B. Tech. (CSE) – 2020 Curriculum

Course Code	Semester - I	Credit
HM101	English for Communication	2
MA101	Mathematics - I	3
PH101	Physics	3
CS101	Introduction to Computer Programming	3
ME101	Basics of Mechanical Engineering	2
ME102	Engineering Practice	2
PH102	Physics Laboratory	2
CS102	Introduction to Computer Programming Laboratory	2
HM102	NSS/NSO/NCC	0
	Total Credits	19

Course Code	Semester - II	Credit
MA151	Mathematics - II	3
ME151	Engineering Graphics	3
EC151	Basics of Electrical and Electronics Engineering	3(2T+2L)
CS151	Introduction to Python Programming	3(2T+2L)
CS152	Programme Core -I / Digital System Design	3
CS153	Programme Core -II / Data Structures	3
ME152	Energy and Environmental Engineering	0
CS154	Digital Laboratory	2
CS155	Data Structures Laboratory	2
	Total Credits	22

Course Code	Semester - III	Credit
CS201	Programme Core -III / Discrete Structures	4
CS202	Programme Core -IV / Design and Analysis of Algorithms	3
CS203	Programme Core -V / Programming Paradigms	3
CS204	Programme Core -VI / Computer Organisation and Architecture	3
CS205	Programme Core -VII / Object Oriented Programming (C++)	3
CS206	DAA laboratory	2
CS207	Programming Paradigms laboratory	2
CS208	Object Oriented Programming laboratory	2
	Total Credits	22

Course Code	Semester - IV	Credit
MA251	Probability, Statistics and Queuing Theory	4
HM251	Economics for Engineers	3
CS251	Programme Core -VIII / Data Communication	3
CS252	Programme Core - IX / Operating Systems	3
CS253	Programme Core - X / Automata and Formal Languages	3
CS254	Programme Core - XI / Microprocessor and Microcontrollers	3
CS255	OS laboratory	2
CS256	Microprocessor and Microcontrollers laboratory	2
	Total Credits	23

Course Code	Semester - V	Credit
MA301	Operations Research	3
CS301	Programme Core - XII / Compiler Design	3
CS302	Programme Core - XIII /Database Management Systems	3
CS303	Programme Core - XIV / Artificial Intelligence	3
E1	Elective -I	3
GE1	Global Elective -I	3
CS304	Compiler Design laboratory	2
CS305	DBMS laboratory	2
HM301	Professional Ethics	0
	Total Credits	22

Course Code	Semester - VI	Credit
CS351	Programme Core - XV / Software Engineering	3
CS352	Programme Core - XVI / Internetworking Protocols	3
CS353	Programme Core - XVII / Web Technology	3
E2	Elective -II	3
GE2	Global Elective -II	3
HM351	Technical English	2
CS354	Networks laboratory	2
CS355	Web Technology laboratory	2
	Total Credits	21

Course Code	Semester - VII	Credit
CS401	Summer Internship	2
CS402	Programme Core - XVIII / Machine Learning	3

E3	Elective -III	3
E4	Elective -IV	3
E5	Elective -V	3
E6	Elective -VI	3
CS403	Machine Learning laboratory	2
	Total Credits	19

Course Code	**Semester - VIII**	**Credit**
CS451	Comprehensive Viva	1
CS452	Project work	6
E7	Elective - VII / MOOC online course	3
E8	Elective -VIII / MOOC online course	3
E9	Elective -IX / MOOC online course	3
	Total Credits	16

Summary:

Branch	**I Sem**	**II Sem**	**III Sem**	**IV Sem**	**V Sem**	**VI Sem**	**VII Sem**	**VIII Sem**	**Total**
CSE	19	22	22	23	22	21	19	16	164

Electives

Elective / Specialization	Hardware Systems	Software Systems	Database	Networks & Security	Programming
Elective-I , II	Advanced Computer Architecture	Object oriented Analysis and Design	Multimedia Systems	Combinatorics and Graph Theory	Unix Programming
Elective-III	Parallel Architectures and Programming	Software Testing	Data Mining and Data Warehousing		Advanced Java Programming
Elective-IV	Embedded Systems	Real Time systems	Advanced DBMS	Cloud Computing	
Elective-V	Principles of Processor Design	Soft Computing	Social Network Analysis	Mobile Computing	Randomized Algorithms
Elective-VI	GPU Computing	Computer Graphics		Principles of Cryptography	Mobile Application Development
Elective-VII	Quantum Computing	Natural Language Processing	Big Data Analytics	Network Security	
Elective-VIII	Architecture of High Performance Computers	Software Project Management	Data Science	Information Security	
Elective-IX		Virtual Reality Pattern Recognition Design Thinking		Malware Analysis and Detection Block Chain Techniques	

Global Electives

Global Elective -I	Global Elective -II
Intellectual Property Rights	Internet of Things
Economics for IT	Digital Image Processing
Health Economics and Health Technology Assessment	Network Processors Design
Managerial Economics	Information Theory and Coding
Management Information Systems	Robotics
Numerical Solution of Differential Equations	Wireless Sensor Networks

Course Code	Electives	Credit
Elective I, II		
CS511	Advanced Computer Architecture	3
CS512	Object oriented Analysis and Design	3
CS513	Multimedia Systems	3
CS514	Combinatorics and Graph Theory	3
CS515	Unix Programming	3
Elective III		
CS516	Parallel Architectures and Programming	3
CS517	Software Testing	3
CS518	Data Mining and Data Warehousing	3
CS519	Advanced Java Programming	3
Elective IV		
CS520	Embedded Systems	3
CS521	Real Time systems	3
CS522	Advanced DBMS	3
CS523	Cloud Computing	3
Elective V		
CS524	Principles of Processor Design	3
CS525	Soft Computing	3
CS526	Social Network Analysis	3
CS527	Mobile Computing	3
CS528	Randomized Algorithms	3
Elective VI		
CS529	GPU Computing	3
CS530	Computer Graphics	3
CS531	Principles of Cryptography	3
CS532	Mobile Application Development	3
Elective VII		
CS533	Quantum Computing	3
CS534	Natural Language Processing	3
CS535	Big Data Analytics	3
CS536	Network Security	3
Elective VIII		
CS537	Architecture of High Performance Computers	3
CS538	Software Project Management	3
CS539	Data Science	3
CS540	Information Security	3

Elective IX		
CS541	Virtual Reality	3
CS542	Pattern Recognition	3
CS543	Design Thinking	3
CS544	Malware Analysis and Detection	3
CS545	Block Chain Techniques	3
Global Elective - I		
HM611	Intellectual Property Rights	3
HM612	Economics for IT	3
HM613	Health Economics and Health Technology Assessment	3
HM614	Managerial Economics	3
HM615	Management Information Systems	3
MA611	Numerical Solution of Differential Equations	3
Global Elective - II		
CS646	Internet of Things	3
CS647	Digital Image Processing	3
CS648	Network Processors Design	3
CS649	Information Theory and Coding	3
CS650	Robotics	3
CS651	Wireless Sensor Networks	3

FIRST SEMESTER

Course Code	:	**HM101**
Course Title	:	**English for Communication**
Number of Credits	:	**2**
Prerequisites (Course code)	:	**None**
Course Type	:	**GIR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Use the features of communication to express themselves orally in English in an intelligible way.
CO2 Develop an awareness of problems related to listening in different contexts.
CO3 Apply reading strategies to comprehend different difficulty levels in English at a speed suited to their needs.
CO4 Employ strategies to write acceptable sentences and coherent paragraphs in English.

Course Content:

Communication: An introduction – Its role and importance in the corporate world – Tools of communication – Barriers – Levels of communication – English for Specific purposes.

Listening: Listening process & practice – Exposure to recorded & structured talks, class room lectures – Problems in comprehension & retention – Note-taking practice – Listening tests – Importance of listening in the corporate world.

Reading: Introduction of different kinds of reading materials: technical & non-technical – Different reading strategies: skimming, scanning, inferring, predicting and responding to content – Guessing from context – Note making – Vocabulary extension.

Speaking: Barriers to speaking – Building self-confidence & fluency – Conversation practice-Improving responding capacity – Extempore speech practice – Speech assessment.

Writing: Effective writing practice – Effective sentences: role of acceptability, appropriateness, brevity & clarity in writing – Cohesion & coherence in writing – Writing of definitions, descriptions & instructions – Paragraph writing – Perspective Writing – Letter Writing – Introduction to report writing

Text Books:

1 William Strunk Jr. and E.B.White "The Elements of Style", Allyn & Bacon, Pearson Education, 1999.
2 Dhanavel, S. P., "English And Communication Skills For Students Of Science And Engineering", Orient Black Swan, Chennai, 2009.
3 Geoffrey Leech, Fan Svartvik, "A Communicative Grammar of English", Pearson Education Asia, 1994.

Reference Books:

1 Krishna Mohan and Meenakshi Raman , "Effective English Communication", Tata McGraw Hill, New Delhi, 2000.
2 Golding S.R., "Common Errors in English Language", Macmillan, 1978.
3 Christopher Turk, "Effective Speaking", E & FN Spon, London, 1985**.**

Web link(s):

1 Communication - https://nptel.ac.in/courses/109/104/109104031/
2 Listening - https://learnenglish.britishcouncil.org/skills/listening
http://www.elllo.org/archive/
3 Speaking - https://nptel.ac.in/courses/109/106/109106067/
4 Reading & Vocabulary - https://nptel.ac.in/courses/109/106/109106129/ (Week 1 & 2)
5 Writing - https://www.time4writing.com/free-writing-resources/
https://www.edx.org/course/academic-and-business-writing
https://www.coursera.org/learn/advanced-writing

Course Code	:	**MA101**
Course Title	:	**Mathematics - I**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**GIR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Examine the system of linear equations with matrices.
CO2 Convert linear first order differential equations into separable form.
CO3 Solve the ordinary linear differential equations with constant coefficients
CO4 Identify the maxima and minima of multivariable functions
CO5 Analyze the physical problems that arise in the field of engineering and apply the concepts to solve them.

Course Content:

Matrices: Rank of a matrix - Consistency of the system of linear equations - linear dependence and independence of vectors. Eigen values and Eigen vectors of a matrix - Caley-Hamilton theorem and its applications - Reduction to diagonal form - Reduction of a quadratic form to canonical form - orthogonal transformation and congruent transformation. Properties of complex matrices - Hermitian, skew-Hermitian and Unitary matrices.

Ordinary differential equations of first order: Separable equations - equations reducible to separable form - exact equations - integrating factors. Linear first order equations - Bernoulli's equation - Orthogonal trajectories - Newton's law of cooling - Law of natural growth and decay.

Ordinary higher order differential equations: Higher order linear equations with constant coefficients. Euler and Cauchy's equations - Method of variation of parameters - System of linear differential equations with constant coefficients – Applications to electrical circuits.

Differential Calculus: Rolle's theorem - Mean value theorem - Taylor's and Maclaurin's theorems (without proof) with remainders – simple illustrations; Functions of several variables - Partial differentiation - Total Differentiation - Euler's theorem and generalization. Maxima and minima of functions of several variables (two and three variables) – Lagrange's method of Multipliers - Change of variables –Jacobians – simple illustrations.

Multiple Integrals: Double and triple integrals - computation of surface areas and volumes; change of variables in double and triple integrals.

Text Books:

1 R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics", 5th ed, Narosa Publishing House, 2016.

2 B.S. Grewal, "Higher Engineering Mathematics", Khanna Publications, 44nd ed, 2015.

3 Erwin Kreyszig, "Advanced Engineering Mathematics", 8th ed, John Wiley and Sons, 2015.

Reference Books:

1 N. Piskunov, "Differential and Integral calculus, Vol. 1&2", MIR Publishers, Moscow - CBS Publishers and Distributors (India).

