design Techniques to Prevent IP and IC Piracy, Using PUFs to prevent Hardware Piracy, Model Building Attacks on PUFs (Case Study: SVM Modelling of Arbiter PUFs, Genetic Programming based Modelling of Ring Oscillator PUF) (5L) **UNIT-VI**: **Hardware Trojans**: Hardware Trojan Nomenclature and Operating Modes,						

	Countermeasures Such as Design and Manufacturing Techniques to Prevent/Detect Hardware Trojans, Logic Testing and Side-channel Analysis based Techniques for Trojan Detection, Techniques to Increase Testing Sensitivity Infrastructure Security: Impact of Hardware Security Compromise on Public Infrastructure, Defence Techniques (Case Study: Smart-Grid Security) (7L)
Text Books, and/or reference material	**Text Books:** 1. Debdeep Mukhopadhyay and Rajat Subhra Chakraborty, "Hardware Security: Design, Threats, and Safeguards", CRC Press 2. Mark Tehranipoor, Swarup Bhunia, Hardware Security: A Hands-on Learning Approach 3. Mohammad Tehranipoor, Cliff Wang, Introduction to Hardware Security and Trust **Reference Books:** 1. Ahmad-Reza Sadeghi and David Naccache (eds.): Towards Hardware-intrinsic Security: Theory and Practice, Springer. 2. Ted Huffmire et al: Handbook of FPGA Design Security, Springer. 3. Stefan Mangard, Elisabeth Oswald, Thomas Popp: Power analysis attacks - revealing the secrets of smart cards. Springer 2007. 4. Doug Stinson, Cryptography Theory and Practice, CRC Press.

CSE 7XX Blockchain Technology 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE7XX	Blockchain Technology	PEL	3	0	0	3	3
Pre-requisite		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Understanding the basic blockchain technology. • CO2: Understanding the distributed consensus and atomic broadcast, Byzantine fault-tolerant consensus methods. • CO3: Understanding the smart contract. • CO4: Understanding the limitations and reality.						
Topics Covered	**Introduction**: Concept of distributed ledger, Byzantine Generals problem, Consensus algorithms and their scalability problems, Introduction to Bitcoin based cryptocurrency, Block datastructure, Block chaining mechanism. (4) **Minting operation:** Concept of PoW, other model – Proof of Stack, Proof or Memory, Proof of Burn etc. Green computing vs Proof systems. (3) **Consensus Model**: Fault tolerance model. P2P network model, Byzantine fault tolerance model, Longest chain model. (2) **Cryptographic Tools:** Hash function, Collision resistant hash function, Elliptic Curve Digital signature (ECDSA). Markle tree representation, zero-knowledge proof. (4) **Bitcoin & Cryptocurrency:** Bitcoin network, Challenges and solutions, SIGHASH, Bitcoin scripting language and their use. (6) **Blockchain 2.0:** Blockchain network, Ethereum and Smart Contracts, The Turing						

	Completeness of Smart Contract Languages, Application of smartcontract, Bitcoin scripting vs. Ethereum Smart Contracts. (6) **Solidity:** Introduction to Solidity programming language, Security issues, Basic coding metric, ERC-20, ERC-721, ERC-777, ERC-1155, Design of distributed applications (DApps). (5) **Blockchain 3.0:** Plug-and-play platform, Permission less vs. permission oriented platform, Blockchain testnet and mainnet, Deployment of smartcontarct. (4) **Anonymity:** Pseudo anonymous, pseudonym, transaction analysis, Sybil attack, Issues related to inheritance, Defining of cryptoasser, Regulation and legal supports. (5) **Application:** Application in IoT, HealthCare, Equity and Financial asset, Some case studies. (4)
Text Books, and/or reference material	Text Books: 1. Mastering in Blockchain: Lorne Lantz, eyDaniel Cawr 2. Mastering Ethereum: Building Smart Contracts and DApps: Andreas M. Antonopoulos, **Gavin Wood** 3. Mastering Bitcoin: Programming the Open Blockchain: Andreas M. Antonopoulos

CSE 7XX Human Computer Interaction 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE7XX	Human Computer Interaction	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
NIL		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		● CO1: Acquire knowledge about Components of HCI. ● CO2: To learn the basic Psychology of Usable Things. ● CO3: To learn about Usability Engineering, Usability Benchmarking. ● CO4: To learn Inspection methods, testing methods, design.					
Topics Covered		Introduction, Psychology of Usable Things. (7L) Usability Engineering, Know the User, Usability Benchmarking. (7L) Goal-Oriented Interaction Design, Prototyping. (7L) Usability Inspection Methods, Usability Testing Methods. (7L) Usability in Practice, Visual Design and Typography. (7L) Icon Design, Case Studies. (7L)					
Text Books, and/or reference material		**Text Books:** 1. Dix A., Finlay J., Abowd G. D. and Beale R. Human Computer Interaction, Pearson Education, 2005. 2. Preece J., Rogers Y., Sharp H., Baniyon D., Holland S. and Carey T. Human. ComputerInteraction, Addison-Wesley, 1994. **Reference Books:** B. Shneiderman, Designing the User Interface, Addison Wesley 2000.					

	Others: NPTEL online course.

CSE 7XX Speech Processing 3-0-0 3 Credits 3 Hours

Department of Computer Science & Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CS7XX	Speech Processing	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Discrete Mathematics, Probability and Statistics, Linear Algebra, Programming	CT+EA

Course Outcomes	• CO1: Understand the basics of speech modelling, recognition, and synthesis. • CO2: More rapidly develop software, especially using skills in scripting and in the customization and combination of existing tools. • CO3: Comfortably use basic machine learning concepts and techniques for speech processing • CO4: Apply knowledge of Language and of English to improve everyday written and spoken, communication, including computer-mediated communication, personally and for groups, organizations, and society.
Topics Covered	**Basic Concepts:** Speech Fundamentals: Articulatory Phonetics – Production and Classification of Speech Sounds; Acoustic Phonetics – acoustics of speech production; Review of Digital Signal Processing concepts; Short-Time Fourier Transform, Filter-Bank and LPC Methods. (10) **Speech Analysis:** Features, Feature Extraction and Pattern Comparison Techniques: Speech distortion measures – mathematical and perceptual – Log Spectral Distance, Cepstral Distances, Weighted Cepstral Distances and Filtering, Likelihood Distortions, Spectral Distortion using a Warped Frequency Scale, LPC, PLP and MFCC Coefficients, Time Alignment and Normalization – Dynamic Time Warping, Multiple Time – Alignment Paths. (10) **Speech Modeling:** Hidden Markov Models: Markov Processes, HMMs – Evaluation, Optimal State Sequence – Viterbi Search, Baum-Welch Parameter Re-estimation, Implementation issues. (5) **Speech Recognition:** Large Vocabulary Continuous Speech Recognition: Architecture of a large vocabulary continuous speech recognition system – acoustics and language models – ngrams, context dependent sub-word units; Applications and present status. (7) **Speech Synthesis:** Text-to-Speech Synthesis: Concatenative and waveform synthesis methods, subword units for TTS, intelligibility and naturalness – role of prosody, Applications and present status. (8)
Text Books,	**Text Books:** 1. Lawrence Rabinerand Biing-Hwang Juang, "Fundamentals of Speech

and/or reference material	Recognition", Pearson Education, 2003. 2. Daniel Jurafsky and James H Martin, "Speech and Language Processing – An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition", Pearson Education. **Reference Book:** 1.Steven W. Smith, "The Scientist and Engineer's Guide to Digital Signal Processing", California Technical Publishing.

CSE 7XX Information Retrieval 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 7XX	Information Retrieval	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
Linear algebra, Probability and statistics, Machine Learning		CE+EA					
Course Outcomes	• CO1: To understand the underlined problems related to Information Retrieval. • CO2: To be familiar with various algorithms and systems • CO3: Analyze the performance of information retrieval using advanced techniques such as classification, clustering, and filtering • CO4: To understand the evaluation strategies						
Topics Covered	**Introduction to Information Retrieval**: Basic concept of information retrieval, Practical issues, The Retrieval process. (2) **Modelling:** A Taxonomy of Information Retrieval Models, *Classic Information Retrieval*: Basic Concepts, Boolean Model, Vector Model, Probabilistic Model, Comparison of Classic Models. *Set Theoretic Models*: Fuzzy Set Model, Extended Boolean Model. *Algebraic Models*: Generalized Vector Space Model, Latent Semantic Indexing Model, Neural Network Model. *Probabilistic Models:* Bayesian Networks, Inference Network Model, Belief Network Model. *Structured Text Retrieval Models*: Model Based on Non-Overlapping List, Model Based on Proximal Nodes. *Models for Browsing*: Flat Browsing, Structure Guided Browsing, the hypertext model. (12) **Retrieval Performance Evaluation:** Introduction, Recall and Precision, Alternative Measures, F-measure, kappa measure. *Reference Collections*: TREC Collection, CACM and lSI Collections, Cystic Fibrosis Collection. (3) **Indexing and Index Compression:** Basic concept, Dictionary, Inverted Index, Forward Index, Partitioning, Caching,						

	Dictionary compression, Posting file compressing. (5) **Text Classification and Filtering:** Introduction to text classification. Naive Bayes models. Spam filtering. Vector space classification using hyperplanes; centroids; k Nearest Neighbours. Support vector machine classifiers. Kernel functions. Boosting. (7) **Text Clustering:** Clustering versus classification. Partitioning methods. k-means clustering. Mixture of gaussians model. Hierarchical agglomerative clustering. Clustering terms using documents. **Advanced Topics**: (4) *Multimedia Information Retrieval:* Similarity Queries, Feature-based Indexing and Searching, Spatial Access Methods, Searching in Multidimensional Spaces. *Web Searching*: Introduction, Challenges, Characterizing the Web, Indexing, Spidering/Crawling, Search Engines, Browsing, Metasearchers, Searching using Hyperlinks, XML retrieval, Semantic web. (9)
Text Books, and/or reference material	**Text Books:** 6. C. D. Manning, P. Raghavan and H. Schutze, Introduction to information retrieval, Cambridge, University Press, 2008. 7. R. Baeza-Yates, B. Ribeiro-Neto, Modern information retrieval, ACM Press / Addison Wesley, 1999 **Reference Books**: 1. G. Kowalski, Information Retrieval Architecture and Algorithms, Springer, 2011. 2. S. Buttcher, Charles L. A. Clarke, Gordon V. Cormack, Information Retrieval Implementing and Evaluating Search Engines, The MIT Press, 2010.

CSE 7XX Quantum Computing 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE7XX	**Quantum Computing**	PEL	3		0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Design and Analysis of Algorithms/Information and Coding Theory /Quantum Mechanics		CT+EA **[CA: 15%, MT: 25%, ET: 60%]**					
Course Outcomes	• CO1: Understanding the fundamental concepts of Information Theory and Quantum System • CO2: Understanding different Quantum Gates and Circuits • CO3: Teleportation of information in Quantum System • CO4: Implementation of Quantum Computing for information processing • CO5: Understanding information security by Quantum Cryptography						
Topics to be Covere	1. Classical Information Theory (2L) Information Theory, Shannon's Entropy, Grouping Theorem, Gibb's Inequality, Communication Systems, Coding, Shannon's Theorem						

d (40L)	2. Quantum Information and Computing – I (6L) Introduction, Postulates of Quantum Mechanics [5 Postulates] , The Qubit, Bloch Sphere Representation of Qubits, Composite Systems, Linear Algebra(Projection Operator, Spectal Theorem, Positive Operator, Polar Decomposition of an Operator, Singular Value Decomposition) 3. Quantum Information and Computing - II (Density Matrix Formulation & Quantum Mechanics) (2L) Introduction, Density Matrix Mixed, State Density Matrix, Density Matrix & Block Sphere, Postulates of Quantum Mechanics - in Density Matrix Representation, Reduced Density Matrix, 4. Multiple Qubit States and Quantum Gates (3L) Introduction, Composite Systems, Matrix Basis in the Space of Two Qubits, Single Qubit Gates, Different Single Qubit Gates (Pauli Matrices, Hadamard), Two Qubit Gates, Three Qubit Gates 5. Quantum Circuits (3L) Introduction, Implementation of Classical Logic Gates, Oracle 6. No-Cloning Theorem and Teleportation (2L) Introduction, Quantum No-cloning Theorem, Quantum Teleportation 7. Super Dense Coding (2L) Introduction, Dense Coding Circuit 8. Measurement postulates (3L) Introduction, Measurement Postulates, Projection on Von-Neumann Measurement , Measurement in a Mixed State, POVM 9. Simple Quantum Algorithms - Deutsch Algorithm and Deutsch - Jozsa Algorithms (3L) Introduction, Quantum Parallelism, Collapse of Wave Function and Process of Measurement, Entanglement, Quantum No-Cloning Theorem, Deutsch Problem, Deutsch - Jozsa Algorithm 10. Simon Problem (2L) Introduction , Simon Problem , Classical Complexity ,Quantum Circuit for Simon Problem 11. Grover's Search Algorithm (2L) Introduction , The Oracle , Grover Operator and its Geometric Inter predation , Maximum Number of Iteration, Matrix Representation of Grover Operator , Quantum Circuit , Success and Failure of Algorithm to Example , The Quadratic Speeding , Maximum Number of Iteration , Matrix Representation of Grover Operator , Quantum Circuit , Success and Failure of the Algorithm to Example 12. Quantum Fourier Transform (2L) Introduction , Discrete Integral Transforms , Quantum Fourier Transform , Period Finding , Unitary Operator for QFT , Implementation , QFT for 3 Qubits 13. Shor's Factorization Algorithm (2L) Introduction, Shor’s Algorithm , Implementation of Quantum Computation Part , Method of Continued Fraction 14. EPR and Bell's Inequality (2L) Introduction , Bell States and Local Measurement, Bell's Inequalities ,CHSH Inequality 15. RSA Algorithm (2L) Introduction , Fermat's Little Theorem , Euler's Theorem , Chinese Remainder Theorem , RSA Encryption and Decryption , Euclid's Algorithm , Extended Euler's Algorithm 16. Quantum Cryptography (2L) Introduction , BB-84 Protocol , Eve's Interception ,B-g2 Protocol , Ekert Protocol using