2 Michael D. Greenberg, "Advanced Engineering Mathematics", Pearson Education Pvt. Ltd.

Web link(s):

1 https://nptel.ac.in/courses/111/101/111101115/
https://nptel.ac.in/courses/111/102/111102133/

2 https://nptel.ac.in/courses/111/104/111104092/

Course Code	:	**PH101**
Course Title	:	**Physics**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**GIR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Define the basic principles of thermodynamics and its significance.
CO2 Describe electromagnetic theory in the field of signal propagation.
CO3 Interpret various concepts and theories of waves and quantum optics.
CO4 Explain the principle of light transmission in a fiber for modern communication.
CO5 Apply the concepts of semiconductor physics in solid state electronic devices and technologies.

Course Content:

Thermodynamics: Introduction to thermodynamic system, surrounding, equilibrium, heat and work, Zeroth Law of Thermodynamics, Equation of state of ideal and real gases, Internal energy, first law and its applications enthalpy, second law, reversible and irreversible processes, Carnot cycle, entropy, Maxwell's relations, Clausius- Clayperon equation, Joule-Thomson process, Clausius inequality, entropy as a property, principle of increase of entropy. Calculation of entropy change, Third law.

Electromagnetics: Gauss's Theorem of Electrostatics, Ampere's law of Magnetostatics, EMF, Ohm's Law and laws of Electromagnetic Induction, Self and Mutual induction, Concept of Displacement Current, Difference between Conduction Current and Displacement Current, Maxwell's Equations in free space and dielectric media, Propagation of Electromagnetic Waves in Free Space.

Waves and Quantum Optics: Wave motion, Wave equation, Superposition of waves along same direction (equal frequency) and in perpendicular directions, Lissajous figures. Transverse waves, solution of wave equation, Theory of interference of light- Newton's rings, Diffraction, applications of Interference (colours of thin films). Diffraction, Farunhofer diffraction due to single slit, double slit and, Diffraction grating (N-slit), applications of Diffraction (List only).

Lasers and Fiber Optics: Introduction, Coherence, Spontaneous and stimulated emissions, Einstein‟s coefficients, population inversion and lasing action, laser systems: Ruby laser, He-Ne Laser, semiconductor laser, Applications. Fiber Optics Introduction, numerical aperture, different types of fibres, attenuation & dispersion mechanism in optical fibers (Qualitative only), application of optical fibres, Fiber optic communication (block diagram only).

Semiconductor Physics: Energy bands; semiconductors different types, charge carriers: electrons and holes, effective mass, doping. Carrier concentration: Fermi level, temperature dependence of carrier concentration. Drift and diffusion of carriers: excess carriers;

recombination and lifetime, Hall effect, p-n Junction: depletion region, forward and reverse-bias, depletion and diffusion capacitances, switching characteristics; breakdown mechanisms.

Text Books:

1 M. N. Avadhanulu and P.G. Kshirsagar, "A textBooks of Engineering Physics", S. Chand and Company, New Delhi 2009.

2 R.K. Gaur and S.L. Gupta, "Engineering Physics",Dhanpat Rai Publications (P) Ltd., 8th ed., New Delhi 2001.

3 R. K. Rajput, "A TextBooks of Engineering Thermodynamics" 4th Edition, L.B. Enterprizes, New Delhi 2010.

Reference Books:

1 Halliday, Resnic and Walker, "Fundamentals of Physics", John Wiley, 9 th Edition, 2011.

2 David J. Griffiths, "Introduction to Electrodynamics", 3rd Edition, Printice Hall of India, New Delhi 2012.

3 Donald A. Neamen, "Semiconductor Physics and Devices: Basic principle", 4th Edition,, McGraw- Hill, New York 2012

Course Code	:	**CS101**
Course Title	:	**Introduction to Computer Programming**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**GIR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the basics of computers and software systems.
CO2 Discuss the various conditional control statements in C programming.
CO3 Apply the concept of arrays to solve sorting and searching problems.
CO4 Define pointers and its association with arrays and functions in C.
CO5 Develop C program with structures and perform Read-Write operations with files.

Course Content:

Introduction to Computers, Number Systems, C language: Introduction to Computers: Computer Systems, Computing Environments, Computer Languages, Creating and Running Programs, Software Development, Flow charts. Number Systems: Binary, Octal, Decimal, Hexadecimal Introduction to C Language - Background, C Programs, Identifiers, Data Types,Variables, Constants, Input / Output Statements Arithmetic Operators and Expressions: Evaluating Expressions, Precedence and Associativity of Operators, Type Conversions.

Control Statements: Conditional Control Statements: Bitwise Operators, Relational and Logical Operators, If, If-Else, Switch-Statement and Examples. Loop Control Statements: For, While, DoWhile and Examples. Continue, Break and Goto statements Functions: Function Basics, User-defined Functions, Inter Function Communication, Standard Functions, Methods of Parameter Passing. Recursion- Recursive Functions. Storage Classes: Auto, Register, Static, Extern, Scope Rules, and Type Qualifiers.

Preprocessors, Arrays: Preprocessors: Preprocessor Commands Arrays - Concepts, Using Arrays in C, Inter-Function Communication, Array Applications, Two- Dimensional Arrays, Multidimensional Arrays, Linear and Binary Search, Selection and Bubble Sort.

Pointers, Strings: Pointers - Introduction, Pointers for Inter-Function Communication, Pointers to Pointers, Compatibility, Lvalue and Rvalue, Arrays and Pointers, Pointer Arithmetic and Arrays, Passing an Array to a Function, Memory Allocation Functions, Array of Pointers, Programming Applications, Pointers to void, Pointers to Functions, Commandline Arguments. Strings - Concepts, C Strings, String Input/Output Functions, Arrays of Strings, String Manipulation Functions.

Structures, Input and Output: Structures: Definition and Initialization of Structures, Accessing Structures, Nested Structures, Arrays of Structures, Structures and Functions, Pointers to Structures, Self Referential Structures, Unions, Type Definition (typedef), Enumerated Types.

Input and Output: Introduction to Files, Modes of Files, Streams, Standard Library Input/Output Functions, Character Input/Output Functions.

Text Books:

1 R G Dromey, "How to Solve It by Computer", Prentice-Hall International Series in Computer Science, 2006.
2 G. Michael Schneider, "Invitation to Computer Science", Eighth Edition, 2018.
3 Byron S Gotrified, "Programming with C", Thrid Edition, McGraw Hill Companies, 2017.

Reference Books:

1 Michael Vine, "C Programming for the Absolute Beginner", Third Edition, 2014.
2 Brian W Kernighan, Dennis M. Ritchie, "C Programming Language", Second Edition, Pearson Education India, 2015.
3 Herbert Schildt, "C++ Complete Reference", McGraw Hill, Fourth Edition, 2017.

Web link(s):

1 http://uru.ac.in/uruonlinelibrary/Cloud_Computing/Basics%20of%20Computer.pdf
2 https://www.tutorialspoint.com/basics_of_computers/index.htm
3 https://en.wikiBookss.org/wiki/Computers_for_Beginners/The_Basics
4 http://ecoursesonline.iasri.res.in/course/view.php?id=94
5 https://www.tutorialspoint.com/cprogramming/index.htm

Course Code	:	**ME101**
Course Title	:	**Basics of Mechanical Engineering**
Number of Credits	:	**2**
Prerequisites (Course code)	:	**None**
Course Type	:	**GIR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Discuss the basic concepts of thermodynamics, systems, and energy resources

CO2 Explain the basic functions of internal combustion engines, refrigeration, and heat transfer in engineering applications

CO3 Select a type of power transmission system as per the application

CO4 Identify the suitable Materials for Engineering Applications

CO5 Describe the functions and operations of various conventional and advanced manufacturing processes

Course Content:

Thermodynamics: Thermodynamic system, State, Properties, Thermodynamic Equilibrium, Process and Cycle, Fundamental Units and conversions, Zeroth law of Thermodynamics, Work and Heat, First law- Cyclic process, Change of State, Limitations of First law, Thermal Reservoirs, Heat Engine, Heat Pump/Refrigerator, Efficiency/COP, Second law, PMM2, Carnot Cycle, Entropy - Example problems. Energy Sources - Conventional/Renewable.

I.C. Engines: 2-Stroke & 4-Stroke Engines, P-v Diagram; S.I. Engine, C.I. Engine, Differences, **Refrigeration**: Vapour Compression Refrigeration Cycle - Refrigerants, Desirable Properties of Refrigerants **Heat Transfer**: Modes of Heat Transfer, Thermal Resistance Concept, Composite Walls and Cylinders, and Overall Heat Transfer Coefficient - Example problems

Power Transmission: Classification of different power transmission systems, Transmission of Power, Belt Drives, Chain Drives, Gears and Gear Trains – Example problems

Engineering Materials Properties of materials, Classification of Materials, Selection of Engineering Materials, Introduction to materials structure, Applications, Testing of materials.

Manufacturing Processes: Casting - Patterns and Moulding, Hot Working and Cold Working, **Metal Forming processes:** Extrusion, Drawing, Rolling, Forging, Welding - Arc Welding & Gas Welding, Soldering, Brazing. **Advanced manufacturing**: introduction to CNC machines, laser based manufacturing processes, 3D printing.

Text Books:

1 Basant Agarwal and C.M. Agarwal, "Basic Mechanical Engineering", Wiley India Pvt. Ltd., 2008.

2 Sadhu Singh, “Basic Mechanical Engineering”, S. Chand & Company Limited, 2009.
3 Praveen Kumar, “Basic Mechanical Engineering”, Pearson Education, India, 2013.

Reference Books:

1 M.L. Mathur, F.S. Mehta and R.P. Tiwari, R.S. Vaishwnar, “Elements of Mechanical Engineering”, Jain Brothers, New Delhi, 2008.
2 P.N. Gupta, M.P. Poonia, “Elements of Mechanical Engineering”, Standard Publishers, 2004
3 C.P. Gupta, Rajendra Prakash, “Engineering Heat Transfer”, NemChand Brothers, New Delhi, 1994.

Web link(s):

1 https://nptel.ac.in/courses/112/105/112105123/
2 https://nptel.ac.in/courses/112/103/112103262/
3 https://nptel.ac.in/courses/112/105/112105234/

Course Code	:	**ME102**
Course Title	:	**Engineering Practice**
Number of Credits	:	**2**
Prerequisites (Course code)	:	**None**
Course Type	:	**GIR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the basic manufacturing processes of Casting, Joining, Fitting and Forming.
CO2 Use hand tools and basic machineries in Foundry, Welding shop, Carpentry, Fitting shop and Sheet Metal work
CO3 Design simple prototypes and produce engineering products.

Course Content:

Foundry: Preparation of sand mould for the following
01. Flange
02. Hand Wheel
Welding: Fabrication of metals joint of the following
01. Butt Joint
02. Lap Joint
Carpentry: Wood sizing exercise in planning, marking, sawing, chiselling and grooving to make
1. Tee through Halving Joint
2. Dovetail Scarf Joint
Fitting: Preparation of joints, markings, cutting and filling for making
1. Semi-circle part
2. Dovetail part
Sheet metal: Fabrication of simple products of the following
1. Dust Pan
2. Corner Tray

Text Books:

1 R.K. Rajput, "Workshop Practice", Laxmi Publications (P) Limited.
2 Shashi Kant Yadav, "Workshop Practice", Discovery Publishing House, New Delhi.
3 K.C.John, "Mechanical workshop practice" PHI Learning Pvt. Ltd., (2010).

Reference Books:

1 H.S. Bawa, "Workshop Practice", Tata McGraw – Hill Publishing Company Limited, (2009).
2 T.Jeyapoovan, M.Saravanapandian & S.Pranitha, "Engineering Practices Lab Manual", Vikas Puplishing House Pvt.Ltd, (2006).
3 S K Hajra Choudhury, A K Hajra Choudhury, N. Roy, "Workshop Technology Vol I & II", Media Promoters & Publishers Pvt. Ltd.

Web link(s):

1 https://nptel.ac.in/courses/112/107/112107145/
2 https://nptel.ac.in/courses/112/107/112107144/
3 https://nptel.ac.in/courses/112/107/112107219

Course Code	:	**PH102**
Course Title	:	**Physics laboratory**
Number of Credits	:	**2**
Prerequisites (Course code)	:	**None**
Course Type	:	**GIR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the basic scientific principles of the designed experiments
CO2 Practice the theoretical concepts of physics through experiments
CO3 Demonstrate experiments through various experimental setups.
CO4 Evaluate, analyze and interpret the experimental data.
CO5 Design new devices based on scientific understanding

Course Content:

Wavelength of laser using diffraction grating

Wavelength of mercury spectrum – Spectrometer

Radius of curvature of lens – Newton's rings

Numerical aperture of an optical fiber

Field along the axis of a circular coil

Measurement of temperature using thermistor

Thermo e.m.f by Potentionmeter

Course Code	:	**CS102**
Course Title	:	**Introduction to Computer Programming Laboratory**
Number of Credits	:	**2**
Prerequisites (Course code)	:	**None**
Course Type	:	**GIR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Develop C program for solving basic mathematical problems.
CO2 Write C program for solving problems that require more iteration.
CO3 Construct C program for various sorting and searching algorithms.
CO4 Perform operations related to strings using C functions.
CO5 Compose file handling programs in C language.

Course Content:

Finding the maximum and minimum of given set of numbers

Finding Roots of a Quadratic Equation

Sin x and Cos x values using series expansion

Conversion of Binary to Decimal, Octal, Hexa and Vice versa

Generating a Pascal triangle and Pyramid of numbers

Recursion: Factorial, Fibonacci, GCD

Matrix addition and multiplication using arrays

Bubble Sort, Selection Sort

Programs on Linear Search and Binary Search using recursive and non-recursive procedures.

Functions for string manipulations

Finding the No. of characters, words and lines of given text file

File Handling programs

SECOND SEMESTER

Course Code	:	**MA151**
Course Title	:	**Mathematics - II**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**Mathematics – I**
Course Type	:	**GIR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Apply the concepts of gradient, divergence and curl to solve engineering problems
CO2 Convert line integrals into area integrals and surface integrals into volume integrals
CO3 Determine the Fourier series for a given function
CO4 Change the given function into transform coefficients using Fourier transformation.
CO5 Apply Laplace transforms to solve physical problems arising in engineering

Course Content:

Vector Calculus: Scalar and Vector fields - Vector Differentiation - Level surfaces - Directional derivative - Gradient of a scalar field - Divergence and Curl of a vector field – Laplacian.

Vector Integrals: Line, surface and volume integrals; Green's theorem in a plane - Gauss Divergence theorem and Stokes' theorem.

Fourier Series: Expansion of a function in Fourier series for a given range - Half range sine and cosine expansions

Fourier Transforms: Complex form of Fourier series -Fourier transformation and inverse transforms - sine, cosine transformations and inverse transforms - simple illustrations.

Laplace Transformation: Laplace transform - Inverse Laplace transform - properties of Laplace transforms - Laplace transforms of unit step function, impulse function and periodic function - Convolution theorem - Solution of ordinary differential equations with constant coefficients and system of linear differential equations with constant coefficients using Laplace transform – Applications to electrical circuits.

Text Books:

1 Erwin Kreyszig, "Advanced Engineering Mathematics", 8th edition, John Wiley and Sons, 2015.
2 R. K. Jain and S. R. K. Iyengar, "Advanced Engineering Mathematics", 5th edition, Narosa Publishing House, 2016.

Reference Books:

1 B.S. Grewal, “Higher Engineering Mathematics”, Khanna Publications, 44nd ed, 2015.

2 Michael D. Greenberg, “Advanced Engineering Mathematics”, Pearson Education Pvt. Ltd.

Web link(s):

1 https://nptel.ac.in/courses/111/105/111105122/

2 https://nptel.ac.in/courses/111/102/111102129/

Course Code	:	**ME151**
Course Title	:	**Engineering Graphics**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**GIR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Discuss the fundamentals and standards of Engineering drawings/ graphics
CO2 Visualize the structure of engineering components
CO3 Create geometric construction, multi-view, dimensioning and detail drawings of typical 3-D engineering objects
CO4 Develop projections, solid objects and surfaces of engineering components
CO5 Devise 3D Isometric View in relation with 2D orthographic views

Course Content:

Fundamentals Drawing standard - BIS, dimensioning, lettering, type of lines, scaling, conventions

Geometrical constructions Dividing a given straight line into any number of equal parts, bisecting a given angle, drawing a regular polygon given one side, special methods of constructing a pentagon and hexagon – conic sections – ellipse – parabola – hyperbola - cycloid.

Orthographic projection: Introduction to orthographic projection, drawing orthographic views of objects from their isometric views - Orthographic projections of points lying in four quadrants, Orthographic projection of lines parallel and inclined to one or both planes Orthographic projection of planes inclined to one or both planes. Projections of simple solids – axis perpendicular to HP, axis perpendicular to VP and axis inclined to one or both planes.

Sectioning of solids: Section planes perpendicular to one plane and parallel or inclined to other plane. **Intersection of surfaces:** Intersection of cylinder & cylinder, intersection of cylinder and cone, and intersection of prisms.

Development of surfaces: Development of prisms, pyramids, cylindrical and conical surfaces. **Isometric and perspective projection:** Isometric projection and isometric views of different planes and simple solids, introduction to perspective projection

Text Books:

1 Natrajan K.V., "A text Books of Engineering Graphics", Dhanalakshmi Publishers, Chennai, 2009.
2 Venugopal K. and Prabhu Raja V., "Engineering Graphics" New Age International (P) Limited, 2008.
3 Giesecke, F. E., Mitchell, A., Spencer, H., Hill, I., Dygdon, J., and Novak, J., "Technical

drawing with engineering graphics", 2016.

Reference Books:

1 Bhatt N.D. and Panchal V.M., "Engineering Drawing", Charotar Publishing House, 50th Edition, 2010.

2 Basant Agarwal and Agarwal C.M., "Engineering Drawing", Tata McGraw Hill Publishing Company Limited, New Delhi, 2008.

3 Shah M.B., and Rana B.C., "Engineering Drawing", Pearson, 2nd Edition, 2009.

Web link(s):

1 https://nptel.ac.in/courses/112/103/112103019/

2 http://www.iitg.ac.in/rkbc/me111.htm

Course Code	:	**EC151**
Course Title	:	**Basic Electrical and Electronics Engineering**
Number of Credits	:	**3 (2T+2L)**
Prerequisites (Course code)	:	**None**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain basic electric terminologies, laws and parameters.
CO2 Describe the basic house wiring system.
CO3 Illustrate the basic properties of semiconductor devices
CO4 Identify different electronic circuits with semiconductor devices and electrical elements
CO5 Explain the function of various digital logic gates and blocks.

Course Content:

Ohms Law -Kirchhoff's Laws - steady state solution of DC Circuits - Introduction to AC circuits - Waveforms and RMS value - power and power factor, single phase and three phase balanced circuits.

House wiring & safety: Single phase and three phase system – phase, neutral and earth, basic house wring - tools and components, different types of wiring – staircase, florescent lamp and ceiling fan, basic safety measures at home and industry.

Classification of solids based on energy hand theory - Intrinsic semiconductors - Extrinsic semiconductors - P type and N type - P-N junction – I-V characteristics of PN junction diode - Zener diode - Zener diode characteristics - Half wave and full wave rectifiers.

Bipolar junction transistor - CB, CE, CC - Configurations and characteristics - Biasing circuits - Field Effect Transistor - Configurations and characteristics - FET amplifier.

Binary number system - AND, OR, NOT, NAND, NOR circuits - Boolean algebra - Exclusive OR gate - Half and Full adders - flip flops - registers and counters - A/D, D/A conversion - Digital computer principle.

Text Books:

1 Salivahanan S, "Basic Electrical and Electronics Engineering", Tata McGraw Hill Education (India) Private Limited, New Delhi, 2013
2 V. K. Mehta, R. Mehta, "Principles of Electrical Engineering", S. Chand & Company Ltd., New Delhi, 2008.
3 Thomas Floyd, "Digital Fundamentals", Prentice Hall, 10th Edition, 2011.

Reference Books:

1 Robert L. Boylestad and Louis Nashelsky, "Electronic Devices & Circuit Theory", 11/e

Pearson, 2013.

Web link(s):

1 https://nptel.ac.in/courses/108/101/108101091/ (NPTEL Video by Dr.Mahesh B. Patil from IIT Bombay)
2 https://nptel.ac.in/courses/117/106/117106108/ (NPTEL Video by Prof. Nagendra Krishnapura from IIT Madras)

Course Code	:	**CS151**
Course Title	:	**Introduction of Python Programming**
Number of Credits	:	**3 (2T+2L)**
Prerequisites (Course code)	:	**None**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the basic data types and operations in Python programming language.
CO2 Explain the various conditional control statements and string manipulations in Python.
CO3 Discuss the advanced data types and built-in functions in Python.
CO4 Develop python programs for simple graphical applications.
CO5 Construct simple web applications using Django

Course Content:

Introduction: Installing Python; basic syntax, interactive shell, editing, saving, and running a script. The concept of data types; variables, assignments; immutable variables; numerical types; arithmetic operators and expressions; comments in the program; understanding error messages; Conditions, boolean logic, logical operators; ranges

Loops, Strings, Files : Control statements: if-else, loops (for, while); short-circuit (lazy) evaluation, String manipulations: subscript operator, indexing, slicing a string, Files; manipulating files and directories, os and sys modules; text files: reading/writing text and numbers from/to a file; creating and reading a formatted file (csv or tab-separated).

Datatypes and Functions: Lists, tuples, and dictionaries; basic list operators, replacing, inserting, removing an element; searching and sorting lists; dictionary literals, adding and removing keys, accessing and replacing values; traversing dictionaries. Design with functions: hiding redundancy, complexity; arguments and return values; formal vs actual arguments, named arguments. Recursive functions.

Graphics, Images, Classes: Simple Graphics and Image Processing: turtle module; simple 2d drawing - colors, shapes; digital images, image file formats, image processing. Simple image manipulations with 'image' module (convert to bw, greyscale, blur, etc). Classes: classes, objects, attributes and methods; defining classes; design with classes, data modeling.

Multithreading, Web development: Multithreading in Python. Concurrent threads, applications, examples. Web development; introduction to HTML, introduction to Django, models, templates, forms etc.

Text Books:

1 Kenneth Lambert, "Fundamentals of Python: First Programs", Course Technology, Cengage Learning, 2012, ISBN-13: 978-1-111-82270-5

2 Swaroop, H. “A Byte of Python”. Independent, 2013. ISBN: 9781365042911
3 Pilgrim, Mark, and Simon Willison. “Dive Into Python 3”. Vol. 2. Apress, 2009. ISBN: 9786612825347

Reference Books:

1 Beazley, David M. “Python essential reference”. Addison-Wesley Professional, 2009. ISBN: 0672329786
2 Beazley, David, and Brian K. Jones. “Python CookBooks: Recipes for Mastering Python 3”. O'Reilly Media, Inc., 2013.
3 George, Nigel. “Beginning django CMS”. Apress, 2015. ISBN: 978-1-4842-1669-9

Web link(s):

1 https://python.swaroopch.com/
2 https://goalkicker.com/PythonBooks/PythonNotesForProfessionals.pdf
3 https://www.w3schools.com/python/
4 https://diveintopython3.problemsolving.io/
5 https://docs.djangoproject.com/en/3.0/intro/tutorial01/
6 https://docs.python.org/3/

Course Code	:	**CS152**
Course Title	:	**Programme Core -I / Digital System Design**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1 Reduce Boolean Functions using KMap.

CO2 Describe the concept of combinational logic.

CO3 Analyze sequential circuits using flipflops, counters and registers.

CO4 Design a VLSI circuit for an application.

CO5 Devise complicated digital systems using Verilog.

Course Content:

Boolean Algebra and Logic Gates: Binary codes - Weighted and non-weighted - Binary arithmetic conversion algorithms, Canonical and standard boolean expressions - Truth tables, K-map reduction - Don't care conditions - Adders / Subtractors - Carry look-ahead adder - Code conversion algorithms - Design of code converters - Equivalence functions.