	EPR Pairs (E-D1),
Text Books, and/or reference material	**Text Books:** 1. Quantum Computation and Quantum Information, by Michael A. Nielsen , Isaac L. Chuang, Cambridge Press 2. An Introduction to Quantum Computing, by Phillip Kaye , Raymond Laflamme , Michele Mosca, Oxford Press 3. The Feynman Lectures on Physics - Vol.3, by Richard P. Feynman, Pearson Publishing

CSE 7XX Cellular Automata and its Application 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE7XX	Cellular Automata and its Application	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Digital Electronics		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		● CO1: Understanding the basic and advanced concepts of Cellular Automata (CA). ● CO2: Understanding the different phases of evolution of CA machine. ● CO3: Understanding the method of characterization of CA machine/tool. ● CO4: Modeling of physical/real-time systems with a mathematical tool such as CA. ● CO5: Applying suitable class of CA for building CA based model to study.					
Topics Covered		**Introduction:** Basic definitions of cellular automata and symbolic dynamics, Injectivity, surjectivity, reversibility, Garden-of-Eden theorem, Hedlund's theorem, Conservation laws, universal computing reversible/irreversible CA, neighbourhood, dimensions, states, follow-up and review. [6L] **Characterization of CA behaviour and its applications:** Initial Phase of Development, CA-Based Models - Language Recognizer, Biological Applications, CA as Parallel and Image Processing Systems, CA based model of physical systems. [6L] **New Phase of Development**–Wolfram's model of CA, 3-neighborhood 2-state CA, CA rules, Classification of rules, CA technology, CA as an FSM, Linear/non-linear/additive CA, Polynomial Algebraic Characterization of CA Behavior, Matrix Algebraic Characterization. [6L] **Irreversible/Group CA characterization in linear domain:** Null/Periodic boundary Characterization of the State-Transition Behavior, Cycle Set Characterization, Isomorphism between a CA and an LFSR. CA based Pseudorandom Pattern Generation, Pseudo noise sequence, CABIST, Pattern Classification. [6L] **Characterization of nongroup CA/non-invertible CA in linear domain**: General Characterization of Cyclic States (attractors), Characterization of Single Length					

	Cycle Single Attractor CA (SACA), D1*CA, Multiple-Attractor Cellular Automata (MACA)[6L] **Non-linear CA:** Characterization of non-linear rules, invertible and non-invertible CA, CA with point states; applications in VLSI domain. [6L] **Advanced Concepts:** Extension of dimension, d-state CA, introduction to Asynchronous CA, follow-up and review**.** [6L]
Text Books, and/or reference material	**Text Books:** 1. Additive Cellular Automata: Theory and Applications, by Parimal Pal Chaudhuri, Dipanwita Roy Chowdhury, Sukumar Nandi, Santanu Chattopadhyay, Wiley. 2. Tommaso Toffoli, Norman Margolus. Cellular Automata Machines: A New Environment for Modelling. MIT Press. 3. *Cellular Automata and Complexity: Collected Papers* by Stephen Wolfram; Westview Press. **Reference Books:** 1. Game of Life Cellular Automata, by Andrew Adamatzky, Springer; 2010 edition. 2. A New Kind of Science, by Stephen Wolfram, Wolfram Media. 3. A New Kind of Computational Biology, by Chaudhuri, P.P., Ghosh, S., Dutta, A., Choudhury, S.P; Springer. 4. Joel L. Schife. Cellular Automata: A Discrete View of the World. Wiley - Interscience.

CSE 7XX Computational Geometry 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE7XX	Computational Geometry	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
A course on Design and analysis of algorithm		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		● CO1: To demonstrate familiarity with some of the basic algorithmic techniques of the area. ● CO2: To design and analyze "new" geometric algorithms and to derive the lower bound for some geometric problems. ● CO3: To map practical problems to computational geometric problems and finding a solution to these geometric problems help to solve a wide range of practical problems in a variety of fields such as graphics, robotics, databases, sensor network ● CO4: To develop skills to work on geometrical manipulating software and to demonstrate acquaintance with modern research in the field.					
Topics Covered		**Computational Geometry Introduction:** Historical perspectives, Geometric preliminaries, Convex Hull, Algorithms to find the Convex Hull of a point set in 2D					

	plane: Graham's Scan Algorithm, Divide and Conquer algorithm, Output sensitive algorithm: Jarvis's March Algorithm, Timothy Chan's Algorithm; Lower bound analysis for Convex Hull Algorithm. [6L] **Line Segment Intersection**: Line Segment Intersection, The Doubly-Connected Edge List, Computing the Overlay of Two Subdivisions, Boolean Operations. [4L] **Polygon Triangulation:** Guarding and Triangulations, Area of a simple polygon, Counting the number of triangulations in a convex polygon, Art Gallery Theorem, Monotone Polygon, Partitioning a Polygon into Monotone Pieces, Triangulating a Monotone Polygon. [6L] **Orthogonal Range Searching:** 1-Dimensional Range Searching, Kd Trees, Range Trees, Higher-Dimensional Range Trees, Fractional Cascading. [6L] **Point Location:** Point Location and Trapezoidal Maps, A Randomized Incremental Algorithm to compute a Trapezoidal Map and a Search structure, Kirkpatrick's planar point location problem. [6L] **Voronoi Diagram and Delaunay Triangulation:** Definition and Basic Properties of Voronoi Diagram, Computing the Voronoi Diagram: Fortune Sweep Algorithm, Divide and Conquer Algorithm. Closest pair Problems. Application of voronoi diagrams, Triangulations of Planar Point Sets, The Delaunay Triangulation, Computing the Delaunay Triangulation. [7L] **Arrangements and Duality:** Arrangement of lines, Zone theorem, Duality, Application of arrangements and duality, Ham Sandwich Cut. [4L] **Geometric Data Structure:** Interval Trees, Priority Search Trees. [3L]
Text Books, and/or reference material	**Text Books:** 1. Franco P. Preparata and Michael Ian Shamos, Computational Geometry- An Introduction, Springer Verlag. 2. Mark de Berg, Marc van Kreveld, Mark Overmars, Otfried Cheong, Computational Geometry: Algorithms and Applications, Third Edition, Springer Verlag. 3. Joseph O' Rourke, Computational Geometry in C, Cambridge University Press. **Reference Books:** **Others:** Lecture notes on Computational geometry by David Mount.

CSE 7XX Incentive Mechanisms in Computer Science 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE7XX	**Incentive Mechanisms in Computer Science**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
Introduction to computing		CT: 15%, MT: 25%, EA: 60%					
Course Outcom	After completion of this course, the students ● CO1: Can have the efficiency to think about incentive issues in computation.						

es	• CO2: Can learn the tools to tackle the incentive issues. • CO3: Can understand the modern state of the art of incentive based computation. • CO4: Can analyze the scenarios of incentive based computation. • CO5: Can apply the knowledge in solving real life problems.
Topics Covered	**Introduction:** Motivation to the course with canonical ideas of game theory (3L) **Incentives in labour market: School Choice, Medical Residency matching, Kidney exchange, House allocation etc.** (5L) **Auctions and Incentive issues.** (5L) **Incentives in Voting, Knapsack Voting , Participatory Democracy** (4L) **Incentives in P2P networks, Incentives for social participation (such as Stack Exchange etc.)**. (5L) **Incentive study in selfish routing** (3L) **Incentives in BGP routing** (2L) **Incentives in cryptocurrencies (**3L**)** **Reputation system and incentive issues** (2L) **Incentivizing Forecasts and Feedback** (2L) **Prediction Markets** (2L) **Time-Inconsistent Planning** (2L) **Fair Division** (4L)
Text Books, and/or reference material	**Text Books:** 1. N. Nisan, T. Roughgarden, E. Tardos, and V. V. Vazirani. Algorithmic Game Theory. Cambridge University Press, New York, NY, USA, 2007, ISSN: 978-0521872829. 2. T. Roughgarden, Twenty Lectures on Algorithmic Game Theory, Cambridge University Press, 2016, ISSN: 978-1316624791. **Reference Books:** 1. T. Roughgarden, CS364A: Algorithmic Game Theory Course (Stanford University), 2013 (Lecture Notes). 2. T. Roughgarden, CS269I: Incentives in Computer Science Course (Stanford University), 2016 and later offerings (Lecture Notes).

CSE 7XX SOFTWARE PROJECT AND QUALITY MANAGEMENT 3-0-0 3 Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 7XX	**SOFTWARE PROJECT AND QUALITY MANAGEMENT**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					

	CT: 15%, MT: 25%, EA: 60%
Course Objectives	1. To understand the fundamental principles of software project management. 2. To have a good knowledge of responsibilities of project manager. 3. To be familiar with the different methods and techniques used for project management. 4. Upon completion of this course student will be able to identify and address quality issues in all phases of project management life cycle.
Course Outcomes	On completion of the course, student will be able to CO1 - Apply project management concepts and techniques. CO2 - Identify issues that could lead to software project success or failure. CO3 - Explain project management in terms of the software development process. CO4 - Describe the responsibilities of software project managers. CO5 - Apply project management concepts through working in a group as team leader CO6 - Be an active team member on a software project.
Topics Covered	**UNIT 1: INTRODUCTION TO PROJECT MANAGEMENT: 7 L** Introduction to Software Project Management, Definition of a Software Project (SP), SP vs. other types of project activities covered by SPM, categorizing SPs, Project Management Cycle, SPM framework, types of Project plan. Software Product or services, Project Management activities of Project Manager, Project Life Cycle, Project Management Process, Project Management Standards, Traditional vs. modern projects. Define the Software Development Process, Software Development life Cycle, Software Process Models types, Feasibility study, write effective business cases. **UNIT 2: PROJECT EVALUATION AND MANAGEMENT: 8 L** Contents of a business case, Risk identification, cost-benefit analysis, interpretation of the analysis results, deal with uncertainty, risk identification, prioritisation, mitigation, benefit management **Unit 3: PROJECT ESTIMATION TECHNIQUES 8 L** Project planning, project monitoring and control, SPMP document, estimation of project cost, COCOMO model, expert judgement based techniques, weighted average estimates, consensus estimates, top-down, bottom up estimation techniques, function point cost estimation method **Unit 4: PROJECT SCHEDULING, MONITORING AND CONTROL 8L** Schedule Monitoring Tools - Gantt Chart, PERT Chart, Critical Path. Project Crashing. Team Management, software configuration management, risk management. Project monitoring and control **UNIT 5: SOFTWARE QUALITY 11 L** Software Quality - Quality Measures - FURPS - Software Quality Assurance - Software Reviews - Format Technical Review (FTR) Formal Approaches to SQA - Software Reliability - Introduction to SQA - The Software Quality Assurance Plan – Formal approaches to SQA - Clean room Methodology. ISO 9000, ISO 9001, SEI CMM
Text Books, and/or reference material	**Text Books:** 1. Roger S. Pressman: Software Engineering-A Practitioners approach, 7th Edition, Tata McGraw Hill. 2. Bob Hughes, Mike Cotterell, Rajib Mall: Software Project Management, 6th Edition, McGraw Hill Education, 2018. **Reference:**

	1. Pankaj Jalote: An Integrated Approach to Software Engineering, Wiley India

CSE 7XX Advanced Optimization Techniques 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE7XX	Advanced Optimization Techniques	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Engineering Mathematics, Discrete Mathematics, Basic Optimization concepts		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	CO1: To understand the necessity of Advanced optimization methods. CO2: To able to learn various advanced optimization approaches. CO3: To know probabilistic models for optimization techniques. CO4: Able to explore a wide range of engineering optimization problems.						
Topics Covered	**Introduction:** Background, linear programming, non-linear programming, linear transformations, system of linear equations, convex and concave functions. 4L **Convex Optimization Problems:** Optimization problems, convex optimization, Quadratic optimization problems, Geometric programming, Generalized inequality constraints, vector optimization. 4L **Constraint Optimization:** problem preparation, Kuhn-Tucker Conditions, Lagrangian Duality Theory, Transformation Methods- Penalty Function Method, Method of Multipliers; Sensitivity Analysis; Direct Search for Constrained Minimization; Linearization methods for constraint problems; Feasible Direction Method; Generalized Reduced Gradient Method and Gradient Projection Method. 9L **Unconstraint minimization:** Problems, Descent methods, Gradient and steepest descent method, Newton's method, Self-confidence, Implementation. 4L **Network Flow Models:** Models: Basics of network models, Shortest route problem-formulation and algorithms; Maximal flow model. 6L **Markov Process and Markov Chains:** Markov process, Markov Chains, State and Transition Probabilities, Applications. 4L **Queueing Theory:** Basics, queueing system, Kendall's Notation for representing Queueing Models, Classification of Queueing Models. 4L **Modern Methods of Optimization:** Heuristic, Metaheuristic, Genetic Algorithms, Particle Swarm Optimization, Differential Evolution, Ant Colony Optimization, Multi-objective optimization, many optimization, applications in engineering optimization problems. (7L)						

Text Books, and/or reference material	**Text Books:** 5. S. Boyd and L. Vandenberghe, Convex Optimization, Cambridge University Press. 6. K. Deb, Optimization for Engineering Design, Prentice Hall of India. 7. A. Ravindran, K. M. Ragsdell and G. V. Reklaitis, Engineering Optimization: Methods and Applications, Wiley. 8. Hillier & Lieberman, Introduction to Operations Research, TMH. **Reference Books:** 4. S. M. Sinha, Mathematical Programming, Elsevier. 5. Handy Taha, Operations Research – An Introduction, Prentice Hall of India, New Delhi. 6. R. Fletcher, Practical Methods of Optimization, Wiley.

CSE 7XX Microservice Architecture 3-0-0 3Credits 3Hours

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 7XX	Computability and Complexity Theory	PEL	3	0	0	3	
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		Continuous Assessment – 15 marks + Midsem – 25 marks + Endsem – 60 marks = 100 marks.					

Course Outcomes	CO1: Understanding the fundamental concepts of Service Oriented System CO2: Learn fine grained system development strategies using Microservices CO3: Understanding the foundational and functional concepts of Microservices CO4: Learn design and testing of Microservices.
Topics Covered	Service Oriented Architecture (SOA) Fundamentals and Principles: Introduction to Service Oriented Computing, SOA Paradigm and service design principles, Introduction to SOA Development Life Cycle, Introduction to the main stages of SOA development and their associated challenges, SOA Reference Models. (12H) Evolution of Microservices: Monolithic Architecture; Distributed Architecture; Service oriented Architecture – REST Architecture principles, Microservice Characteristics, Inter-Process Communications, Microservice Transaction Management; Microservice and API Ecosystem; SOA vs. Microservice. (10H) Microservices Design: Domain Driven Design; Big Mud Ball to Sweet Gems; Untangling the Ball of MUD; Kill the MUD Ball growth; Repackaging/Refactoring; Decouple the User interface and Backend Business Logic; MUD Ball to Services; Microservice Design Patterns; Microservice Reference Architecture; Microservice Architecture Decisions. (10H)

	Microservices Testing & Security: Testing scenarios, methodology and strategy, Test at Different Levels, Testing Best Practice for Microservices; Microservice Security Principles, Microservice Security techniques, Access Tokens concepts. (8H)
Text Books, and/or reference material	**TextBooks:** **1.** Building Microservices, 2nd Edition by Sam Newman, O'Reilly **2.** Microservice Architecture: Aligning Principles, Practices, and Culture By Irakli Nadareishvili, Ronnie Mitra, Matt McLarty, Mike Amundsen, O'Reilly **3.** Microservices in Action By Morgan Bruce, Paulo A Pereira, Manning Publication

CSE 7XX Computability and Complexity Theory 3-0-0 3 Credits 3 Hours

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 7XX	Computability and Complexity Theory	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
C Programming, Data Structures and Algorithms, Design and Analysis of Algorithms I, II, Discrete Mathematics, Theory of Computation/Formal Languages and Automata Theory	Continuous Assessment – 15 marks + Midsem – 25 marks + Endsem – 60 marks = 100 marks.
Course Outcomes	• CO1: To introduce the formal notions of Turing machines and computability theory with examples • CO2: To introduce the time/space complexity and different complexity classes • CO3: Students should be able to apply the theory of computability to new scenarios • CO4: Students should be able to analyse complexity of novel problems and relationship with different complexity classes
Topics Covered	**Computability Theory** Turing Machines and Effective Computability, The Church-Turing Thesis and a Definition of Algorithms, Different Models of Turing Machines and their Equivalence. (5L) Universal Machines and Diagonalization, Decidable and Undecidable Problems, Reduction, Mapping Reducibility, Computable Functions, Undecidable Problems about Turing Machines and Rice's Theorem, Undecidable Problems about CFLs. (5L) Other Formalisms, λ-Calculus. (3L) The Recursion Theorem, Decidability of Logical Theories, Turing Reducibility, A Definition of Information and Kolmogorov Complexity.

	(5L) Beyond Undecidability, Godel's Incompleteness Theorem, Proof of the Incompleteness Theorem. (3L) **Complexity Theory** Time Complexity: Measuring Complexity, Definitions of the Classes P and NP, NP-completeness, Cook-Levin Theorem, Examples of NP-complete Problems - Vertex Cover, Hamiltonian Path, Subset Sum etc. (5L) Space Complexity: Savitch's Theorem, PSPACE, PSPACE-completeness-The TQBF Problem, Winning Strategies for Games, Generalized geography, The Classes L and NL, NL-completeness – Searching in Graphs, NL=co-NL. (6L) Intractability: Hierarchy Theorems, Relativization, Circuit Complexity. (3L) Advanced Topics: Approximation Algorithms, Probabilistic Algorithms and the class BPP, Alternation, Interactive Proof Systems – Graph Non-isomorphism, IP=PSPACE, Parallel Computation and the Class NC, P-completeness, A Brief Introduction to Cryptography – Secret keys, Public-key Systems, One-way Functions, Trapdoor Functions. (7L)
Text Books, and/or reference material	***Text Books:*** 1. Automata and Computability by Dexter C. Kozen 2. Introduction to the Theory of Computation by Michael Sipser (3rd Edition) ***Reference Books:*** **1.** Computability and Complexity Theory (Texts in Computer Science) by Alan L. Selman and Steven Homer **2.** Computational Complexity: A Modern Approach by Sanjeev Arora and Boaz Barak **3.** Computational Complexity: A Conceptual Perspective by Oded Goldreich **4.** Computational Complexity by Christos Papadimitriou **5.** Kolmogorov Complexity and Computational Complexity (Monographs in Theoretical Computer Science. An EATCS Series) by Osamu Watanabe **6.** Theory of Computational Complexity 2e (Wiley Series in Discrete Mathematics and Optimization) by DZ Du **7.** P, NP, and NP-Completeness: The Basics of Computational Complexity by Oded Goldreich **8.** Theory of Computation (Texts in Computer Science) by Dexter C. Kozen

CSE7XX Explainable AI 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 7XX	Explainable AI (XAI)	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))
AI, ML DL, Linear Algebra, Probability and Statistics, Python Programming	CE+EA(CA: 15%, MT: 25%, ET:60%)

Course Outcomes	• CO1: Understand the importance of XAI. • CO2: Account for different approaches/techniques of well-known XAI methods. • CO3: Familiarity with different metrics of evaluating XAI methods. • CO4: To understand ethical considerations and the impact of explainability. • CO5: Case studies and future directions of XAI.
Topics Covered	**Introduction to Explainable AI**: Overview of AI, MLand DL, Importance of Explainability in AI, Definition and Scope of Explainable AI, Historical Context and Evolution. (7L) **Pre-Model Interpretability and Explainability:** Basic concepts and differences between interpretability and explainability, Exploratory Data Analysis, Feature engineering, Evaluation of interpretability, Properties and Human-friendly Explanations. (6L) **Visualization and Interpretability of Traditional Models:** Model validation, evaluation, selection and visualization; Classification, regression and clustering models visualization; Interpretable models: regression (linear and logistic), linear and adaptive models, decision trees, rule-based models, and other interpretable models. (8L) **Post-Hoc Interpretability and Explainability:** Visual explanation: partial dependence plots(PDP), Individual Conditional Expectation (ICE), Accumulated Local Effects (ALE) Plot; Feature importance: feature interaction and importance, Shapley Additive explanations (SHAP), global surrogate and Local Interpretable Model-agnostic Explanations (LIME). (6L) **Explainability in Deep Learning:** Challenges of explainability in deep learning, Various intrinsic, perturbation and gradient based methods for neural networks. (4L) **Ethical Considerations of XAI:** Fairness, accountability, and transparency in XAI, Legal implications of AI decisions, Current regulations impacting AI explainability. (4L) **Applications of XAI:** Real-world applications of XAI in healthcare, education, finance, law, etc. Case studies analysis. (5L) **Challenges and Future Directions of XAI:** Emerging trends and research directions, Challenges and opportunities in XAI research. (2L)
Text Books, and/or reference material	**Text Books:** 1. Uday Kamath and John Liu: Explainable Artificial Intelligence: An Introduction to Interpretable Machine Learning, Springer. 2. Christoph Molnar: Interpretable Machine Learning, LeanPUB. 3. Serg Masís, Interpretable Machine Learning with Python, Packt. **Reference Books:** 1. Michael Munn and David Pitman: Explainable AI for Practitioners, O'Reilly Media. 2. A. Anitha Kamaraj and Debi Prasanna Acharjya: Explainable Artificial Intelligence in Healthcare Systems, NOVA Science Publishers. 3. Online Study Materials and Relevant Research Articles will be provided in due time.

CSE7XX Big Data Analytics 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course	Title of the course	Program Core (PCR) / Electives	Total Number of contact hours				Credit
			Lectur	Tutoria	Practical	Total	

Code		(PEL)	e (L)	l (T)	(P)	Hours	
CSE 7XX	Big Data Analytics	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA)). **CT: 15%, MT: 25%, EA: 60%**					
Course Description		Today, we are surrounded by data. People upload videos, take pictures on their cell phones, text friends, update their Facebook status, leave comments around the web, click on ads, and so forth. Machines, too, are generating and keeping more and more data. Field of Big data, processing and analyzing of this large amounts of data requires a significant number of engineers to work with. This course is designed to provide a concrete knowledge of big data analytics, required by the students who intend to specialize and get a job in this field. The emphasis will be on MapReduce as tools for creating parallel algorithms that can process very large amounts of data.					
Course Objective		• To understand the financial value of big data analytics. • To explore tools and practices for working with big data. • To familiarize with different machine learning techniques that handles massive datasets. • To understand how big data analytics can leverage into a key component.					
Course Outcomes		• Knowledge in handling and analyzing extremely large datasets. • Learns the techniques of uncovering hidden patterns, correlations and other insights out of these datasets. • Ability to apply the concepts of big data analytics in different domains. • Ability to contextually integrate and correlate large amounts of information.					
Topics Covered		**Introduction to Big Data Analytics(4L)** 1.1 Motivation and significance 1.2 Big data analytics and use cases 1.3 Structured, unstructured and semi-structured data 1.4 Descriptive, diagnostic, predictive and prescriptive analytics **Frequent itemsets and Association rules(4L)** 2.1 Market-basket model 2.2 Association rule mining 2.3 Apriori algorithm 2.4 FP-Growth method **Large-Scale Machine Learning(6)** 3.1 Support vector machines 3.2 Stochastic gradient descent 3.3 K-means clustering algorithm 3.4 Decision trees **Analysis of massive graphs(6L)** 4.1 Link analysis: PageRank 4.2 Centrality measures: Degree, Closeness, Betweenness, etc. 4.3 Community structures 4.4 Community detection techniques 4.5 Quality metrics: Modularity, Normalized mutual information					

	Recommendation Systems(6L) 5.1 Introduction 5.2 Collaborative and content-based filtering 5.3 Similarity measures 5.4 Prediction approaches 5.5 Precision, recall and F-measure **Technologies for Handling Big Data(8)** 6.1 Introduction to Hadoop 6.2 Functioning of Hadoop 6.3 Hadoop ecosystem (HDFS, Map-Reduce, etc.) 6.4 Word count program using Map-Reduce **Big Data Analytics - Case Studies(8)** 7.1 Big data analytics in e-commerce 7.2 Big data analytics in agriculture 7.3 Text and social media big data analytics
Text Books, and/or reference material	**Reference Book** 1. Mining of Massive Datasets, Cambridge University Press, 3rd Edition, 2020. 2. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, EMC Education Services (Editor), Wiley, 2015 3. Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph, David Loshin, Morgan Kaufmann, 2013 4. Big Data Analytics: A Practical Guide for Managers, Kim H. Pries, Robert Dunnigan, CRC Press, 2015

CSE7XX Natural Language Processing 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 7XX	Natural Language Processing	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
1. Basics of probability and statistics 2. CSC 403: Design and Analysis of Algorithms 3. CSC303: Data Structures and Algorithms 4. CSC 01: Introduction to Computing		**CT: 15%, MT: 25%, EA: 60%**					
Course Outcome		• CO1: Knowing the fundamental concepts underlying natural language processing (NLP)					

s	• CO2: Understanding morphology, tokenization and stemming • CO3: Understand approaches to syntax and semantics in NLP. • CO4: Understanding some NLP applications
Topics Covered	Introduction to natural language processing. (1) Basic Text Processing: Tokenization, Stemming(2) Minimum Edit Distance (2) Language Modeling: Introduction to N-grams, Estimating N-grams probabilities. Application of language modeling to real-life examples (such as text -classification). (5) Generative Vs. Discriminative Models. (4) POS Tagging (4) Parsing : Introduction of Probabilistic Parsing , Lexicalized Parsing , Dependency Parsing. (6) Information Retrieval (3) Semantics : Word meaning and Senses.(3) Machine Translation (rule based techniques, Statistical Machine Translation (SMT), parameter learning in SMT (IBM models)) (5) Two applications: Question Answering and Text Summarization. (4) Recent trends (3)
Text Books, and/or reference material	Text Books: Jurafsky, David, and James H. Martin. Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition. Prentice-Hall, 2000. ISBN: 0130950696. Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Introduction to Information Retrieval, Cambridge University Press. 2008 **Reference Books:** Manning, Christopher D., and Hinrich Schütze. Foundations of Statistical Natural Language Processing. Cambridge, MA: MIT Press, 1999. ISBN: 0262133601. **Others:** 1. **CS124: YouTube lecture videos by Dan Jurafsky** 2. **2012 NLP MOOC by Dan Jurafsky with Chris Manning: Youtube channel lecture videos**