Combinational Logic: Binary/Decimal Parallel Adder/Subtractor for signed numbers - Magnitude comparator - Decoders / Encoders - Multiplexers / Demultiplexers - Boolean function implementation using multiplexers

Synchronous and Asynchronous Sequential Logic: Sequential logic - Basic latch - Flip-flops (SR, D, JK, T and Master-Slave) - Triggering of flip-flops - Counters - Design procedure - Ripple counters - BCD and Binary - Synchronous counters, Registers - Shift registers - Registers with parallel load, Reduction of state and flow tables - Race-free state assignment - Hazards.

VLSI: Introduction to VLSI design - Basic gate design - Digital VLSI design - Design of general boolean circuits using CMOS gates. Verilog Concepts – Basic concepts – Modules & ports & Functions – useful modeling techniques – Timing and delays – user defined primitives. Modeling Techniques.

Advanced VLSI: Advanced Verilog Concepts – Synthesis concepts – Inferring latches and flip-flops – Modeling techniques for efficient circuit design. Design of high-speed arithmetic circuits – Parallelism Pipelined Wallace tree tipliers - Systolic algorithms - Systolic matrix multiplication.

Text Books:

1 Morris Mano and Michael D. Ciletti, "Digital Design", 6th Edition, Pearson Education, 2018

2 Samir Palnitkar, "Verilog HDL", 2nd Edition, Pearson Education, 2003

3 R. P. Jain, “Modern Digital Electronics”, Fourth Edition, McGraw Hill Education, 2009.

Reference Books:

1 Michael D. Ciletti, "Advanced Digital Design with the Verilog HDL”, 2nd Edition, Pearson Education, 2010

2 Charles H. Roth Jr, Larry L. Kinney, “Fundamentals of Logic Design”, Sixth Edition, CENGAGE Learning, 2013.

3 Malvino and Leach, “Digital Principles and Applications”, Eighth Edition, McGrawHill, 2014.

Web link(s):

1 https://nptel.ac.in/courses/117/105/117105080/

2 https://freevideolectures.com/course/2319/digital-systems-design

Course Code	:	**CS153**
Course Title	:	**Programme Core – II / Data Structures**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1 Compare Time Complexity and Space Complexity for algorithm.
CO2 Develop programs to implement linear data structures such as stacks, queues, linked lists, etc.
CO3 Apply the concept of trees and graph data structures in real world scenarios.
CO4 Review sorting and searching algorithms.
CO5 Decide appropriate data structure for any practical problem.

Course Content:

Introduction: Development of Algorithms - Notations and analysis - Storage structures for arrays - Sparse matrices - Stacks and Queues: Representations and applications.

Linked list, Stacks, and Queues: Linked Lists - Linked stacks and queues - Operations on polynomials - Doubly linked lists - Circularly linked lists - Dynamic storage management - Garbage collection and compaction.

Trees: Binary Trees - Binary search trees - Tree traversal - Expression manipulation - Symbol table construction - Height balanced trees – AVL trees - Red-black trees.

Graphs: Graphs - Representation of graphs - BFS, DFS - Topological sort. String representation and manipulations - Pattern matching.

Sorting and Searching: Sorting Techniques - Selection, Bubble, Insertion, Merge, Heap, Quick, and Radix sort - Address calculation - Linear search - Binary search - Hash table methods.

Text Books:

1 J. P. Tremblay and P. G. Sorenson, "An Introduction to Data Structures with applications", Second Edition, Tata McGraw Hill, 1981
2 M. Tenenbaum and Augestien, "Data Structures using C", Third Edition, Pearson Education 2007.
3 Mark Allen Weiss, "Data Structures and Algorithm Analysis in C", 2nd edition, Addison-Wesley Educational Publishers, 2006.

Reference Books:

1 Alfred V. Aho, John E. Hopcroft, Jeffrey D.Ullman, "Data Structure and Algorithms",

Second Edition, Pearson Education, 2009
2 Sara Baase and Allen Van Gelder, “Computer Algorithms - Introduction to Design and Analysis”, Third Edition, Pearson Education, 2008.
3 Sartaj Sahni, “Data Structures, Algorithms and Applications in C++”, Universities Press (I) Pvt. Ltd.

Web link(s):

1 https://courses.cs.washington.edu/courses/cse373/20sp/
2 https://nptel.ac.in/courses/106/102/106102064/

Course Code	:	**ME152**
Course Title	:	**Energy and Environmental Engineering**
Number of Credits	:	**0**
Prerequisites (Course code)	:	**None**
Course Type	:	**GIR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Examine the impact of various types of pollution.
CO2 Discuss the methods used for waste management.
CO3 Analyze the demand for solar and thermal energy.
CO4 Identify the alternative energy resources that reduce pollution.
CO5 Evaluate the engineering applications for agriculture and irrigation.

Course Content:

Pollution: Air pollution - Sources, effects, control, air quality standards -Air pollution act, air pollution measurement. Water pollution-Sources, impacts, control, and measure –Quality of water for various purposes-Noise pollution - Sources, impacts, control, measure.

Waste Management: Pollution aspects of various industries- Impacts of fossil fuels and transport emissions – impacts - Municipal solid waste generation and management - Swachh Bharat Mission – E-waste management - Challenges and activities - Environment and forest conservation – Greenhouse gases and global warming- climate change.

Solar and Thermal Energy: Present energy resources in India and its sustainability - Different types of conventional power plants -Energy demand scenario in India - Advantage and disadvantage of conventional Power Plants – Conventional vs. non-conventional power generation - Basics of Solar Energy, Solar thermal and Solar photovoltaic systems.

Wind and Geo Thermal Energy: Power and energy from wind turbines -Types of wind turbines-Biomass resources Biomass conversion technologies- Feedstock pre-processing and treatment methods Introduction to geothermal energy and tidal energy.

Agriculture Engineering: Introduction to agriculture engineering -Major crops of India–Types and categories of Crops-Types of farming and cultivation procedures-Different monsoon seasons-Types of irrigation systems-Major draughts-Agricultural machinery-Dairy farming and its economic importance.

Text Books:

1 B. H. Khan, “Non-Conventional Energy Resources”, The McGraw –Hill Second Edition, 2009.
2 Gilbert M. Masters, “Introduction to Environmental Engineering and Science”, Prentice Hall, Second Edition, 2003.

3 G.L. Asawa, “Elementary Irrigation Engineering”, New Age International, First Edition, 2014.

Reference Books:

1 Sukhpal Singh, “Agricultural Machinery Industry in India”, Allied Publishers, New Delhi, 2010.
2 Dilip R. Shah, “Co-Operativization Liberalization and Dairy Industry in India”, A.B.D. Publishers, 2000.
3 G. Boyle, “Renewable energy: Power for a sustainable future”, Oxford University press, 2004.

Course Code	:	**CS154**
Course Title	:	**Digital Laboratory**
Number of Credits	:	**2**
Prerequisites (Course code)	:	**None**
Course Type	:	**ELR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Devise simplified combinational circuits using basic logic gates

CO2 Practice combinational circuits using MSI devices

CO3 Construct sequential circuits like registers and counters

CO4 Design multipliers using Verilog

CO5 Simulate combinational and sequential circuits using Verilog

Course Content:

Design and implementation of combinational circuits using basic gates for arbitrary functions, code converters.

Design and implement Half/Full Adder and Subtractor using MSI devices.

Design of a 32-bit carry look-ahead adder with logarithmic depth using Verilog.

Design and implement synchronous and asynchronous counters.

Design of a Wallace tree multiplier using Verilog

Design of a 4-bit DSP processor using Verilog

Burning the 4-bit DSP processor on a FPGA

Course Code	:	**CS155**
Course Title	:	**Data Structures Laboratory**
Number of Credits	:	**2**
Prerequisites (Course code)	:	**None**
Course Type	:	**ELR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Demonstrate data structures such as stacks, queues, linked lists, trees and graphs.
CO2 Practice the applications of data structures.
CO3 Design and analyze the time and space efficiency of the data structure.
CO4 Identity the appropriate sorting and searching techniques for the given problem.
CO5 Discuss different data structures to solve real-world problems.

Course Content:

Problems in C/C++/ Java using data structures involving arrays, stacks, queues, strings, linked lists, trees, graphs.

Operations on stacks, queues and linked lists

Conversion of infix expressions to postfix and evaluation of postfix expressions

Implementation of priority queue

Implementation of Binary Tree and Binary Search Tree

Implementation of Sorting Techniques

THIRD SEMESTER

Course Code	:	**CS201**
Course Title	:	**Programme Core -III / Discrete Structures**
Number of Credits	:	**4**
Prerequisites (Course code)	:	**None**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1 State basic set equalities, mappings and identify the type of relations.
CO2 Identify techniques to test the logic of a program and discuss the counting principles.
CO3 Analyze the computer algorithms using recurrence relations.
CO4 Examine the properties of algebraic structures such as groups, rings and fields.
CO5 Apply graph theory to solve the real world problems.

Course Content:

Set, Functions and Relations: Sets: Set Opertions, Countable and Uncountable Set, Functions: Mapping, Inverse, Composition, Partial and Total Function, Binary and N-Ary Operations, Relations: Properties, Representation, Closure, Equivalence Relation, Partial Orderings, Poset, Well Ordereded Set, Hasse Diagram, Maximal and Minimal Elements, Lattices, Topological Sorting

Logic and Proofs: Propositional Logic, Truth Tables, Tautologies, Contradictions, and Contingencies, Normal Forms, Propositional Equivalences, Predicates and Quantifiers, Nested Quantifiers, Rules of Inference, Introduction to Proofs, Proof Methods and Strategy.

Induction and Combinatorics: Peano's Axioms, Mathematical Induction, Strong Induction and Well Ordering; The Basics Of Counting, The Pigeonhole Principle, Permutations and Combinations, Binomial Coefficients and Identities, Generalized Permutations and Combinations, Generating Permutations and Combinations.

Recurrence Relations (RR): Introduction, Homogenous and Nonhomogenous Recurrences and Their Solutions, Solving Linear RR, Linear Homogeneous RR, Linear Nonhomogeneous RR, Generating Functions: Counting Problems and Generating Functions, Using Generating Functions to Solve RR.

Group, Ring and Field: Semi-Groups, Monoids, Groups, Subgroups and Their Properties – Cyclic Groups – Generators and Evaluation of Powers- Cosets and Lagrange's Theorem – Permutation Groups and Burnside's Theorem– Isomorphisms and Automorphisms-Homomorphisms and Normal Subgroups– Introduction to Rings, Integral Domains, and Fields.

Graph Theory: Definitions, Representation of graph by a matrix and Adjacency list, Trees,

Cycles, Properties, Paths and Connectedness, Subgraphs, Graph Isomorphism, Vertex and Edge cuts, Vertex and Edge connectivity, Euler and Hamilton paths, Operations on Graphs

Text Books:

1 Kenneth H.Rosen, "Discrete Mathematics and its Applications", McGraw Hill, Seventh Edition, 2012 (Indian Adaptation by Kamala Krithivasan, IIT Madras)

2 C.L.Liu and D.P.Mohapatra, "Elements of Discrete Mathematics: A Computer oriented Approach", McGraw Hill, Third Edition, 2012.

3 Tremblay J.P. and Manohar R, "Discrete Mathematical Structures with Applications to Computer Science", Tata McGraw Hill Pub. Co. Ltd, New Delhi, 30th Reprint, 2011.

Reference Books:

1 J.L. Mott, A. Kandel, T.P. Baker, "Discrete Mathematics for Computer Scientists and Mathematicians", Second Edition, PHI, 2008

2 Ralph. P. Grimaldi, "Discrete and Combinatorial Mathematics: An Applied Introduction", Pearson Education Asia, Delhi, 4th Edition, 2007.