CSE 7XX Computer Vision 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE7XX	Computer Vision	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
Probability and Statistics, Algebra, Optimization, Computer Graphics		CT+EA					
Course Outcome	• CO1: Understanding basic architecture and principles of computer vision systems.						

s	• CO2: Implementation of computer vision algorithms including depth estimation, multi-camera view and motion analysis components. • CO3: Apply basic image processing and feature extraction techniques in order to design computer vision algorithms. • CO4: Analysis of pattern analysis and image segmentation techniques used for computer vision systems. • CO5: Design and development of real time computer vision systems.
Topics Covered	Digital Image Formation and low-level processing: Overview and State-of-the-art, Fundamentals of Image Formation, Transformation: Orthogonal, Euclidean, Affine, Projective, etc; Fourier Transform, Convolution and Filtering, Image Enhancement, Restoration, Histogram Processing. [5] Depth estimation and Multi-camera views: Perspective, Binocular Stereopsis: Camera and Epipolar Geometry; Homography, Rectification, DLT, RANSAC, 3-D reconstruction framework; Auto-calibration. Apparel. [6] Feature Extraction: Edges - Canny, LOG, DOG; Line detectors (Hough Transform), Corners - Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space Analysis- Image Pyramids and Gaussian derivative filters, Gabor Filters and DWT. [8] Image Segmentation: Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs, Texture Segmentation; Object detection. [5] Pattern Analysis: Clustering: K-Means, K-Medoids, Mixture of Gaussians, Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised; Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA, ICA; Non-parametric methods. [8] Motion Analysis: Background Subtraction and Modeling, Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation. [4] Shape from X: Light at Surfaces; Phong Model; Reflectance Map; Albedo estimation; Photometric Stereo; Use of Surface Smoothness Constraint; Shape from Texture, color, motion and edges. [6]
Text Books, and/or reference material	**Text Books:** • Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London Limited 2011. • D. A. Forsyth, J. Ponce, Computer Vision: A Modern Approach, Pearson Education, 2003. **Reference Books:** • Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, Second Edition, Cambridge University Press, March 2004. • K. Fukunaga; Introduction to Statistical Pattern Recognition, Second Edition, Academic Press, Morgan Kaufmann, 1990. • R.C. Gonzalez and R.E. Woods, Digital Image Processing, Addison- Wesley, 1992. **Others:** Swayam Online Course 1. https://swayam.gov.in/nd1_noc19_cs58/preview

	2. https://www.coursera.org/courses?query=computer%20vision 3. https://www.edx.org/course/computer-vision-and-image-analysis-3 4. https://www.mooc-list.com/tags/computer-vision

CSE 7XX Expert Systems 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE7XX	EXPERT SYSTEMS	PEL	3	0	0	3	3
Pre-requisites Artificial Intelligence, Data Mining, Pattern Recognition, OOP		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA)) cT, MT and ET					
Course Outcomes	CO1: Idea about Knowledge Base & Expert Systems CO2: Idea of Inference Tool and Inference Engine and different methods of Inference Methodologies. CO3: Idea about Reasoning under Uncertainty and Uncertainty Management which is really crucial under present day scenario. CO4: Concept of the Design of Expert System Components and Experts Systems CO5: Some Examples of Practical Experts System.						
Topics Covered	1. Introduction to Expert Systems : Definition of an Expert System – Advantages of Expert Systems – Characteristics of Expert Systems - Applications and Domains – Procedural and Non procedural Systems [6L] 2. The Different Techniques for Knowledge Representation: Meaning of Knowledge – Productions – Semantic Nets- Frames – Logics – Propositional and Predicate Logic – The universal and existential quantifiers [7L] 3. The Different Methods of Inference : Trees, Lattice and Graph – State and Problem Space – Rules of Inference – Logic Systems – Resolution Systems and Deductions – Forward and Backward Reasoning – Meta knowledge [7L] 4. The Reasoning Under Uncertainty and Inexact Reasoning – Uncertainty – Types of Errors – Classical Probability – Experimental and Subjective probabilities – Compound and Conditional Probabilities – Temporal Reasoning – Uncertainty in Inference Chains – Evidence Combination – Uncertainty and Rules – Certainty Factors – Dempster- Shafer Theory – Approximate Reasoning. [8L] 5. The Design of Expert Systems Tool and Expert Systems : Selecting Appropriate Problem – Stages in the development – Errors in Development – Expert System Life Cycle – A Life Cycle Model. [7L] 6. Some Practical Examples of Expert System Design – Modular Design – Phases and Control Facts – Importing and Exporting facts – Modules and Execution Control – Certainty Factors – Decision Trees – Backward Chaining – A Monitoring Problem [7L]						

Text Books, and/or reference material	**Text Books:** **1. Expert Systems Principles and Programming – Bikash Publishing House.** **2. Pattern Classification- – Duda, Hart & Stork – J. Wiley & Sons.** **Reference Books:** **1. Artificial Neural Networks – B. Yegnanarayana – PHI** **2. Neural Networks for Pattern Recognition – C.M. Bishop – Oxford** **Others:**

CSE 7XX Introduction to Cognitive Computing 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE7XX	Introduction to Cognitive Computing	PEL	3(42)	0	0	3(42)	3
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
Basic Concepts of AI and Information Processing.		CE+EA					
Course Outcomes	• CO1: The philosophical approach of working principle brain and mind; • CO2: Cognitive approach towards Vision and Attention. • CO3: Cognitive approach towards Memory, Language Processing. • CO4: Cognitive Architecture and Basics of Neuroscience.						
Topics Covered	• The Cognitive Revolution, Part 1 (2) • The Cognitive Revolution, Part 2 (Philosophical issues, neuropsychological perspective) (2) • Working Principle of the Brain (2) • Memory- Memory models: Episodic memory, Sensory memory, Short term memory, Long term memory, Explicit & Episodic Memory, Implicit Memory, Memory Accuracy, Nonverbal Memory, Semantic Memory knowledge) & Concepts (8) • Attention and Perception, Part 1 (role of brain) (Review of different approaches) (5) • Attention and Perception, Part 2 (Automaticity; Attention odds & ends) (5) • Cognitive approach to vision and pattern recognition: Template matching theory, Feature detection theory, Computational theory of vision, Feature integration theory (4) • Cognition architecture of reasoning: ACT* model, Spread of activation theory, General problem solver model, SOAR model (3) • Problem Solving (2) • Cognitive Load and its measurement (2) • Language and cognition: language formation and the brain, Word recognition, Surface level structures, Word and sentence production, Cognitive linguistic issues (3) • Introduction to Neuroscience - Looking into the Brain (4)						

Text Books, and/or reference material	Text Books: 8. Cognitive Science-An Introduction to the Study of Mind, Jay Friedenberg, Gordon Silverman, SAGE 9. Cognition, Brain and Consciousness- Introduction to Cognitive Neuroscience, Bernard J. Baars, Nicole M Gage, Elsevier 10. The MIT Encyclopedia of the Cognitive Sciences edited by Robert A. Wilson and Frank C. Keil

CSE 7XX Deep Learning 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE7XX	Deep Learning	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
Linear algebra, Calculus, Probability and statistics, Machine Learning		CE+EA					
Course Outcomes	• CO1: To understand the mathematical, statistical and computational challenges of building stable representations for high-dimensional data, such as images, text and data. • CO2: To obtain a concept of deep learning and its advantages. • CO3: To understand deep network models, optimization for training of deep models. • CO4: To achieve the knowledge on some popular deep learning models. • CO5: To explore the research domain of deep learning.						
Topics Covered	**Machine Learning Basics**: Extracting meaning from data, expert system, learning algorithms, overfitting and underfitting, regularization, hyperparameters and validation sets, estimator, bias and variance, ML estimation, Bayesian statistics, supervised learning, unsupervised learning, Stochastic Gradient Descent, building a machine learning algorithm, challenges motivating Deep Learning. (8) **Fundamentals of feedforward networks:** Single-layer and multilayer feedforward networks, Neural Network Graphs, activation functions, deep feedforward networks, hidden units, Learning XOR, gradient-based learning, Back-propagation algorithm and other differentiation algorithms. (4) **Regularization for deep learning** Parameter Norm Penalties, Norm Penalties as Constrained Optimization, Regularization and Under-Constrained Problems, Dataset Augmentation, Early Stopping, Sparse Representations, Dropout. (5) **Optimization for Training Deep Models**: How Learning Differs from Pure Optimization, Challenges in Neural Network Optimization, Basic Algorithms, Parameter Initialization Strategies, Algorithms with Adaptive Learning Rates, Approximate Second-Order Methods, Batch Normalization. (5)						

	Convolutional Networks: The Convolution Operation, Pooling, Variants of the Basic Convolution Function, Structured Outputs, Structured outputs and datatypes. (4) **Sequence Modelling, Recurrent Neural Networks (RNN):** Unfolding Computational Graphs, RNNs, Bidirectional RNNs, LSTM. (5) **Autoencoders:** Undercomplete Autoencoders, Regularized Autoencoders, Stochastic Encoders and Decoders, Denoising Autoencoders, Contractive Autoencoders. (5) **Some Popular Deep networks and Applications:** Generative Adversarial Networks, VGG net, ResNet, Inception Net. Applications of deep learning. (6)
Text Books, and/or reference material	Text Books: 11. I. Goodfellow, Y. Bengio, and A. Courville, Deep Learning, The MIT Press, 2017. 12. Charu C. Aggarwal, Neural Networks and Deep Learning, Springer, 2018. Reference Books: 3. Deep Learning, From Basics to Practice, Vol 1 and Vol 2, A. Glassner, Published by The Imaginary Institute, Seattle, WA, 2018 4. F. Chollet, Deep Learning with Python, Manning Publications Co., 2018. 5. N. Buduma, Fundamentals of deep learning: Designing Next-Generation Machine Intelligence Algorithms, O'REILLY, 2017

CSO7XX Software Engineering 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO7XX	Software Engineering	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		● CO1: Identify and describe software life cycle model and their roles in building software project. ● CO2: Recognize the feasibility of functional and non-functional requirements applying decision tree/table minimization techniques/methodologies for a particular problem. ● CO3: Apply modularity in project resulting design of flexible software code with reusability. ● CO4: Effectively use existing testing strategy to test the software and make sure the reliability of the software and analysis of quality of the software. ● CO5: Apply the project management tools, estimation techniques to handle the project.					
Topics Covered		**UNIT I:** Overview of System Analysis & Design, Software Development Life Cycle, Waterfall Model , Spiral Model, Feasibility Analysis, Technical Feasibility, Cost-Benefit Analysis, COCOMO model. [10L] **UNIT II:** System Requirement Specification – DFD, Data Dictionary, ER diagram, Process Organization & Interactions. [10L] **UNIT III:** System Design – Problem Partitioning, Top-Down And Bottom-Up design;					

	Decision tree, decision table and structured English; Functional vs. Object- Oriented approach. [10L] **UNIT IV**: Coding & Documentation - Structured Programming, OO Programming, Information Hiding, Reuse, System Documentation. Testing – Levels of Testing, Organizing for software testing; Software Testing Strategy; Unit Testing: Unit Test Considerations; Integration Testing, OO testing, Reliability Assessment, Validation & Verification Metrics, Monitoring & Control. [8L] **UNIT V:** Software Project Management– Project Scheduling, Staffing, Software Configuration Management, Quality Assurance, Project Monitoring. [4L] CASE TOOLS : Concepts, use and application.
Text Books, and/or reference material	**Text Books:** 1. Roger S. Pressman, Software Engineering: A practitioner's approach, McGraw Hill. 2. Ian Sommerville, Software Engineering, Pearson. **Reference Books:** 1. Rajib Mall, Fundamentals of Software Engineering, Prentice Hall India. 2. Pankaj Jalote, An integrated approach to Software Engineering, Springer/Narosa.

CSO7XX Multimedia Technologies 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO 7XX	**Multimedia Technologies**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Knowledge of data structures databases and compression techniques		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: In depth understanding of media characteristics and resource requirement. • CO2: Understanding text, graphics. Audio, video media types. • CO3: Knowledge of issues on dealing simultaneously with multiple data formats, temporal and spatial constraints, synchronization aspects, SAS factors. • CO4: Understanding of data compression techniques of different media. • CO5: Understanding of multimedia database storage and retrieval.						
Topics Covered	Overview of multimedia system: Text, audio, video and graphics. (3L) Video and Animation: Capturing Graphics and Images Computer Assisted Graphics and Image Processing; Reconstructing Images; Graphics and Image Output Options. Basics; Television Systems; Digitalization of Video Signals; Digital Television; Basic Concepts; Virtual Reality, Video signal representation, Computer Video Format, Computer- Based animation, Animation Language, Methods of controlling Animation, Display of Animation Transmission of Animation. (10L)						

	Information representation, media synchronisation, SAS factors, relative and absolute temporal specifications, networking delays, Skew, Jitter. (6L) Data Compression: Storage Space requirement, Coding Requirements Source, Entropy Coding, Lossy Sequential DCT- based Mode, Expanded Lossy DCT-based Mode, JPEG and MPEG. (8L) Multimedia file systems: Difference of MM file systems with traditional systems, disk management, disk scheduling, common scheduling algorithms. (5L) Multimedia databases, multimedia query types, index structures to handle multimedia databases, data storage and retrieval. (10L)
Text Books, and/or reference material	**Text Books:** Multimedia: Computing, Communications and Applications, Ralf Steinmetz. and Klara Nahrstedt, Pearson Education Asia. Multimedia Communications, Applications, Networks, Protocols and Standards, Fred Halsall, Pearson Education Asia. Multimedia Systems, John F. Koegel Buford, Pearson Education Asia. **Reference Books:** Subrahmanian and Jajodia, Multimedia Database Systems, Springer.