3 Susanna S. Epp, "Discrete Mathematics with Applications" Cengage Learning, New Delhi, 8th Edition, 2016.

Web link(s):

1 NPTEL video lectures by Prof. Kamala Krithivasan, IIT Madras
https://www.youtube.com/playlist?list=PL8FA5147BB09B2B03

2 https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-042j-mathematics-for-computer-science-fall-2010/video-lectures/

Course Code	:	**CS202**
Course Title	:	**Programme Core -IV / Design and Analysis of Algorithms**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**Data structures**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the time and space complexity for any algorithm.
CO2 Describe divide-and-conquer techniques for solving problems.
CO3 Analyze the graphical problems related to greedy paradigm.
CO4 Apply dynamic programming, backtracking and branch & bound design technique for solving real-world problems
CO5 Evaluate NP class of problems and propose approximation algorithms for the same.

Course Content:

Introduction: What is an algorithm?, Fundamentals of Algorithmic Problem Solving, Analysis of Algorithm Efficiency -The Analysis Framework, Asymptotic Notations and Basic Efficiency Classes, Mathematical Analysis of Nonrecursive and Recursive Algorithms, Example: Computing the nth Fibonacci Number, Empirical Analysis of Algorithms, Algorithm Visualization, Recurrences- Substitution, Recursion-tree and Master method.

Divide and Conquer: Merge sort, Quicksort, Binary Tree Traversals and Related Properties, Karatsuba's Large Integer Multiplication and Strassen's Matrix Multiplication, The Closest-Pair and Convex-Hull Problems, Binary Search, Finding Maximum and Minimum, O(n) median finding algorithm.

Greedy Algorithms: Prim's and Kruskal's Algorithms for finding Minimum Spanning Tree, Dijkstra's single source shortest path algorithm, Huffman trees and codes, Knapsack Problem, Tree Vertex Splitting, Job sequencing with deadlines.

Dynamic Programming: Three Basic Examples, Knapsack Problem and Memory Functions, Optimal Binary Search Trees, Warshall's and Floyd's Algorithms, String Editing, Travelling salesperson problem, Assembly-line scheduling, Matrix-chain multiplication, Longest common subsequence.

Backtracking: n-Queens Problem, Hamiltonian Circuit Problem, Subset-Sum Problem- graph coloring problem. Branch and Bound: Assignment Problem, Knapsack Problem, Traveling Salesman Problem. Complexity classes – P, NP and NP-Complete Problems, NP-Hard, Cook's theorem- Clique Decision Problem, NP-Completeness reductions - Vertex cover- 3-CNF- clique, Hamiltonian cycle, Approximation Algorithm, Planar Graph Coloring.

Text Books:

1 Anany Levitin, "Introduction to the Design and Analysis of Algorithms", Third Edition, Pearson Education, 2012.

2 Ellis Horowitz, Sartaj Sahni and Sanguthevar Rajasekaran, "Fundamentals of Computer Algorithms", Second Edition, Universities Press, 2011.

3 Thomas H Cormen, Charles E Leiserson, Ronald L Rivest, Clifford Stein, "Introduction to Algorithms", MIT Press, Third Edition, 2010.

Reference Books:

1 Steven S. Skiena, "The Algorithm Design Manual", Second Edition, Springer, 2008.

2 M. Tenenbaum and Augestien, "Data Structures using C", Third Edition, Pearson Education 2007.

3 Jon Kleinberg, Eva Tardos, "Algorithm Design" ,Pearson Addison, Wesley, 2013.

Web link(s):

1 https://www.geeksforgeeks.org/fundamentals-of-algorithms/

2 https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-046j-introduction-to-algorithms-sma-5503-fall-2005/video-lectures/

Course Code	:	**CS203**
Course Title	:	**Programme Core -V / Programming Paradigms**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe syntax and semantics of programming languages.
CO2 Explain data, data types, and basic statements of programming languages.
CO3 Design and implement subprogram constructs.
CO4 Apply object-oriented, concurrency, and event handling programming constructs.
CO5 Develop programs in Scheme, ML, and Prolog.

Course Content:

Names, Scopes and Bindings, Control Flow: Names and Scopes, Binding Time, Scope Rules, Storage Management, Binding of Referencing Environments. Control Flow: - Expression Evaluation, Structured and Unstructured Flow, Sequencing, Selection, Iteration, Recursion, Non-determinacy.

Data Types: Type Systems, Type Checking, Records and Variants, Arrays, Strings, Sets, Pointers and Recursive Types, Lists, Files and Input/Output, Equality Testing and Assignment.

Subroutines and Control Abstraction: Subroutines and Control Abstraction: - Static and Dynamic Links, Calling Sequences, Parameter Passing, Generic Subroutines and Modules, Exception Handling, Co-routines.

Functional and Logic Languages: Lambda Calculus, Overview of Scheme, Strictness and Lazy Evaluation, Streams and Monads, Higher-Order Functions, Logic Programming in Prolog, Limitations of Logic Programming.

Data Abstraction, Object Orientation and Concurrency: Encapsulation, Inheritance, Constructors and Destructors, Aliasing, Overloading, Polymorphism, Dynamic Method Binding, Multiple Inheritance. Innovative features of Scripting Languages:-Scoping rules, String and Pattern Manipulation, Data Types, Object Orientation. Concurrency:- Threads, Synchronization. Run-time program Management:- Virtual Machines, Late Binding of Machine Code, Reflection, Symbolic Debugging, Performance Analysis.

Text Books:

1 1. Michael L. Scott, "Programming Language Pragmatics", Third Edition, Morgan Kaufmann,2009.
2 2. Robert W. Sebesta, "Concepts of Programming Languages", Tenth Edition, Addison Wesley, 2012.
3 R. Kent Dybvig, "The Scheme programming language", Fourth Edition, MIT Press,

2009.

Reference Books:

1 Jeffrey D. Ullman, “Elements of ML “, Second Edition, Prentice Hall, 1998.
2 Richard A. O, Keefe, “The craft of Prolog”, MIT Press, 2009.
3 W. F. Clocksin and C. S. Mellish, “Programming in Prolog: Using the ISO Standard”, Fifth Edition, Springer, 2003.

Web link(s):

1 https://www.ktustudents.in/2018/11/cs403-programming-paradigms-notes-textBooks-syllabus-question-papers-s7-cse.html
2 https://www.cs.bgu.ac.il/~mira/ppl-Books-full.pdf

Course Code	:	**CS204**
Course Title	:	**Programme Core -VI / Computer Organization and Architecture**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the functions of a computer.
CO2 Differentiate between representations of data.
CO3 Describe the hierarchical organization of memory.
CO4 Define the interaction between CPU and peripheral devices.
CO5 Apply parallel execution mechanism for improving CPU performance.

Course Content:

Basic functional blocks of a computer: CPU, memory, input-output subsystems, control unit. Instruction set architecture of a CPU - registers, instruction execution cycle, RTL interpretation of instructions, addressing modes, instruction set. Case study - instruction sets of some common CPUs.

Data representation: signed number representation, fixed and floating point representations, character representation. Computer arithmetic - integer addition and subtraction, ripple carry adder, carry look-ahead adder, etc. multiplication - shift-and-add, Booth multiplier, carry save multiplier, etc. Division - non-restoring and restoring techniques, floating point arithmetic.

CPU Design: Control unit design - hardwired and micro-programmed design approaches, Case study - design of a simple hypothetical CPU. Memory system design - semiconductor memory technologies, memory organization. Memory interleaving, concept of hierarchical memory organization, cache memory, cache size vs block size, mapping functions, replacement algorithms, write policy. Performance enhancement techniques.

Peripheral devices and their characteristics: Input-output subsystems, I/O transfers - program controlled, interrupt driven and DMA, privileged and non-privileged instructions, software interrupts and exceptions. Programs and processes - role of interrupts in process state transitions.

Parallel Organization: Pipelining- Basic concepts of pipelining, throughput and speedup, pipeline hazards. Multiple Processor Organizations, Closely and Loosely coupled multiprocessors systems, Symmetric Multiprocessors, Clusters, UMA NUMA, Vector Computations, RISC: Instruction execution characteristics,, RISC architecture and pipelining. RISC Vs CISC.

Text Books:

1 William Stallings, “Computer Organization and Architecture”, 8 th Edition, Pearson Education, 2010.
2 V. Carl Hamacher, Zvonko G. Varanesic, and Safat G. Zaky, “Computer Organization”, 6th edition, McGraw-Hill Inc, 2012.
3 Smruti Ranjan Sarangi, “Computer Organization and Architecture”, McGraw Hill Education, 2015.

Reference Books:

1 David A. Patterson and John L. Hennessey, “Computer organization and design, The Hardware/Software interface”, Morgan Kauffman / Elsevier, Fifth edition, 2014.
2 G. George, “Computer Organization: Hardware and Software”, 2nd Edition, Prentice Hall of India, 1986.
3 J. Hays, “Computer Architecture and Organization”, 2nd Edition, McGraw-Hill, 1988.

Web link(s):

1 https://nptel.ac.in/courses/106/105/106105163/
2 https://nptel.ac.in/courses/106/103/106103068/

Course Code	:	**CS205**
Course Title	:	**Programme core – VII / Object oriented programming (C++)**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1 Develop programs efficiently using basic features of C++.

CO2 Employ object oriented concepts using classes and objects.

CO3 Explain advanced features of C++ specifically Polymorphism and Inheritance.

CO4 Design programs with dynamic binding to handle the memory efficiently.

CO5 Apply standard templates available in C++.

Course Content:

Introduction: Introduction to Objects, Encapsulation, Polymorphism, Inheritance, Dynamic binding, Message Passing, Abstract Classes, Access Modifiers. Basics of a Typical C++ Environment, Pre-processor Directives, Header Files and Namespaces, Library files.

Classes and Data Abstraction: Introduction, Structures - Class - Constructors - Destructors, Const Object And Const Member Functions - Friend Function and Friend Classes, Using This Pointer, Dynamic Memory Allocation, Static Class Members, Container Classes And Integrators, Proxy Classes.

Polymorphism and Inheritance: Polymorphism - Function Overloading, Operator Overloading, Inheritance and its types, Casting - Overriding.

Virtual Functions and Files handling: Introduction to Virtual Functions - Abstract Base Classes and Concrete Classes - virtual base class - dynamic binding - pure virtual functions. Streams and formatted I/O- File handling - object serialization, namespaces - String - STL.

Templates and Exception Handling: Function Templates, Overloading Template Functions, Class Template. Exception Handling: Try, Throw, Catch, Rethrow - Exception specifications.

Text Books:

1 Bjarne Stroustrup, "The C++ Programming Language", Third Edition, Pearson Education, 2000.

2 Robert Lafore, "Object Oriented Programming in C++", Fourth Edition, Sams Publishers, 2001.

3 P.J. Deitel, “C++ How to Program”, Prentice-Hall of India Pvt Ltd., Sixth edition, 2013.

Reference Books:

1 E. Balagurusamy, “Object Oriented Programming with C++”, McGraw Hill Company Ltd., 2013.

2 B. Trivedi, “Programming with ANSI C++”, Oxford University Press, 2012.

3 Ira Pohl, “Object Oriented Programming using C++”, Pearson Education, Second Edition, Reprint 2013.

Web link(s):

1 https://nptel.ac.in/courses/106/105/106105151/

2 www.w3schools.com

Course Code	:	**CS206**
Course Title	:	**Design and Analysis of Algorithms Laboratory**
Number of Credits	:	**2**
Prerequisites (Course code)	:	**DS**
Course Type	:	**ELR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Evaluate the complexity of algorithms.
CO2 Analyze internal and external sorting algorithms using divide and conquer technique.
CO3 Demonstrate graph and string algorithms.
CO4 Apply fundamental algorithms and data structures to real-world problems.
CO5 Design, develop, and optimize algorithms in different paradigms.