CSO7XX Computer Networks 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO7XX	Computer Networks	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Fundamental knowledge in Data Structures		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		● CO1: Understand the basic taxonomy and terminology of the computer networking and enumerate the layers of OSI model and TCP/IP model. ● CO2: Comprehend the fundamentals of Physical layer, and will apply them in real time applications. ● CO3: Identify data link layer concepts, design issues, and protocols. ● CO4: Classify the routing protocols and analyze how to assign the IP addresses for the given network. ● CO5: Acquire knowledge of Application layer and Presentation layer paradigms and protocols.					
Topics Covered		**Introduction:** Data communications: components, data representation, direction of data flow; physical structure (type of connection, topology), categories of network (LAN, MAN, WAN); Protocols and standards; Reference models: OSI reference model, TCP/IP reference model. [3L] **Physical Layer:** Overview of data (analog & digital), signal (analog & digital), transmission (analog & digital) & transmission media (guided & unguided); Circuit switching: time division & space division switch, TDM bus. [5L] **Data link Layer:** Types of errors, error detection & correction methods; framing, Flow control Protocols: Stop & wait ARQ, Go-Back- N ARQ, Selective repeat ARQ,					

	Medium Access sublayer: Token Ring; Reservation, Polling, Multiple access protocols: Pure ALOHA, Slotted ALOHA, CSMA, CSMA/CD, CSMA/CA. [10L] **Network layer:** Internetworking & devices, Addressing: IP addressing, subnetting; Routing : techniques, static vs. dynamic routing , Unicast Routing Protocols, Congestion Control and Quality of service (QoS). [12L] **Transport layer:** Process to Process delivery; Socket address, UDP; TCP. [5L] **Application Layer:** Introduction to DNS, SMTP, SNMP, FTP, HTTP & WWW. [5L] **Network Security :** Encryption/and decryption algorithms, authentication, access control, Security standards - IS/ISO 27000, 18000 introduction. [2L]
Text Books, and/or reference material	**Text Books:** 1. B. A. Forouzan – "Data Communications and Networking (3rd Ed.) " – TMH. 2. A. S. Tanenbaum – "Computer Networks (4th Ed.)" – Pearson Education/PHI. 3. W. Stallings – "Data and Computer Communications (5th Ed.)" – PHI/ Pearson Education. **Reference Books:** 1. Comer – "Internetworking with TCP/IP, vol. 1, 2, 3(4th Ed.)" – Pearson Education/PHI.

CSO 7XX Computational Biology and its Applications 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO7XX	Computational Biology and its Applications	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and End assessment (EA))					
Introduction to Computing, Linear Algebra, Fundamentals of Probability and Statistics							
Course Outcomes	● CO1: To develop the problem solving skill using the concept of algorithms ● CO2: To understand different computational algorithms including few clustering and classification techniques and genetic algorithm. ● CO3: To aware the basic principles and concept of Biology and identify the potential application areas. ● CO4: To correlate the computational algorithms and the applicable biological domain. ● CO5: To develop new computer modelling for different types of biological data						

Topics Covered	1) Algorithms in Computing: Algorithms, Pseudocode, Time & Space Complexity, Dynamic Programming. (4) 2) Pattern Matching and Optimisation: Hashing, Pattern Finding using Clustering, Genetic Algorithms, Evolutionary Computation Techniques, Case Study on GA based feature selection on microarray gene expression (8) 3) Hidden Markov Model: Markov process and Models, HMM applications (6) 4) Support Vector Machine: Introduction, Margin, Hyperplane, Classification. Bayes Theorem, Bayes Classifier. Case Study on Disease Classification(6) 5. Artificial Neural Network: Perceptron, Hidden Layers, Activation Functions, Feed Forward Neural Network and Back Propagation, Case Study on Biological Image Classification(6) 6) Basics of Biology: Central Dogma of Molecular Biology, Molecular Visualisation Softwares, Protein Sequence and Structure Analysis, Protein Structure Modelling, Protein-protein Docking, Genomics. (12)
Text Books, and/or reference material	**References:** 1. An Introduction to Bioinformatics Algorithms, Neil C. Jones, Pavel Pevzner, MIT Press. 2. Bioinformatics: the Machine Learning Approach, Pierre Baldi, Soren Brunak MIT Press. 3. Genetic Algorithms in Search, Optimization and Machine Learning, David E. Goldberg.

CSO 7XX Machine Learning 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO 7XX	Machine Learning	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Basic concept of Probability and Statistics.		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		● CO1: Understanding of the basic concepts, fundamental issues and challenges of machine learning. ● CO2: Comprehend the principle and techniques of supervised learning. ● CO3: Explain the basic concepts and techniques of unsupervised learning. ● CO4: Understanding of the basic concepts and challenges of reinforced learning. ● CO5: Ability to apply the concepts of machine learning in different domains.					
Topics Covered		1. Introduction: what is Machine Learning; Human learning and Machine learning; Well-posed learning problem; Types of Machine Learning: Supervised, Unsupervised, and Reinforcement learning; Applications, Issues, and tools of Machine Learning. (03 L) 2. Concept Learning: Inductive learning hypothesis, general to specific ordering of hypothesis; FIND-S algorithm; Version space, candidate elimination					

	algorithm; Inductive bias. (04 L) 3. Bayesian Learning, Naïve Bayes Classifier, Optimal Classifier. (03 L) 4. Supervised learning: Classification- k-Nearest Neighbour, Decision Tree, Support vector machine. Regression- Simple and Multiple linear regression. (12L) 5. Artificial Neural Networks: Biological neuron and artificial neuron, How ANN works, Parallel distributed model of ANN; Activation functions; Perceptron, McCulloch-Pits model, ADALINE network model; Architecture of ANN- single-layer feed forward, multi-layer feed forward, competitive network, recurrent network; Backpropagation algorithm; Basic concept of deep learning. (05L) 6. Unsupervised learning: Different clustering techniques- Partitioning methods (k-means, k-medoid, etc. clustering techniques), Hierarchical methods (Agglomerative and Divisive techniques: MIN, MAX, Group average, Ward's etc. methods), and Density-based method (DBSCAN). (05 L) 7. Unsupervised learning: Rule mining and Association analysis- different terminology (itemset, support count, support, association rule, confidence, etc.); Association rule mining techniques; Market-Basket analysis; Apriori principle, Apriori algorithm for frequent itemset generation, Rule generation for apriori algorithm. (05 L) 8. Genetic Algorithm based Learning. (02 L) 9. Reinforcement Learning: Basic concept, Model based learning, Temporal difference based learning. (03 L) 10. Standards: Introduction to standardization efforts IS/ISO/IEC/22417 and 20546 (2L)
Text Books, and/or reference material	Text Books: 1. Machine Learning by Tom Mitchell [Mc. Graw-Hill]. 2. Machine Learning by S. Dutt, S. Chandramouli, and /A. K. Das [Pearson, 2019]. 3. Applied machine Learning by M. Gopal [Mc. Graw-Hill, 2018]. 4. NPTEL Course materials. Reference Books: Introduction to Machine Learning by Ethem Alpaydin [MIT Press].

CSO 7XX Data Analytics 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO 7XX	Data Analytics	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	● CO1: Classify the labelled dataset into different classes and group the unlabelled dataset into different clusters by uncovering hidden patterns and correlations among them..						

	• CO2: Model a problem into a graph database after absorbing and connecting a large volume of data and performing the analytical task over the graph. • CO3: Develop a recommendation system by predicting users' preferences based on similarity measures and evaluating its performance using the metrics such as Precision, recall, and F1-score. • CO4: Understand and set up the Hadoop framework, which will allow them to efficiently manage and process big data in a distributed computing environment.
Topics Covered	Introduction to Data Analytics, Types of Data Analytics: Descriptive Analytics, Diagnostic Analytics, Predictive Analytics, and Prescriptive Analytics. Use Cases, Issues and Challenges in Big Data Analytics. (4L) Fundamentals of Statistics: Population, Sample, Parameter, Statistic, Variable. Descriptive Statistics, Inferential Statistics. Basic Probability Theory: Random Experiment, Sample Space, Random Variables, Probability, Conditional Probability, Independence, Conditional Independence, Expectation, Variance, Probability Distribution, Joint Probability Distribution, Conditional Probability Distribution. (8L) Similarity Measures: Jaccard Similarity, Cosine Similarity, Adjusted Cosine Similarity. Missing Value Prediction Techniques: Mean Centering, Weighted Average, Z-Score. (6L) Basics of Complex Network: Scale-Free Networks, Small-World Phenomenon, Degree Distributions, Transitivity or Clustering. Centrality Measures: Degree Centrality, Betweenness Centrality, Closeness Centrality, Eigenvector Centrality, PageRank Centrality. Community Structure, Community Detection Algorithms: Girvan-Newman, Fast Greedy, Label Propagation, Clique Percolation Method. Community Quality Metrics: Modularity, NMI, Conductance. (10L) Introduction to Data Mining, Machine Learning Techniques: Least Square Regression, Decision-trees, SVM. Clustering Techniques: K-Means. (8L) Introduction to Hadoop Ecosystem – HDFS, Map-Reduce, PIG, HIVE, HBase, Mahout, Zookeeper, Flume, Sqoop, etc. (6L)
Text Books, and/or reference material	**Text Books:** 1. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data – EMC Education Services – Wiley. 2. Machine Learning: Hands-On for Developers and Technical Professionals – Jason Bell – Wiley. **Reference Books:** 1. Networks: An Introduction – M. E. J. Newman – Oxford University Press. 2. Hadoop: The Definitive Guide – Tom White – O'Reilly.

CSO 7XX Distributed Computing 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO7XX	Distributed Computing	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Operating Systems,		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					

Computer networks.	
Course Outcomes	● CO1: To explain the paradigm of distributed computing. ● CO2: To explore various existing and possible architectures of distributed systems. ● CO3: To properly appreciate the issues that arise in distributed systems and explore solutions for the problems. ● CO4: To fully appreciate the advantages to be obtained from a distributed environment wrt fault tolerance, load sharing etc.
Topics Covered	Introduction to Distributed Systems. Motivations. Design Issues. (3L) Clocks in a Distributed System. Synchronization Issues. Logical Clocks. Causal relationships. Vector Clocks. (3L) Distributed State Detection. Global State. Consistent Cut. Global State recording algorithm. (2L) Termination Detection. Credit based algorithm. Diffusion Computation based algorithm. (2L) Distributed Mutual Exclusion. Token based and non-token based algorithms. (4L) Deadlocks in Distributed Systems. Resource allocation Models. Deadlock Prevention. Deadlock Avoidance – Safe states. Deadlock detection and Correction. Phantom Deadlocks. Centralized, Distributed and Hierarchical deadlock detection algorithms (5L) Fault recovery. Classes of Faults. Backward and Forward recovery. Log based recovery. Checkpoints. Shadow paging. (5L) Fault Tolerance. Data Replication. Quorum Algorithms . Distributed Commit Protocols. 2-phase commit. 3-phase commit. Election Algorithms. Bully algorithm. Ring topology algorithm. (8L) Byzantine faults and Agreement Protocols. (2L) Distributed File systems. Mechanisms. Stateful and Stateless servers. Scalability. Naming and Name Servers. (4L) Distributed Scheduling. Load Balancing. Load Estimation. Stability. Process Migration. Remote Procedure Calls. Transparency. Binding. (4L)
Text Books, and/or reference material	**Text Books:** Advanced Concepts in Operating Systems. Singhal and Sivaratri. McGraw Hill. **Reference Books:** 1. Operating Systems : A Concept Based Approach. Dhamdhere. McGraw Hill. 2. Distributed Operating Systems : Concepts and Design. P.K.Sinha. Prentice Hall. 3. Distributed Operating Systems. A.Tanenbaum. Pearson Education. 4. Distributed Systems : Concepts and Design. Coulouris et.al. Pearson Education

CSO 7XX Game Theory and its Applications 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO 7XX	Game Theory and its	PEL	3	0	0	3	3

	Applications						
1. MAC 01: Mathematics - I 2. MAC 02: Mathematics - II		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Can have the efficiency to act in a strategic situation. • CO2: Can analyse the strategic interactions among agents. • CO3: Can understand modern state of the art in Game Theory. • CO4: Will have the knowledge of related area where Game Theory can be applied.						
Topics Covered	**Introduction:** Motivation to the course. (2L) **Non-Coperative Game Theory:** Introduction to Game Theory, Extensive Form Games, Strategic Form Games, Dominat Strategy Equilibria, Pure Strategy Nash Equlibrium, Mixed Strategy Nash Equilibrium with examples. (8L) **Mechanism Design without Money**: One sided and two sided matching with strict preferences, Voting theory, and Participatory democracy. (5L) **Mechanism Design with Money:** Auction basics, sponsored search auctions, Revenue optimal auctions, VCG Mechanisms. Online auctions. (6L) **Cooperative Game Theory**: Coalitional Games, The Core, and The Shapley Value. (4L) **Repeated Games:** Introduction to repeated games and its Applications. (4L) **Applications:** Incentive Study in - P2P Networks, Crowdsourcing. (5L) **Some Special Topics**: Fair Division, Price of Anarchy, Scoring rules, Learning in Auction, Synergies between Machine Learning & Game Theory. (8L)						
Text Books, and/or reference material	**Text Books:** 1. N. Nisan, T. Roughgarden, E. Tardos, and V. V. Vazirani. Algorithmic Game Theory. Cambridge University Press, New York, NY, USA, 2007, ISSN: 978-0521872829. 2. M. Maschler, E. Solan, and S. Zamir. Game Theory, Cambridge University Press; 1st Edition, ISSN: 978-1107005488, 2013. 3. Y. Narahari. Game Theory and Mechanism Design. World Scientific Publishing Company Pte. Limited, 2014, ISSN: 978-9814525046. 4. T. Roughgarden, Twenty Lectures on Algorithmic Game Theory, Cambridge University Press, 2016, ISSN: 978-1316624791. **Reference Books:** 1. T. Roughgarden, CS364A: Algorithmic Game Theory Course (Stanford University), 2013. 2. T. Roughgarden, CS269I: Incentives in Computer Science Course (Stanford University), 2016. 3. S. Barman and Y. Narahari, E1:254 Game Theory Course (IISc Bangalore), 2012.						

CSO 7XX Information Security 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hour	

						s	
CSO 7XX	Information Security	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Programming Languages, Computer Networks and Operating Systems		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	By the end of the course, Students will be able to: ● CO1: Learn fundamental concepts of Information Security viz. Security Models (like the CIA triad), Access Control Mechanisms, Security policies and Security Mechanisms like authentication, identification, authorization, non-repudiation, etc. ● CO2: Understand program security issues, attack vectors, and malicious code including worms, viruses, and Trojan horse and logic bombs. ● CO3: Understand common vulnerabilities like Buffer Overflow, TOC-TOU flaws. Learn secure programming requirements; write robust security code and exploit/recreate-and-fix common vulnerabilities in software. ● CO4: Define trusted computing base and Operating System hardening as defence mechanisms, Intrusion detection and prevention. ● CO5: Get introduced to trusted computing and multilevel security. ● CO6: Explain concepts related to applied cryptography, including plain-text, cipher-text, four techniques for crypto-analysis, symmetric cryptography, asymmetric cryptography, digital signature, message authentication code, hash functions, and modes of encryption operations. ● CO7: Explain and compare security mechanisms for conventional operating systems, OS hardening. Case Study on Linux. ● CO8: Exposed to network and distributed systems security issues and solutions including authentication, key distribution and management and network security protocols like SSL/TLS. ● CO9: Introduced to Laws and regulatory requirements, security standards and controls, risk management, security metrics and performance indicators, security auditing, education, training and awareness and digital forensics.						
Topics Covered	▪ Information Security Introduction -- Defining and Understanding security through security models, Confidentiality, Integrity and Availability, formal description of security, Attacks and Defences, Threats, Vulnerabilities and Risk, Assurance, Prevention, Detection, Security Controls. [2L] ▪ Identification and Authentication. [2L] ▪ Authorization and Access Control, Access Control Models & Mechanisms and Multilevel Security. [2L] ▪ Auditing and Accountability. [2L] ▪ Computational Number Theory & Cryptography -- Fermat's theorem, Euler's theorem, Euclid's algorithm, manually and computationally encrypt/decrypt, sign/verify signatures for small messages using RSA, Deffie-Hellman and DSA algorithms. Applied cryptography viz. Symmetric key Cryptography, asymmetric Cryptography and Digital Signatures, message authentication codes, hash functions and modes of cryptographic operations.[6L] ▪ Physical Security. [1L]						

	▪ Network Security – Network threats: eavesdropping, spoofing, modification, denial of service attacks o Introduction to network security techniques: firewalls, virtual private networks, intrusion detection. Different Network Security Protocols.[6L] ▪ Operating System Security & Trusted OS-- Memory, time, file, object protection requirements and techniques, Protection in contemporary operating systems, ACLs, DAC, MAC, RBAC, Identification and authentication, Identification goals, Authentication requirements, Human authentication, Machine authentication, OS Forensics. Assurance & Trust, Design principles, Evaluation criteria, Evaluation process.[8L] ▪ Application & Program Security– Flaws, Malicious code: viruses, Trojan horses, worms, Program flaws: buffer overflows, time-of-check to time-of-use flaws, incomplete mediation o Defenses, Software development controls, Testing techniques.[5L] ▪ Secure Coding. [2L] ▪ Distributed Systems Security. [2L] ▪ Digital Forensics. [2L] ▪ Cyber Laws. [2L]
Text Books, and/or reference material	**Text Books:** 1. The Basics of Information Security by Jason Andress, Syngress Publication. 2. Security in Computing (3rd Edition) 3rd Edition by Charles P. Pfleeger (Author), Shari Lawrence Pfleeger (Author), PHI. 3. B. Tjaden Fundamentals of Secure Computer Systems Franklin Beedle & Associates 2003. 4. D. Russell & G.T. Gangemi, Sr, Computer Security Basics. 5. W. Stallings, Network Security Essentials. Prentice Hall, 2003.

CSO 7XX Optical Network 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO 7XX	Optical Network	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Basic Concepts of Computer Networks		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	● CO1: Learn the fundamental concepts of optical networks. ● CO2: Understanding the basic concepts and solution techniques for the different fundamental problems like routing and wavelength assignment (RWA), virtual topology design, wavelength rerouting, and traffic grooming in optical network design. ● CO3: Acquire knowledge of the wavelength convertible network. ● CO4: Comprehend the basic concepts of multicast routing in optical networks.						
Topics Covered	1. **Fundamentals and Optical Components**: Optical fiber principles, Optical transmission system, Wavelength Division Multiplexing(WDM), optical networking evolution, Optical Network Architectures; Optical Components-						

	Couplers, Multiplexers and Filters, Optical Amplifiers, Transmitter, Detectors, switches and wavelength converters; Different issues in wavelength routed networks. (12L) 2. **Routing and Wavelength Assignment (RWA) algorithms**: ILP formulation of the RWA problem, Route Selection algorithms – Fixed Routing, Fixed Alternate Routing, Exhaust Routing, Least Congested Path Routing, Limited alternate Routing. Wavelength Selection algorithms. Joint wavelength-Route selection algorithm. (08L) 3. **Wavelength Convertible Networks**: Need for Wavelength Converters, Wavelength convertible Switch Architecture, Routing in Convertible Networks, Performance Evaluation of Convertible networks, Network with Sparse Wavelength Conversion, Converter Placement problem. (04L) 4. **Wavelength Rerouting Algorithm**: Benefits of wavelength rerouting, Issues in wavelength rerouting, Different rerouting algorithms. (05L) 5. **Virtual Topology Design**: Concept of virtual topology, Limitations on virtual topology, Virtual topology problem formulation, Virtual topology design algorithms. (06L) 6. **Traffic Grooming:** Basic concepts, Grooming node architecture, ILP formulation of the traffic grooming problem, Different heuristics (MST, MRU, TGCP, etc) for the traffic grooming problem. (05L) 7. **Basic concepts of** Multicast routing and wavelength assignment. (02L)
Text Books, and/or reference material	**Text Books:** 1. WDM OPTICAL NETWORKS Concepts, Design and algorithm by C. Siva Ram Murthy and Mohan Gurusamy (PHI). 2. OPTICAL NETWORKS by Biswanath Mukherjee (TMH). **Reference Books:** 1. Optical Networks: A Practical Perspective (3rd Edition) by R. Ramaswami, K. Sivarajan, G. Sasaki (Morgan Kaufmann Publishers).

CSO7XX CAD for VLSI 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO7XX	CAD for VLSI	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Digital Electronics, Computer Organisation, Algorithm Analysis and Design.		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	● CO1: To visit the various stages of the VLSI design cycle and appreciate the role of automation therein.						

	• CO2: To appreciate how High Level Synthesis converts an HDL code into an architecture level design. • CO3: To discuss the algorithmic approach to physical design. • CO4: To emphasize the importance to testability measures in the design.
Topics Covered	VLSI Design cycle. Design styles. System packaging styles. Fabrication of VLSI devices. Design rules-overview. (3L) HLS: Scheduling in High Level Synthesis. ASAP and ALAP schedules. Time constrained and Resource constrained scheduling. (4L) HLS: Allocation and Binding. Datapath Architectures and Allocation tasks. (4L) Partitioning. Clustering techniques. Group Migration algorithms. (4L) Floorplanning. Constraint based Floorplanning. Rectangular Dualization. Hierarchical Tree based methods. Simulated Evolution approaches. Timing Driven floorplanning. (5L) Placement.Simulation based placement algorithms. Partitioning based placement algorithms.ClusterGrowth.(5L) Global Routing. Maze Routing algorithms. Line probe algorithms. Shortest Path based algorithms. Steiner's Tree based algorithms. (5L) Detailed Routing. Channel Routing Algorithms. Switchbox Routing. Over-the-cell routing. Clock and Power Routing. (4L) Design for testability. Fault testing. Ad-hoc and structured DFT techniques. (8L)
Text Books, and/or reference material	**Text Books:** 1. Algorithms for VLSI Physical Design Automation. N.A.Sherwani. Kluwer Academic Publishers. 2. High-Level Synthesis: Introduction to Chip and System Design. Gajski et. al. . Kluwer Academic Publishers. 3. Digital Systems Testing and Testable Design. Abramovici et.al. Jaico Publications. **Reference Books** 1. VLSI Physical Design Automation. Sadiq M. Sait and Habib Youssef. Kluwer Academic Publishers. 2. Algorithms for VLSI Design Automation. Sabih H. Gerez. Wiley India. 3. Essentials of Electronic Testing for Digital, Memory and Mixed Signal VLSI Circuits. Bushnell and Agrawal. Kluwer Academic Publishers.

CSO7XX Internet and Web Technologies 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO 7XX	Internet and Web Technologies	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Programming Fundamentals, Data Structure and		CT+EA [CA: 15%, MT: 25%, ET: 60%]					

Algorithms, Operating Systems, Data networks (may be carried out simultaneously)	
Course Outcomes	• CO1: Understanding the fundamental concepts of Internet Structure and Protocols. • CO2: Using TCP/IP protocols, SOCKET API and HTTP. • CO4: Designing and developing Web applications with security enhancement. • CO5: Understanding Semantic Web and Applying Web Analytics over Semantic Web.
Topics Covered	INTERNET TECHNOLOGY: Brief review of Data Networking; Introduction to Data Communication, OSI Layered Architecture, Introduction to Networking Devices, Network Performance Metrics. (4L) Data transmission over point to point links, link sharing and MACs, Forwarding and Routing, TCP-IP layered network concepts. (3L) Internet specific issues like scalability, inter operability. (1L) Internet Structures – logical and physical grouping with sub netting and super netting. (3L) Review of TCP-IP protocols – processing, performance and variations. (3L) Security Implementations - secured IP, Transport Layer security. (3L) Quality of Service Issues and their Application in Internet. (2L) HTTP: Requests and Responses - Message Formats, Headers and Fields; TCP Keep-alive and pipe-lining concepts; Server Architecture, Performance and Deployment. (3L) WEB PROGRAMMING: Document Object Model; Client side scripting fundamentals: Server Side Scripting and Programming – Data base connectivity, session management and security enhancement; Introduction to Web Application Development Platforms – JavaEE, Dzango. (7L) XML: DTD and Schema; Visualisation using XSLT; Web Application using XML; Service Oriented Architecture and Web services based application development and deployment; Xquery and SOA based application development platforms. (6L) SEMANTIC WEB: General Concept of Semantic Web and linked Data; RDF based relation description; Web Ontology concepts and use; Putting XML, RDF and Ontology together to develop semantic web applications; Capturing Information from semantic web pages; Data analytics over semantic and linked Web. (7L)
Text Books, and/or reference material	**Text Books:** 1. B. A. Forouzan, "TCP/IP Protocol Suite", 4th Edition, 2010, McGrawHIll Publishers. 2. P. Deitel, H. Deitel, A Deitel, "Internet and World Wide Web – How to Program", Pearson. 3. G. Antoniou, P. Groth, F. Harmelen and R. Hoekstra, "A Semantic Web Primer" Prentice Hall India. **Reference Books:** 1. D. E. Comer and D L Stevens, "Internetworking with TCP/IP vol.II", Pearson. 2. www.w3schools.com

CSO7XX Soft Computing Techniques 3-0-0 3 Credits 3 Hours

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSO7XX</td><td>Soft Computing Techniques</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="2">Introduction to computing, Data Structures and Analysis of Algorithms</td><td colspan="6">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● CO1: Understand the fundamental concepts, different architectures and learning algorithms for neural networks and its limitations.
● CO2: To introduce evolutionary computing and understanding single and multi-objective genetic algorithms and their applications in optimization problems.
● CO3: To introduce the fuzzy sets, fuzzy logic and fuzzy inference system.
● CO4: To introduce tools and techniques of Soft Computing.
● CO5: To apply soft computing techniques to solve application problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I: Introduction (6L)
Introduction and different definitions of Soft Computing with their application in real life problems, Basic tools/members of Soft Computing: Fuzzy Logic, Neural Network and Evolutionary Computing.
Module II: Fuzzy Logic (12L)
Fuzzy Logic-I: Crisp Sets, Fuzzy sets, Fuzzy membership functions, Basic operations on fuzzy sets, Fuzzy relations and Composition of fuzzy relations.
Fuzzy Logic –II (Fuzzy Rules and Approximate Reasoning): Fuzzy if-then rules: M-A and TSK Rules, Fuzzification, Compositional rule of Inference/Approximate Reasoning, Defuzzification and Applications.
Module III: Neural Networks (10L)
Neural Networks-1 (Introduction & Architecture): Introduction to neural networks: Artificial Neuron and its model, Activation functions, Neural network architecture, learning algorithms/rules, Training and testing.
Neural Networks-II: Perceptron model: single layer and multilayer perceptron (MLP), Error back propagation, Radial basis function network (RBFN), Self-organizing map network (SOMN).
Module IV: Evolutionary Computing (14L)
Evolutionary Computing-I: Evolutionary Computing, Basic concepts and working principle of simple GA (SGA), Genetic Operators: Selection, Crossover and Mutation, flow chart of SGA, Chromosome Encoding & Decoding, Population Initialization, Objective/fitness Function, variable length Chromosome, Introduction to Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Local Search and Memetic algorithm, Application to Travelling Salesman Problem (TSP).