Course Content:

Estimating worst-case/average-case complexity of algorithms via programs,
a) Linear and binary search algorithm
b) Basic sorting methods
Implementation of Sorting Algorithms using Divide Conquer Technique.
i) Quick Sort
ii) Merge Sort
iii) Heap Sort
Implementation of Binary Search Tree Algorithm using Divide Conquer Technique.
Implementation of Minimum Spanning Tree using Prim's and Kruskal's Algorithm.
Implementation of Knapsack Problem using Greedy method.
Implementation of Single source shortest path algorithm using greedy method.
Implementation of All Pair Shortest Path Algorithm using Floyd's Algorithm.
Implementation of Matrix-chain multiplication and Longest common subsequence
Implementation of Travelling Salesman Problem using Dynamic Programming
Implementation of 0/1 Knapsack using dynamic programming.
Implementation of 8 Queen's Problem using Backtracking Algorithm.
Implementation of Subset-Sum Problem using Backtracking Algorithm.
Implementation of 0/1 Knapsack using branch and bound programming.

Course Code	:	**CS207**
Course Title	:	**Programming Paradigms Laboratory**
Number of Credits	:	**2**
Prerequisites (Course code)	:	**None**
Course Type	:	**ELR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe syntax and semantics of programming languages.
CO2 Explain data, data types, and basic statements of programming languages.
CO3 Design and implement subprogram constructs.
CO4 Apply object-oriented, concurrency, and event handling programming constructs.
CO5 Develop programs in Scheme, ML, and Prolog.

Course Content:

Programs to determine type compatibility rules of a C compiler
Program to determine the scope of variables having the same name and different names declared within a while / for loop
Program that behaves differently if name equivalence is used against structural equivalence
Program to determine the factors in passing a large array by reference and the same using value
Program that determines whether it is legal to call a function that has been passed by passing a pointer to it to another function
Devise a subprogram and calling code in which pass-by-reference and pass-by-value-result of one or more parameters produces different results
Design a skeletal program and a calling sequence that results in an activation record instance in which the static and dynamic links point to different activation recorded instances in the run-time stack
Implementation of Functional programming (Scheme, Lisp, ML)
Implementation of Logic programming (Prolog)
Implementation of Imperative programming (ALGOL-60, Pascal, C)

Course Code	:	**CS208**
Course Title	:	**OOPS laboratory**
Number of Credits	:	**2**
Prerequisites (Course code)	:	**None**
Course Type	:	**ELR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Design and test programs to solve mathematical and scientific problems

CO2 Practice code reusability with inheritance property

CO3 Perform various operations on operators with polymorphism

CO4 Use standard template library for efficient programming.

CO5 Apply exception handling techniques to manage runtime exceptions.

Course Content:

Programs on basic C++ features.
Programs on Classes and Objects.
Programs on Inheritance.
Programs on Polymorphism and Virtual Functions.
Programs on File handling.
Programs on Templates
Programs on Exception Handling.

FOURTH SEMESTER

Course Code	:	**MA251**
Course Title	:	**Probability, Statistics and Queuing theory**
Number of Credits	:	**4**
Prerequisites (Course code)	:	**None**
Course Type	:	**GIR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the fundamental concepts of probability.
CO2 Interpret the concept of random variable to perform regression analysis.
CO3 Examine the distribution of data through various methods.
CO4 Test the hypothesis for large and small samples
CO5 Solve queuing theory problems relevant to engineering applications.

Course Content:

Introduction: Review of fundamental concepts of probability, Conditional Probability - Baye's Rule - illustrations

Random Variable: Concept of a random variable - probability functions, density and distribution functions, mean and variance, Moments and Moment generating function. Probability mass function, Density function, Distribution function – function of two random variables - Covariance – Correlation and Regression analysis

Distributions: Bernoulli Trials – Binomials Distribution – Poisson Distribution–Geometric and Hypergeometric distributions. Continuous Uniform Distribution, Exponential distribution, Gamma distribution, Normal Distribution, Areas under the Normal Curve, Applications of the Normal Distribution.

Estimation & Tests of Hypotheses: Introduction, Statistical Inference, Classical Methods of Estimation.: Estimating the Mean, Standard Error of a Point Estimate, Prediction Intervals, Tolerance Limits, Estimating the Variance, Estimating a Proportion for single mean, Difference between two Means, between two Proportions for two Samples and Maximum Likelihood Estimation. Statistical Hypotheses: General Concepts, Testing a Statistical Hypothesis, Tests Concerning a Single Mean, Tests on two Means, Test on a Single Proportion, Tests on Two Proportions - Time series analysis

Queuing theory: Elements of Queuing model, Exponential distribution, Pure Birth and Pure Death Models, M/M/1 model with finite capacity and infinite capacity.

Text Books:

1 S C Gupta and V K Kapoor, “Fundamentals of Mathematical statistics”, Khanna

publications.
2 Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers, Keying Ye, “Probability & Statistics for Engineers & Scientists”, 9th edition, Pearson Publishers.

Reference Books:

1 T.T. Soong, “Fundamentals of Probability And Statistics For Engineers”, John Wiley & Sons Ltd, 2004.
2 S. D. Sharma, “Operations Research”, Kedarnath and Ramnath Publishers, Meerut, Delhi
3 A. O. ALLEN, “Introduction to Probability, Statistics and Queueing Theory with Computer Science Applications”, Academic Press, 2006 reprint.

Web link(s):

1 https://nptel.ac.in/courses/111/104/111104032/

2 https://nptel.ac.in/courses/111/104/111104098/

Course Code	:	**HM251**
Course Title	:	**Economics for Engineers**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**GIR**

Course outcomes: At the end of the course, the student will be able to:

CO1	Explain the various forms of Business and define the impact of economic variables.
CO2	Perform demand and supply analysis.
CO3	Analyze production function, cost analysis, pricing methods suitable for different market structures.
CO4	Review the elements of Financial Statements and prepare Final Accounts.
CO5	Discuss and interpret the framework for financial analysis through ratios.

Course Content:

Introduction to Business and Economics: Business: Structure of Business Firm, Theory of Firm, Types of Business Entities, Limited Liability Companies, Sources of Capital for a Company, Non-Conventional Sources of Finance. Economics: Significance, Micro and Macro Economic Concepts, Concepts and Importance of National Income, Inflation, Money Supply in Inflation, Business Cycle, Features and Phases of Business Cycle. Nature and Scope of Business Economics, Role of Business Economist, Multidisciplinary nature of Business Economics.

Demand and Supply Analysis: Demand and Supply Analysis: Determinants, Law of Demand and supply and its exceptions. Elasticity of Demand and Supply: Definition, Types, Measurement and Significance of Elasticity of Demand and Supply. Demand and Supply Forecasting, Methods of forecasting, Factors governing forecasting

Production, Cost, Market Structures & Pricing: Production Function - Isoquants and Isocosts, MRTS, Least Cost Combination of Inputs, Cobb-Douglas Production function, Laws of Returns, Economies of Scale. Cost analysis: Concepts, Types, Short run and Long run Cost Functions, Break Even Analysis (BEA), Determination and Limitations. Market Structures: Nature of Competition and Markets, Features of Perfect competition, Monopoly, and Monopolistic Competition. Pricing: Types of Pricing, Product Life Cycle based Pricing

Financial Accounting: Financial accounting objectives, functions, importance, Accounting concepts and Conventions, Double-Entry system of Accounting, Rules for maintaining Bookss of Accounts, Journal, Posting to Ledger, Preparation of Trial Balance, Elements of Financial Statements, Preparation of Final Accounts.

Financial Analysis through Ratios: Concept of Ratio Importance, Analysis, and interpretation of Liquidity Ratios, Activity ratio, Turnover Ratios, Profitability Ratios, Proprietary Ratios, Leverage Ratios – Analysis and Interpretation (simple problems).

Text Books:

1 Dhanesh K Khatri, “Financial Accounting”, Tata McGraw Hill, 2011.
2 Robert Pindyck, and Daniel Rubinfeld, “Microeconomics”, 9th Edition,Pearson, 2018
3 Geethika Ghosh, Piyali Gosh, Purba Roy Choudhury, Managerial Economics, 2e, Tata McGraw Hill Education Pvt. Ltd. 2012.

Reference Books:

1 Paresh Shah, “Financial Accounting for Management”, 2e, Oxford Press, 2015.
2 Lipsey & Chrystel, “Economics”, Oxford University Press, 2012.
3 S. N. Maheshwari, Sunil K Maheshwari, Sharad K Maheshwari, Financial Accounting, 5e, Vikas Publications, 2013.

Web link(s):

1 https:// thenthata.web4kurd.net/mypdf/managerial-economics-and- financialanalysis
2 https://open.umn.edu/opentextBookss/textBookss/principles-of-microeconomics

Course Code	:	**CS251**
Course Title	:	**Programme Core -VIII / Data Communication and Networks**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the basic concepts of data communication and computer networks
CO2 Articulate the components required to build different types of networks.
CO3 Apply routing and congestion control algorithms.
CO4 Identify the lacunae in the existing protocols of various layers of the protocol Stack and propose mechanisms to overcome the gaps.
CO5 Create communication between hosts.

Course Content:

Data Communications and Computer Networks: Data Communications, Networks, Protocols and Standards – Analog and Digital, Periodic Analog Signals, Digital Signals, Transmission Impairment, Data Rate Limits, Performance, Uses of Computer Networks, Network Hardware, Network Software, Reference Models, Example Networks

Physical Layer and Data Link Layer: Digital Transmission, Analog Transmission, Multiplexing, Guided Transmission Media, Wireless Transmission, Communication Satellites, Switching, PSTN, Mobile Telephone System. Data Link Layer Design Issues, Error Detection and Correction, Elementary Data Link Protocols, Sliding Window Protocols.

MAC and Network Layer: Channel Allocation Problem, Multiple Access Protocols, Ethernet, Wireless LANs, Broadband Wireless, Bluetooth, RFID, Data Link Layer Switching. Network Layer Design Issues, Routing Algorithms, Congestion Control Algorithms, Quality of Service, Internetworking, Network Layer in the Internet.

Transport Layer: Transport Service, Elements of Transport Protocols, Congestion Control, UDP, TCP, Performance Issues, Delay-Tolerant Networking.

Application Layer: DNS, Electronic Mail, World Wide Web, Streaming Audio And Video, Content Delivery

Text Books:

1 Andrew S. Tanenbaum and David J. Wetherall, "Computer Networks", 5th edition, Prentice Hall, 2011
2 Behrouz A. Foruzan, "Data Communication and Networking", 5th edition, Science Engineering& Math Publications, 2013

3 Larry L. Peterson and Bruce S. Davie, “Computer Networks: A Systems Approach”, Fifth Edition, Morgan Kaufmann Publishers Inc., 2012.

Reference Books:

1 W. Stallings, "Data and Computer Communication", 10th Edition, Pearson Education, 2014

Web link(s):

1 Lecture Series on Data Communication by Prof.A. Pal, Department of Computer Science Engineering,IIT Kharagpur: https://nptel.ac.in/courses/106/105/106105082/
2 https://nptel.ac.in/courses/106/106/106106091/

Course Code	:	**CS252**
Course Title	:	**Programme Core - IX / Operating Systems**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the services rendered by operating systems.
CO2 Apply the various scheduling policies and provide solutions for critical section and deadlock problems.
CO3 Describe the various memory management techniques.
CO4 Discuss the file-system design and its implementation issues.
CO5 Examine the advantages of distributed systems.

Course Content:

Introduction: Need for Operating Systems – Computer Systems – OS Structures - OS Operations, -Abstract view of OS – Computing Environments – OS Services - System Calls– Building and Booting OS, Virtualization.

Process Management: Process –Threads –Multithreading - Process Scheduling- Process Co-ordination –Synchronization –Semaphores –Monitors –Deadlocks –Methods for Handling Deadlocks.

Memory Management: Memory Management Strategies –Contiguous memory allocation – Segmentation – Paging -Virtual memory Management –Demand Paging- Page Replacement Policies – Allocation of frames – Thrashing – Memory mapped files – Allocating kernel memory.

Storage Management: Mass Storage Structure –Disk Scheduling –Disk Management – RAID - File System –Basic concepts - File System design and Implementation —I/O Systems- Kernel I/O subsystem - System Protection and Security.