Evolutionary Computing-II: Multi-objective Genetic Algorithm (MOGA)): Conflicting objectives, Objective space and variable space, Domination, Pareto front, Pareto Set, NSGA-II: Non-domination Sorting, Crowding distance operator, Applications.</td></tr>
</table>

Text Books, and/or reference material	**Text Books:** 1. S. Rajsekharanand and Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications", Prentice Hall of India. 2. N. P. Padhy, "Artificial Intelligence and Intelligent Systems", Oxford University Press. 2. G. Klir and B. Yuan, "Fuzzy sets and Fuzzy logic", Prentice Hall of India. 3. K. H. Lee., "First Course on Fuzzy Theory and Applications", Springer-Verlag. 4. G. J. Klir and T. A. Folger: Fuzzy Sets, Uncertainty, and Information, PH. 5. J. Yen and R. Langari, "Fuzzy Logic, Intelligence, Control and Information", Pearson Education. 6. D. Goldberg: Introduction to Genetic Algorithm. **Reference Books:** 1. Siman Haykin, "Neural Networks", Prentice Hall of India. 2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications", Wiley India. 3. Kumar Satish, "Neural Networks", Tata Mc. Graw Hill. 4. B. Yegnanarayana , "Artificial Neural Networks" 5. A. Konar, "Computational Intelligence", Springer. 6. Y. H. Pao: Adaptive Pattern Recognition and Neural Networks, Addison-Wesley.

CSO7XX Quantum Computing 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CS 7XX	**Quantum Computing**	PEL	3		0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Design and Analysis of Algorithms/Information and Coding Theory /Quantum Mechanics		CT+EA **[CA: 15%, MT: 25%, ET: 60%]**					
Course Outcomes	• CO1: Understanding the fundamental concepts of Information Theory and Quantum System • CO2: Understanding different Quantum Gates and Circuits • CO3: Teleportation of information in Quantum System • CO4: Implementation of Quantum Computing for information processing • CO5: Understanding information security by Quantum Cryptography						
Topics to be Covered (40L)	1. Classical Information Theory (2L) Information Theory, Shannon's Entropy, Grouping Theorem, Gibb's Inequality, Communication Systems, Coding, Shannon's Theorem 2. Quantum Information and Computing – I (6L) Introduction, Postulates of Quantum Mechanics [5 Postulates] , The Qubit, Bloch Sphere Representation of Qubits, Composite Systems, Linear Algebra(Projection Operator, Spectal Theorem, Positive Operator, Polar Decomposition of an Operator, Singular Value Decomposition)						

	3. Quantum Information and Computing - II (Density Matrix Formulation & Quantum Mechanics) (2L) Introduction, Density Matrix Mixed, State Density Matrix, Density Matrix & Block Sphere, Postulates of Quantum Mechanics - in Density Matrix Representation, Reduced Density Matrix, 4. Multiple Qubit States and Quantum Gates (3L) Introduction, Composite Systems, Matrix Basis in the Space of Two Qubits, Single Qubit Gates, Different Single Qubit Gates (Pauli Matrices, Hadamard), Two Qubit Gates, Three Qubit Gates 5. Quantum Circuits (3L) Introduction, Implementation of Classical Logic Gates, Oracle 6. No-Cloning Theorem and Teleportation (2L) Introduction, Quantum No-cloning Theorem, Quantum Teleportation 7. Super Dense Coding (2L) Introduction, Dense Coding Circuit 8. Measurement postulates (3L) Introduction, Measurement Postulates, Projection on Von-Neumann Measurement , Measurement in a Mixed State, POVM 9. Simple Quantum Algorithms - Deutsch Algorithm and Deutsch - Jozsa Algorithms (3L) Introduction, Quantum Parallelism, Collapse of Wave Function and Process of Measurement, Entanglement, Quantum No-Cloning Theorem, Deutsch Problem, Deutsch - Jozsa Algorithm 10. Simon Problem (2L) Introduction , Simon Problem , Classical Complexity ,Quantum Circuit for Simon Problem 11. Grover's Search Algorithm (2L) Introduction , The Oracle , Grover Operator and its Geometric Inter predation , Maximum Number of Iteration, Matrix Representation of Grover Operator , Quantum Circuit , Success and Failure of Algorithm to Example , The Quadratic Speeding , Maximum Number of Iteration , Matrix Representation of Grover Operator , Quantum Circuit , Success and Failure of the Algorithm to Example 12. Quantum Fourier Transform (2L) Introduction , Discrete Integral Transforms , Quantum Fourier Transform , Period Finding , Unitary Operator for QFT , Implementation , QFT for 3 Qubits 13. Shor's Factorization Algorithm (2L) Introduction, Shor's Algorithm , Implementation of Quantum Computation Part , Method of Continued Fraction 14. EPR and Bell's Inequality (2L) Introduction , Bell States and Local Measurement, Bell's Inequalities ,CHSH Inequality 15. RSA Algorithm (2L) Introduction , Fermat's Little Theorem , Euler's Theorem , Chinese Remainder Theorem , RSA Encryption and Decryption , Euclid's Algorithm , Extended Euler's Algorithm 16. Quantum Cryptography (2L) Introduction , BB-84 Protocol , Eve's Interception ,B-g2 Protocol , Ekert Protocol using EPR Pairs (E-D1),
Text Books, and/or reference	**Text Books:** 1. Quantum Computation and Quantum Information, by Michael A. Nielsen , Isaac L. Chuang, Cambridge Press 2. An Introduction to Quantum Computing, by Phillip Kaye , Raymond Laflamme , Michele Mosca, Oxford Press

material	3. The Feynman Lectures on Physics - Vol.3, by Richard P. Feynman, Pearson Publishing

CSO7XX Object Oriented Technology 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO7XX	Object Oriented Technology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
CSO442 (Object Oriented Technology)		CT+EA **[CA: 15%, MT: 25%, ET: 60%]**					
Course Outcomes		● CO1: Apply Object oriented approach to design software. ● CO2: Implement programs using classes and objects. ● CO3: Specify the forms of inheritance and use them in programs ● CO4: Analyze polymorphic behavior of objects. ● CO5: Design and develop GUI programs. ● CO6: Develop Applets for web applications.					
Topics Covered		Introduction to problem solving through computer, Design of algorithm to solve a problem, Concepts of functions, loops, strings, arrays, pointers, structures etc. Procedure Oriented Programming, Object Oriented Programming, Objects and Classes, 3 basic features of OOP, Comparison of procedural programming and object oriented programming, C++ language, cout, cin operator, return type of main, structure of a C++ program, example with description, Tokens, keywords, identifiers, declaration of variables, dynamic initialization of variables, reference variables, scope resolution operator, difference between C and C++. Examples and Practice Sessions. (7L) Declaration of classes and objects, member functions, accessing class members, inline function, Nesting of member function, Private member function, Static data members, static member function, Objects as function argument, Friend functions, structure and class, returning objects, Examples and Exercises. (5L) Overview of constructors, default constructors, parameterized constructors, constructors with default arguments, dynamic initialization of objects, copy constructors, dynamic constructors & destructors, constraints on constructors & destructors. Examples and Exercises. (4L) Operator overloading overview, defining operator overloading function, Overloading unary operator, binary operators and arithmetic operators, Overloading using friend function, multiple overloading, Overloading comparison operators, conversion between objects and basic types, conversion between objects of different classes, overloading					

	various operators, such as +, -, *, /, =, ==, (), [], {}, &&, ||, ++ (preincrement and post increment) etc. Examples and Exercises. (6L) Overview, defining derived classes, types of inheritance, single inheritance, making private member inheritable, multilevel inheritance, Multiple inheritance, ambiguity in multiple inheritance Hierarchical inheritance,hybrid inheritance, Virtual base classes, abstract classes, Constructors in derived classes, initialisation list, nesting of classes, Examples and Exercises (7L) Overview, late binding, early binding, Pointers to objects, accessing class members using pointers, creating objects at runtime, This pointer, pointers to derived classes, virtual functions, pure virtual functions, Examples and Exercises. (5L) Overview of Templates, generic class, function template, function template with multiple argument, Class template, Class template with multiple argument, overloading template function, templates as member function of a class, Examples and Exercises. (3L) Exception handling overview, exception handling mechanism, throwing and catching mechanism, Multiple catch, catch All exceptions, rethrowing an exception, Examples and Exercises. (3L) Mini Project Implementation using the concepts. (2L)
Text Books, and/or reference material	**Text Books:** 1. E Balagurusamy, "Object oriented programming in C++", Mc Graw Hill, ISBN 978-93-5260-779-0 2. Herbert Schildt, "Teach yourself C++", Mc Graw Hill, 3rd Edition, ISBN 0-07-882311-0 3. Herbert Schildt, "C++: The Complete Reference", Mc Graw Hill, 4th Edition, ISBN 0-07-212124-6 **Reference Books:** 1. Stroustrup, "The C++ Programming Language", 3rd Edition, 2002,Addison Wesley. 2. Eckel, "Thinking in C++", Vol1, 2nd Edition, 2002, Pearson. 3. R. Lafore, "Object Oriented Programming with C++", 4th Edition, 2008, Pearson.

CSO7XX Digital Computer Design 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR)/ Elective (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO7XX	Digital Computer Design	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Basic Electronics		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		● CO1: Design the hardware building blocks of a computer system. ● CO2: Analyze the various parts of a modern computer functional units, bus structure, addressing modes and computer arithmetic.					

	• CO3: Identify the process involved in executing an instruction and fetching the word from memory. • CO4: Design the hardwired and micro-programmed control units and implementation of interrupts. • CO5: Understand the memory hierarchy and design a memory system.
Topics Covered	**UNIT-I**: **Digital logic circuits**: Digital Systems, Binary Logic and Basic Gates, Boolean Algebra, Logic Simplification using K-Map, Combinational Logic Circuits : Binary Adder, Subtractor, Magnitude Comparator, Decoder, Multiplexer; Sequential logic circuits : Flip-flop, register, shift register, Ring counter. (12L) **UNIT-II**: **Introduction to Computer Organization**: Evolution of computers, Basic Structure of Computers: Basic Operational Concepts, GPR based organization. Bus Structures, Machine Instructions and Programs: Memory Location and Addresses, Memory Operations, Instructions and Instruction Sequencing, Addressing Modes (10L) **UNIT-III**: **Processing Unit**: Combinational and Sequential ALU, ALU expansion strategies, Floating Point Numbers (IEEE754), Floating Point Operations. Fetching and Storing words, Register Transfer, Execution of instruction, timing & control, instruction cycle, Hard-wired Control, Micro programmed Control: Micro instruction, Microprogram sequencing (10L) **UNIT-IV: Input/output Organization**: Accessing I/O Devices, Interrupt. (4L) **UNIT-V**: **Memory System**: Basic Concepts, Semiconductor RAM Memories, Read Only Memories, Speed, Size, and Cost, Cache Memories – Mapping Functions, Replacement Algorithms, Virtual Memories, Secondary Storage. (6L)
Text Books, and/or reference material	**Text Books:** 1. M.Morris Mano : "Digital logic and Computer Design" Pearson. 2. M.Morris Mano : "Computer System Architechture", Pearson. 3. Carl Hamacher, Zvonko Vranesic, Safwat Zaky: Computer Organization, Tata McGraw Hill. **Reference Books:** **1. William Stallings, "Computer Organization and Architecture".** 2. Nicholas P Carter, "Computer Architecture & Organisation".

CSO7XX Fundamentals of Algorithms 3-0-0 3Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO7XX	Fundamentals of Algorithms	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))					
Data							

Course Outcomes	
Topics Covered	1. Non-linear data structures. Trees. Binary search trees, AVL tree. [5] 2. Set Representations. Disjoint Set Union. Priority Queues. [4] 3. Graph Representations. AND-OR graphs. BFS. DFS. [4] 4. Algorithm analysis techniques, asymptotic complexity, Big-Oh, Big-omega and Theta notation, Lower bound analysis. [5] 5. Divide and Conquer. Analysis of Binary Sort, Merge sort, Heap sort, Quicksort, Selection problem, Multiplication of two large n-bit numbers, Strassens' Matrix Multiplication. [7] 6. Greedy Techniques. Minimal Spanning Trees, Knapsack problem, Huffman's Codes. Job Scheduling. [6] 7. Dynamic Programming. All Pairs. Shortest Paths, Matrix Chain Multiplication Problem, Traveling Salesperson Problem. [5] 8. Backtracking. N-Queens problem. Sum of Subsets. [3] 9. Introduction to NP Hard problems. [3]
Text Books, and/or reference material	**Text Books:** **Reference Books:** **Others:**

CSO7XX Database Management System 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO7XX	Database Management System	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Fundamental knowledge in Programming and Data Structures		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		● CO1: Understand the basic concepts and appreciate the applications of database systems. ● CO2: Comprehend the fundamentals of design principles for logical design of relational databases. ● CO3: Apply the query writing skill and its subsequent optimization. ● CO4: Discuss the basic issues of transaction processing and concurrency control.					
Topics Covered		**Introduction:** Concept & Overview of DBMS, Applications, Data Models, Database Languages, Database Administrator, Database Users, Three Schema architecture of DBMS.					