Distributed Systems: Distributed Systems –Distributed operating systems –Distributed file systems –Distributed Synchronization, Case study on LINUX and Windows OS.

Text Books:

1 Silberschatz, Galvin, Gagne, "Operating System Concepts", John Wiley and Sons, Tenth edition, 2018.
2 William Stallings, "Operating Systems –Internals and Design Principles", 8/E, Pearson Publications, 2014.
3 Andrew S. Tanenbaum, "Modern Operating Systems", 4/E, Pearson Publications, 2014.

Reference Books:

1 Dhananjay M. Dhamdhere, "Operating Systems - A Concept-Based Approach", Tata McGraw-Hill Education, Third Edition, 2012.

2 Charles Crowley, "Operating Systems -Design Oriented Approach", Mc. Graw Hill Education, First edition, 2017.

Web link(s):

1 https://nptel.ac.in/courses/106/105/106105214/

2 https://www.youtube.com/playlist?list=PLGvfHSgImk4Y6htSDkXHZWTaC99rz_ApY

Course Code	:	**CS253**
Course Title	:	**Programme Core - X / Automata and Formal Languages**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**Discrete Structures**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1 Classify languages based on Chomsky hierarchy
CO2 Design finite automata or Type x grammar
CO3 Identify the equivalence of the different language representations within a class of the Chomsky hierarchy
CO4 Devise Turing machine for any language.
CO5 Conclude the decidable / undecidable nature of any language.

Course Content:

Finite Automata: Alphabets, Strings and Languages; Automata and Grammars, Deterministic finite Automata (DFA)-Formal Definition, Simplified notation: State transition graph, Transition table, Language of DFA, Nondeterministic finite Automata (NFA), NFA with epsilon transition, Language of NFA, Equivalence of NFA and DFA, Minimization of Finite Automata, Distinguishing one string from other, Myhill-Nerode Theorem.

Regular Expression (RE): Definition, Operators of regular expression and their precedence, Algebraic laws for Regular expressions, Kleen's Theorem, Regular expression to FA, DFA to Regular expression, Arden Theorem, Non Regular Languages, Pumping Lemma for regular Languages. Application of Pumping Lemma, Closure properties of Regular Languages, Decision properties of Regular Languages, FA with output: Moore and Mealy machine, Equivalence of Moore and Mealy Machine, Applications and Limitation of FA.

Context Free Grammar (CFG) and Context Free Languages: Definition, Examples, Derivation, Derivation trees, Ambiguity in Grammar, Inherent ambiguity, Ambiguous to Unambiguous CFG, Useless symbols, Simplification of CFGs, Normal forms for CFGs: Chomsky Normal Form (CNF) and Greibach Normal Form (GNF), Closure properties of CFLs, Decision Properties of CFLs: Emptiness, Finiteness and Membership, Pumping lemma for CFLs.

Push Down Automata (PDA): Description and definition, Instantaneous Description, Language of PDA, Acceptance by Final state, Acceptance by empty stack, Deterministic PDA, Equivalence of acceptance by empty stack and final state, Conversion of CFG to PDA and PDA to CFG.

Turing machines (TM) and Undecidability: Basic model, definition and representation, Instantaneous Description, Language acceptance by TM, Variants of Turing Machine, TM as Computer of Integer functions, Universal TM, Church's Thesis, Recursive and recursively

enumerable languages, Halting problem, Introduction to Undecidability, Undecidable problems about TMs. Post correspondence problem (PCP), Modified PCP and undecidable nature of post correspondence problem. Introduction to recursive function theory.

Text Books:

1 John Hopcroft, Rajeev Motwani and Jeffrey Ullman,"Introduction to Automata Theory, Languages and Computation", Pearson Education, 3rd edition, 2014

2 Micheal Sipser, "Introduction of the Theory and Computation", Thomson Brokecole, 1997.

3 K.Krithivasan and R.Rama, "Introduction to Formal Languages, Automata Theory and Computation", Pearson Education, 2009

Reference Books:

1 Mishra K L P and Chandrasekaran N, "Theory of Computer Science - Automata, Languages and Computation", Third Edition, Prentice Hall of India, 2004.

2 Peter Linz, "An Introduction to Formal Language and Automata", Narosa Pub. House, 2011

3 Martin J. C., "Introduction to Languages and Theory of Computations", TMH, 4th edition, 2010

Web link(s):

1 NPTEL videos by Prof. Kamala Krithivasan, Department of Computer Science and Engineering, IIT Madras: https://www.youtube.com/playlist?reload=9&list=PLwi7ySzY5bVKn6gPAEHzWC0hQ0Q0nvsA6

2 NPTEL videos by IIT Guwahati: https://freevideolectures.com/course/3379/formal-languages-and-automata-theory/10

Course Code	:	**CS254**
Course Title	:	**Programme Core - XI / Microprocessor and Microcontrollers**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**Digital Systems Design**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the architecture of 8086 microprocessor.
CO2 Review I/O circuits and Memory Interfacing circuits 8086 processor.
CO3 Discuss the components of ARM processor.
CO4 Develop program using instructions available in ARM processor.
CO5 Use ARM processor for IoT applications.

Course Content:

8086 Microprocessor: Introduction to 8086 – Microprocessor architecture – Addressing modes - Instruction set and assembler directives – Assembly language programming – Modular Programming - Linking and Relocation - Stacks - Procedures – Macros – Interrupts and interrupt service routines – Byte and String Manipulation

8086 System Bus Structure: 8086 signals – Basic configurations – System bus timing –System design using 8086 – IO programming – Introduction to Multiprogramming – System Bus Structure – Multiprocessor configurations – Coprocessor, Closely coupled and loosely Coupled configurations – Introduction to advanced processors.

ARM processor fundamentals: Introduction to microprocessors and microcontrollers, 8-bit and 16- bit, von Neumann and Harvard architectures, CISC and RISC architectures, open source core (LEOX)-Architecture-Data types-Processor Modes-Registers-program Status Registers-The Vector Table-Exercises-Addressing Modes –ARM V4T Instructions Set -Assembler Rules and Directives. Case Study for Beagle Bone Black Kit.

Programming in ARM processor: Loads, Stores and Addressing-Constants and Literal Pools-Logic and Arithmetic-Loops and Branches-Subroutines and Stacks-Memory-Mapped Peripherals

CPUs: Input/output mechanisms, isolated and memory mapped IO; interrupts and real time operations, ARM interrupts vectors, priorities and latency; supervisor modes, exceptions, traps, co-processors; cache memory and memory management. Exception Handling-Thumb-Inline Assembler-Embedded Assembler-Running Keil Tools-Embedded and IoT Applications

Text Books:

1 Yu-Cheng Liu, Glenn A.Gibson, "Microcomputer Systems: The 8086 / 8088 Family - Architecture, Programming and Design", Second Edition, Prentice Hall of India, 2009
2 William Hohl, "ARM Assembly Language fundamentals and Techniques", 2012

3 W. Wolf, Computers as components: Principles of embedded computing system design, 2nd Ed., Elsevier, 2008.

Reference Books:

1 A. N. Sloss, D. Symes and C. Wright, ARM system developer's guide: Designing and optimizing system software, Elsevier, 2008.
2 Andrew N. Sloss, Dominic Symes, Chris Wright and John Rayfield, “ARM System Developer's Guide, Designing and Optimizing System Software”, Elsevier, 2004.
3 David Seal, “ARM Architecture Reference Manual”, Pearson Education, 2007.

Web link(s):

1 https://nptel.ac.in/courses/108/105/108105102/

Course Code	:	**CS255**
Course Title	:	**Operating Systems laboratory**
Number of Credits	:	**2**
Prerequisites (Course code)	:	**None**
Course Type	:	**ELR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Practice various UNIX commands.
CO2 Create multithread applications using Pthread.
CO3 Demonstrate various CPU scheduling algorithms and measure its performance.
CO4 Apply synchronization techniques to solve critical section problems.
CO5 Employ memory management techniques efficiently.

Course Content:

Hands on Unix Commands
Shell programming for file handling
Shell Script programming using the commands grep, awk, and sed
Programs on Multithread using Pthread
Implementation of CPU scheduling algorithms
Implementation of Synchronization problems using Semaphores, Message Queues and Shared Memory
Implementation of Bankers algorithm for deadlock avoidance
Implementation of Memory Management - Allocation, Placement and replacement Algorithms
Implementation of various Disk scheduling algorithms

Course Code	:	**CS256**
Course Title	:	**Microprocessors and Microcontrollers Laboratory**
Number of Credits	:	**2**
Prerequisites (Course code)	:	**None**
Course Type	:	**ELR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Write programs in assembly language using 8086 trainer kits.
CO2 Use Interface development kits effectively for connecting various peripheral devices with the microprocessor.
CO3 Develop programs using Beagle Bone Black kit.
CO4 Employ Beagle Bone Black for the real time applications using peripheral devices.
CO5 Assemble and validate hardware devices.

Course Content:

Solving problems using 8086 Microprocessor.
Interfacing 8255 Programmable parallel I/O device with 8086 microprocessor.
Interfacing A.D convertor, D/A convertor with 8086 microprocessor.
Interfacing A.D convertor, D/A convertor with 8086 microprocessor.
Solving 8086 procedure and macro oriented programs in Turbo Assembler TASM.
Solving problems using Beagle Bone Black.
Interfacing Beagle Bone Black with peripheral devices.
PC hardware assembly, Installation and trouble shooting.

FIFTH SEMESTER

Course Code	:	**MA301**
Course Title	:	**Operations Research**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**GIR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Identify input-output-parameters of the real problems and formulate their relationships.
CO2 Determine optimal solutions for transportation problem.
CO3 Solve sequencing problems using graphical method.
CO4 Analyze queuing theory problems relevant to engineering applications.

Course Content:

Linear Programming: Formulation of LPP, Simplex method, Big-M method. Solution in case of unrestricted variables. Dual linear programming problem. Solution of the primal problem from the solution of the dual problems.

Transportation Problems: Balanced and unbalanced Transportation problems. Initial basic feasible solution using N-W corner rule, row minimum method, column minimum, least cost entry method and Vogel's approximation method. Optimal solutions. Degeneracy in Transportation problems.

Game Theory And Sequencing: Two Person Zero Sum Game, Pure and Mixed Strategies, Algebraic Solution Procedure, Graphical Solution, Solving by Linear Programming; Sequencing Problem, Processing of n Jobs Through Two Machines and m Machines, Graphical Method of Two Jobs m Machines Problem

Queueing Theory: Poisson process and exponential distribution. Pure Birth Death Model, Poisson queues – Model (M/M/1), (M/M/C) and its characteristics.

Elements of Inventory Control: Economic lot size problems, Fundamental problems of EOQ. The problem of EOQ with finite rate of replenishment. Problems of EOQ with shortages, production instantaneous, replenishment of the inventory with finite rate. Stochastic problems with uniform demand.

Text Books:

1 Kanti Swarup, Man Mohan and P.K.Gupta, "Introduction to Operations Research", S.Chand & Co., 2006
2 J.C.Pant, "Introduction to Operations Research", Jain Brothers, New Delhi, 2008.

Reference Books:

1 H.A.Taha, "Operations Research: An Introduction", 7th edition, Person Education, Asia, New Delhi, 2002.
2 N.S.Kambo, "Mathematical Programming Techniques", East-West Pub., Delhi, 1991.
3 B.S. Grewal, "Higher Engineering Mathematics", Khanna Publications, 44nd ed, 2015.

Web link(s):

1 https://nptel.ac.in/courses/111/107/111107128/

2 https://nptel.ac.in/courses/111/104/111104027/

Course Code	:	**CS301**
Course Title	:	**Programme Core - XII / Compiler Design**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**Automata and Formal Languages**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1 Develop scanner and parser using LEX & YACC tool.

CO2 Apply different parsing algorithms to develop the parsers for a given grammar.

CO3 Recommend the necessity for appropriate code optimization techniques.

CO4 Conclude the appropriate code generator algorithm for a given source language.