	(3L) **Entity-Relationship Model:** Basic concepts, Design Issues, Mapping Constraints, Keys, Entity-Relationship Diagram. (5L) **Relational Model:** Structure of relational Databases, Various Relational Algebra operations used to write a query, Views. (5L) **SQL:** Concept of DDL, DML, DCL. Basic Structure, Set operations, Aggregate Functions, Referential views, Nested Subqueries. (5L) **Index Structures:** Necessity of index structures, Types of Single-Level Index (primary, secondary, clustering), Multilevel Indexes. (3L) **Normalization:** Functional Dependency, Anomalies in a Database, The normalization process: Conversion to first normal form, Conversion to second normal form, Conversion to third normal form and BCNF, Fourth Normal form and fifth normal form, Denormalization, Loss-less join decomposition, Dependency preservation. (6L) **Transaction processing:** Introduction of transaction processing, advantages and disadvantages of transaction processing system, online transaction processing system, serializability. (4L) **Concurrency Control:** Serializability by Locks, Lock Modes, Lock based Concurrency Control, Concurrency Control by Timestamps. (4L) **Query Optimization:** Heuristics in Query Optimization, Converting Query Tree to Query Evaluation Plan. (3L) **Distributed Database (DDB):** Introduction of DDB, DDBMS architectures, Data Replication, Data Fragmentation. (4L)
Text Books, and/or reference material	**Text Books:** 1. "DatabaseSystem Concepts", Abraham Silberschatz, Henry F. Korth and S. Sudarshan, McGraw-Hill. 2. "Distributed Databases Principles & Systems", Stefano Ceri and Giuseppe Pelagatti, McGraw-Hill International Editions. **Reference Books:** 1. "Fundamentals of Database Systems", Ramez Elmasri and Shamkant B. Navathe, Addison-Wesley

CSO7XX Advanced Algorithms 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO7XX	Advanced Algorithms	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					

CSC 303, CSC 403	CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**
Course Outcomes	● CO1. Can have the efficiency in the complexity analysis of the algorithms. ● CO2. Detecting and applying the algorithmic structures in many different fields of engineering. ● CO3. Will have the knowledge for state of the art development in the field of algorithms. ● CO4. Can have the proficiency of coding and comparing different algorithms.
Topics Covered	**Revisit:** Different Complexity analysis and Algorithm's correctness by Loop-Invariant techniques. (2L) **Data Structures:** van Emde Boas Trees, Dynamic graphs, Bloom filters, Hashing (Open addressing). (5L) **Randomized Algorithm-** Las Vegas and Monte Carlo algorithms, Essential mathematical tools for Randomized algorithms: Linearity of expectation, Markov inequality, Chebyshev's inequality, Chernoff bound, and Union bound with examples to Randomized algorithm design. Examples and analysis of: Hiring Assistant Problem, Randomized selection, Skip list. (4L) **Network Flow -** Flow networks, Augmenting paths, Ford- Fulkerson Algorithm, Edmonds - Karp algorithm, Max flow min-cut theorem, Push-relabel algorithm, Maximum bipartite matching, Some applications of network flow. (5L) **Linear Programming:** Introduction, algorithms, and its applications, Linear programming duality. (4L) **Parallel Algorithms** – Multithreaded Algorithms: Multithreaded matrix multiplication, Multithreaded merge sort. (3L) **Online Algorithms:** Overview, Online scheduling and online Steiner tree, Online Bipartite matching, Online learning and multiplicative weights algorithm. (5L) **NP- Completeness -** Reduction revisited; NP-Completeness proof of different problems: CLIQUE, VERTEX COVER, INDEPENDENT SET, SET COVER. (4L) **Approximation Algorithms** - Constant factor approximation algorithm: VERTEX COVER and TSP; Christofides algorithm on TSP with 1.5 approximation factor; SET-COVER problem with log n factor approximation algorithm; PTAS and FPTAS, Linear programs and approximation algorithms. (7L) **Semidefinite Programming:** Introduction with the problem: The Maximum Cut Problem and Semidefinite Programming. (2L) **Overview of some Special Topics:** Communication complexity, Spectral graph theory, Compressive sensing . (1L)

Text Books, and/or reference material	**Text Books:** 1. Rajeev Motwani and Prabhakar Raghavan, Randomized Algorithms, 2nd Edition, Cambridge University press, Cambridge, MA, 1995. 2. Thomas H. Cormen, Charles Leiserson, Ronald Rivest, and Clifford Stein. Introduction to Algorithms. 3rd ed. MIT Press, 2009, ISBN: 9780262033848. 3. S. G. Akl, The Design and Analysis of Parallel Algorithms, Prentice-Hall, 1989. 4. M. J. Quinn, Designing Efficient Algorithms for Parallel Computers, McGraw Hill Higher Education, 1987, ISBN: 978-0070510715. 5. J. Kleinberg and E. Tardos, Algorithm Design, Pearson. 6. D. V. Williamson and D. B. Shmoys, The Design of Approximation Algorithms, Cambridge University Press. 7. S. Arora and B. barak, Computational Complexity: A Modern Approach, Cambridge University Press. **Reference Books:** 1. Dimitri P. Bertsekas and John N. Tsitsiklis, Introduction to Probability, 2nd Edition, Athena Scientific, July 2008. 2. M. Mitzenmacher and E. Upfal, Probability and Compuitng: Randomized Algorithms and Probabilistic Analysis, Cambridge University Press. 3. T. Roughgarden, CS261: A Second Course in Algorithms (Stanford University), 2016. 4. T. Roughgarden, CS168: Modern Algorithmic Toolbox (Stanford University), 2017. **Others:** *NMEICT video on:* *Design of Algorithms(http://www.nmeict.iitkgp.ac.in/Home/videoLink/10/3gp)*

CSO7XX Compiler Design 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO7XX	Compiler Design	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
CSC-01 (Introduction to Computing)		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		● CO1: Understand the fundamental idea of compiler. ● CO2: Implement a part of a compiler. ● CO3: Know how a compiler recovers from an error.					
Topics Covered		● Introduction to Regular Expressions, NFA and DFA. 3L ● Introduction to the philosophy of compilers and course Overview. Introducing different phases of compilers with an example. 1L ● Details of Lexical analysis phase. Implementation of a Lexical analyzer. 4L ● Regular expression versus Grammars. Different types of Top-Down parsing. Different types of Bottom -up parsing. Implementing one					

	Bottom -up parsing algorithm. 12L ● Introduction to Error Recovery Routine, Type Checking and Symbol Table. Introduction to lex and yacc. 4L ● Syntax Directed Translation scheme. 6L ● Intermediate code generation. Three Address Codes. 5L ● Code generation and code optimization. 5L ● Linker, Loader 2L
Text Books, and/or reference material	**Text Books:** Compilers: Principles, Techniques, and Tools (Latest Edition). Alfred Aho, Monica Lam, Ravi Sethi, and Jeffrey Ullman. Addison-Wesley **Reference Books:** Engineering a Compiler. Keith Cooper and Linda Torczon. Morgan Kaufman

CSO7XX Artificial Intelligence 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO7XX	Artificial Intelligence	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Data Structure and Algorithm, DBMS, Object Oriented Programming		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		● CO1: Learns Concepts of Intelligence, Artificial Intelligence, Problem Representation and Characterization. ● CO2: Conceptualizes Intelligent Search, different heuristics. ● CO3: Understands Knowledge Representation Techniques and Uncertainty Managements. ● CO4: Learns Semantic Knowledge, Semantic Net and Frame. ● CO5: Learns Game Playing Program Design. ● CO6: Learns Expert Systems and Various Machine Learning Systems. ● CO7: Learns Neural Networks.					
Topics Covered		Introduction to Artificial Intelligence (AI): Features of natural intelligence, Definition of Artificial Intelligence (AI), Turing Test. (4L) Problem Representation and Characterization: State Space Representation, Production Systems, Search, Problem Characterization. (5L) Intelligent Search Techniques: Search Classifications, Heuristic Function, Various Types of Heuristic Search Techniques, Performance Measure of Heuristic Search with					

	Penetrance. (5L) Knowledge Representation Methodologies: Types of Knowledge, Propositional vs. Predicate Logic, Resolution Proof, Logic Programming, Knowledge representation using Rules, Declarative and Procedural Representation, Uncertainty Management in Knowledge Representation, Certainty Factors in facts and rules, Concept of Fuzzy Logic. (5L) Semantic Knowledge Representation: Syntactic vs. Semantic Knowledge, examples of Semantic Knowledge, Semantic Net, Frame, OOP, Property Inheritance, Tangled Hierarchies. (4L) Game Playing: Game Tree, Minimax Search, Search Reduction by alpha and beta cutoffs. Planning: Introduction to Planning, Goal Stack Planning, Nonlinear, Hierarchical and Reactive Planning. (4L) Learning: Learning and Intelligence, Learning Spectrum, Various Types of Learning Techniques and Systems. (5L) Expert Systems (ES) and ES Shells: Definition of Expert Systems, Components of Expert Systems. Types of ES – Manual, Semi-automatic, and Automatic ES, Techniques of Knowledge Acquisition (KA) for ES.-- ES Shell. Advantages and disadvantages of ES Shell over ES. (5L) Neural Networks: Symbolic vs. Neural Network AI, Hofield Network, Perceptron as a model of neuron, Single and multiplayer Perceptron for classification and knowledge representation, Back propagation Network, Supervised, Reinforcement and Unsupervised Learning. AI standardization: Needs for standardization, Data quality analysis standards, bias compliance standard, standardization efforts under ISO/IEC/ CD 42000 series and ISO/IEC CD 5200X series. (5L)
Text Books, and/or reference material	**Text Books:** 1. Artificial Intelligence -- Rich and Knight. -- Tata McGraw Hill. 2. Artificial Intelligence – A New Synthesis – Nilsson. -- Morgan Kaufmann Publishers. **Reference Books:** 1. Artificial Intelligence and Expert Systems -- Paterson. -- PHI. 2. Artificial Neural Networks – B. Yegnanarayanana. PHI.

CSO7XX Operating Systems 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO7XX	Operating Systems	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Introduction to Computing		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					

(CSC01), Data Structures and Algorithms (CSC303)	
Course Outcomes	● CO1: Explain the functional architecture of an operating system. ● CO2: Design the process control algorithms, solution to deadlocks and multi-threading applications ● CO3: Implement application programs using UNIX system calls. ● CO4: Design and solve control & data access synchronization problems. ● CO5: Explain virtual memory organization and management in OS. ● CO6: Implementation of standard FAT & UNIX file system.
Topics Covered	**Introductory Concepts:** Introduction to Operating System as a whole, memory, CPU(registers and ALU), Evolution of Operating System-types of OS(advantages and drawbacks), Performance measurement metrics. (4L) **Process Data Structures and State transitions:** Process management, Basic Definitions, Process table, PCB(process control block), PTE(process table entry), Process states, Transition diagram, context of process-user level, kernel-level and process Level. (3L) **Process Control:** Process creation, Parent and Child processes, System calls--fork(), exit(), wait(), kill(), Signal handling, Process scheduling strategies-FCFS, SPN, SRT, Round Robin, HRRN, Fair share scheduling. (5L) **Multi-threading:** Threads in OS, thread vs process, Applications of threads, Use of POSIX threads library. (3L) **Process synchronization -** Race condition, Critical section, Process Sync Solution using Algorithmic approach (Lamport bakery Algorithm), Creating shared memory using POSIX library. (2L) **Semaphore**- Binary and Counting semaphore, P() and V() operations, Solving Classical problem using semaphores- Sleeping barber, Producer-consumer, Reader-writer, Dining philosophers's problem, Posix library for semaphores. (6L) **Deadlocks** - Necessary and sufficient conditions for deadlocks, approaches to deal with deadlocks, Deadlock Prevention, Avoidance (Banker's algorithm) and Detection. (3L) **Memory organization & management** - Virtual memory organization, Pure Paging, Pure Segmentation, Combined Paging-Segmentation, Inverted PMT, Page fault handling algorithms, Working set theory. (10L) **File management**- Directory structure, Storage of files on disks, contiguous and non-contiguous file allocation strategies, Internal and external fragmentation, FAT & Inode Structure, Free Space management, Disk scheduling strategies. (4L) **I/O management concepts** (2L)
Text Books, and/or reference	**Text Books:** 1. "Operating System Concepts", Silberschatz and Galvin. 2. "Operating Systems: Internals and Design Principles" by William Stalling. 3. "Operating Systems: A Concept-Based Approach" by D M Dhamdhere.

material	**Reference Books:** 1. "Operating System: A Design-oriented Approach" by Charles Crowley. 2. "Operating Systems: A Modern Perspective" by Gary J Nutt. 3. "Design of the Unix Operating Systems" by Maurice Bach. 4. "MODERN OPERATING SYSTEMS" by Andrew S Tanenbaum. **Others:** ● https://nptel.ac.in/courses/106/106/106106144/# Course "Introduction to Operating Systems" by PROF. CHESTER REBERIO, IIT Madras. ● https://nptel.ac.in/courses/106105214/ Course "Operating System Fundamentals" by Prof. Santunu Chattopadhyay, IIT Kharagpur.