CO5 Design a compiler for any programming language.

Course Content:

Introduction to Compiling: Compilers – Analysis of the source program – Phases of a compiler – Compiler construction tools – Lexical Analysis – Role of Lexical Analyzer – Input Buffering – Specification of Tokens, – Recognition of Tokens – Lex – Finite Automata – Regular Expressions to Automata – Minimizing DFA.

Syntax Analysis: Role of the parser – Grammars –Context-Free Grammars – Top Down parsing – Recursive Descent Parsing – Predictive Parsing – Bottom-up parsing – Shift Reduce Parsing – Operator Precedent Parsing – LR Parsers – SLR Parser – Canonical LR Parser – LALR Parser - YACC

Intermediate Code Generation: Syntax Directed Definitions, Evaluation Orders for Syntax Directed Definitions, Intermediate Languages: Syntax Tree, Three Address Code, Types and Declarations, Translation of Expressions, Type Checking.

Run Time Environments and Code Generation: Storage Organization, Stack Allocation Space, Access to Non-local Data on the Stack, Heap Management – Issues in Code Generation – Design of a simple Code Generator.

Code Optimization: Introduction– Principal Sources of Optimization – Peep-hole optimization – DAG- Optimization of Basic Blocks-Global Data Flow Analysis – Efficient Data Flow Algorithm.

Text Books:

1 Alfred V. Aho, Jeffrey D Ullman, S. Lam, and Ravi Sethi, “Compilers: Principles, Techniques and Tools”, Pearson Education, 2015

2 Jean Paul Tremblay, Paul G Serenson, "The Theory and Practice of Compiler Writing", BS Publications, 2005

3 Dhamdhere, D. M., "Compiler Construction Principles and Practice", 2nd edition, Macmillan India Ltd., New Delhi,2008

Reference Books:

1 Allen I. Holub, “Compiler Design in C”, Prentice Hall of India,2003

2 C. N. Fischer and R. J. LeBlanc, “Crafting a compiler with C”, Benjamin Cummings, 2003

3 HenkAlblas and Albert Nymeyer, “Practice and Principles of Compiler Building with C”, PHI,2001

Web link(s):

1 https://nptel.ac.in/courses/106/105/106105190/

2 https://freevideolectures.com/course/3051/compiler-design

Course Code	:	**CS302**
Course Title	:	**Programme Core - XIII /Database Management Systems**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the architecture of relational database management system.

CO2 Apply the basics of SQL and construct queries using SQL.

CO3 Design the database with normalization techniques.

CO4 Describe transaction concurrency techniques and employ optimal query processing.

CO5 Develop an efficient storage scheme for saving and retrieving Records and Files.

Course Content:

Introduction: Purpose of Database System -– Views of data – data models, database management system, three-schema architecture of DBMS, components of DBMS. E/R Model - Conceptual data modeling, entities, entity types, attributes, relationships, relationship types, E/R diagram notation, examples.

Relational Model: Relational Data Model - Concept of relations, schema-instance distinction, keys, referential integrity and foreign keys, relational algebra operators, SQL - Introduction, data definition in SQL, table, Data Manipulation in SQL, Querying in SQL- aggregation functions group by and having clauses, embedded SQL, PL/SQL, Triggers. Introduction to NoSQL.

Database Design: Dependencies and Normal forms, dependency theory - functional dependencies, Armstrong's axioms for FD's, closure of a set of FD's, minimal covers, Normal Forms - 1NF, 2NF, 3NF and BCNF, 4NF, 5NF, decompositions and its desirable properties.

Transactions and Query Processing: Transaction Management - ACID properties, Concurrency control – Schedules - Serializability, Locking Protocols, Recoverability, Query Processing and optimization, Database Recovery methods.

Storage and Indexing: Data Storage and Indexes - file organizations, primary, secondary index structures, various index structures - hash-based, dynamic hashing techniques, multi-level indexes, B+ trees.

Text Books:

1 A. Silberschatz, Henry F. Korth, and S. Sudharshan, "Database System Concepts", 7th Edition, Tata McGraw Hill, 2010

2 C. J. Date, A. Kannan and S. Swamynathan, "An Introduction to Database Systems", 8th Edition, Pearson Education, 2006.

3 RamezElmasri and Shamkant B. Navathe, "Fundamentals of Database Systems", 7th Edition, Pearson Education, 2015

Reference Books:

1 Raghu Ramakrishnan, "Database Management Systems", Third Edition, McGraw Hill,2002.

2 K. Singh, "Database Systems Concepts, Design and Applications", First Edition,Pearson Education, 2006.

3 Peter Rob and Carlos Coronel, "Database System- Design, Implementation and Management",7th edition, Cengage Learning, 2007.

Web link(s):

1 https://nptel.ac.in/courses/106/105/106105175/

2 https://freevideolectures.com/course/2668/database-management-system

Course Code	:	**CS303**
Course Title	:	**Programme Core - XIV /Artificial Intelligence**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the basic concepts of Artificial Intelligence.
CO2 Analyze the structures and search strategies for state space search methods.
CO3 Explain the implementation of various Stochastic Methods.
CO4 Employ artificial intelligence based knowledge representation and reasoning techniques for problem solving.
CO5 Apply the concept of artificial intelligence based expert systems to deal with current challenges of real world applications.

Course Content:

Introduction: History of AI, Intelligence, Knowledge, and Human artifice, Overview of AI application Areas –Propositional Calculus, Predicate Calculus, Using Inference Rules to Produce Predicate Calculus Expressions, Application: A Logic-Based Financial Advisor.

Structures and search strategies for state space search: Defining problem as a state space search, Production system, Problem characteristics, Production system characteristics, Issues in the design of search programs, Graph Theory, Strategies for State Space Search, Using the State Space to Represent Reasoning with the Predicate Calculus, Hill Climbing and Dynamic Programming, The Best-First Search Algorithm, Admissibility, Monotonicity, and Informedness, Using Heuristics in Games, Complexity Issues.

Stochastic Methods and Implementation: Elements of Counting, Elements of Probability Theory, Applications of the Stochastic Methodology, Bayes' Theorem, Recursion– Based Search, Production Systems, Blackboard Architecture for Problem Solving

Representation and Reasoning; Knowledge Representation issues, Using Predicate logic, Representing knowledge using rules, Symbolic reasoning under uncertainty, A Brief History of AI Representational Systems, Conceptual Graphs: A Network Language, Alternative Representations and Ontologies Agent Based and Distributed Problem Solving.

Case Study: Applications of AI, Natural Language Processing, Computer Vision, Robotics.

Text Books:

1 G. Luger, "Artificial Intelligence, Structures and Strategies for Complex Problem Solving", Sixth Edition, Addison-Wesley Pearson, 2008.

2 Elaine Rich and Kevin Knigh, “Introduction to Artificial Intelligence”, McGraw Hill, Third Edition, 2017.
3 Stuart Russel and Peter Norvig, “AI – A Modern Approach”, Pearson Education, Fourth Edition, 2020.

Reference Books:

1 Michael Negnevitsley, Artificial Intelligence: A guide to Intelligent Systems, Addison Wesley, Third Edition, 2017.
2 Peter Jackson, “Introduction to Expert Systems”, 3rd Edition, Pearson Education, 2007
3 C.S. Krishnamoorthy and S. Rajeev, “Artificial Intelligence and Expert Systems for Engineers”, CRC Press, 1996.

Web link(s):

1 https://towardsdatascience.com/artificial-intelligence/home
2 https://dzone.com/articles/the-beginners-guide-to-artificial-intelligence

Course Code	:	**CS304**
Course Title	:	**Compiler Design Laboratory**
Number of Credits	:	**2**
Prerequisites (Course code)	:	**Compiler Design**
Course Type	:	**ELR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Practice the working principles of a compiler.

CO2 Design and implement lexical analyzer using LEX, YACC tools.

CO3 Apply various parsing techniques.

CO4 Demonstrate simple code generation techniques.

CO5 Design a compiler for any programming language..

Course Content:

Implementation of symbol table.

Design of lexical analyzers and parsers like recursive-descent parser for a block structured language with typical constructs .

Exercises using LEX and YACC.

Program on Left Recursion elimination and Left factoring, SLR, and LALR.

Implement Intermediate code generation for simple expressions.

Quadruples/Triples generation using LEX and YACC for a subset of a block structured language.

Implementation of simple code optimization techniques

Course Code	:	**CS305**
Course Title	:	**DBMS Laboratory**
Number of Credits	:	**2**
Prerequisites (Course code)	:	**None**
Course Type	:	**ELR**

Course outcomes: At the end of the course, the student will be able to:

CO1	Create and manipulate database using SQL statements.
CO2	Write queries efficiently according to user needs.
CO3	Apply PL/SQL blocks for handling database.
CO4	Design GUI to access database.
CO5	Develop a real-time database application.

Course Content:

Working with DDL,DML and DCL

Inbuilt functions in RDBMS, Nested Queries & Join Queries.

Set operators & Views in SQL

PL/SQL –Control Structures, Procedures and Functions.

Triggers, Dynamic & Embedded SQL

Forms & Reports

Database Design and implementation (Mini Project/ Group project)

Course Code	:	**HM301**
Course Title	:	**Professional Ethics**
Number of Credits	:	**0**
Prerequisites (Course code)	:	**None**
Course Type	:	**GIR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Identify the core values that shape the ethical behavior of an engineer.
CO2 Create awareness on professional ethics and Human Values.
CO3 Appreciate the rights of others.
CO4 Examine one's own ethical decision-making process.
CO5 Develop guidelines to enhance one's ability to generate solutions for conflicts.

Course Content:

Human Values: Morals, Values and Ethics – Integrity – Work Ethic – Service Learning – Civic Virtue – Respect for others – Living Peacefully – Caring – Sharing – Honesty – Courage – Valuing time – Co-operation – Commitment – Empathy – Self-confidence – Character – Spirituality – The role of engineers in modern society – Social expectations.

Engineering Ethics: Sense of 'Engineering Ethics' – Variety of moral issued – types of inquiry – moral dilemmas – moral autonomy – Kohlberg's theory – Gilligan's theory – Consensus and Controversy – Models of Professional Roles & Professionalism – theories about right action – Self-interest – customs and religion – uses of ethical theories.

Engineering as Social Experimentation: Engineering as experimentation – engineers as responsible experimenters – Research ethics – Codes of ethics – Industrial Standard – Balanced outlook on law – the challenger case study.

Safety, Responsibilities and Rights: Safety and risk – assessment of safety and risk – Risks – Risk benefit analysis and reducing risk – Govt. Regulator's approach to risks – the three mile island and Chernobyl case studies & Bhopal – Threat of Nuclear Power, depletion of ozone, greenery effects – Collegiality and loyalty – respect for authority – collective bargaining – Confidentiality – conflicts of interest – occupation crime – professional rights – employees' rights – Intellectual Property Rights (IPR) – discrimination.

Global Issues: Multinational corporations – Business ethics – Environmental ethics – computer ethics – Role in Technological Development – Weapons development – engineers as managers – consulting Engineers – engineers as expert, witnesses and advisors – Honesty – Leadership – sample code of conduct ethics like ASME, ASCE, IEEE, Institution of Engineers (India), Indian Institute of Materials Management, Institution of Electronics and Telecommunication Engineers (IETE), India, etc.,

Text Books:

1 Mika Martin and Roland Scinger, 'Ethics in Engineeering', Pearson Education/Prentice Hall, New York 1996.
2 Govindarajan M., Natarajan S., Senthil Kumar V. S., 'Engineering Ethics' Prentice Hall of India, New Delhi, 2004
3 Charles D. Fleddermann, 'Ethics in Engineering', Pearson Education/Prentice Hall, New Jersey

Reference Books:

1 Charles E. Harris, Michael S. Protchard and Michael J. Rabins, 'Engineering Ethics – Concept and Cases', Wadsworth Thompson Learning, United States, 2000 (Indian Reprint now available).
2 John R. Boatright, 'Ethics and Conduct of Business', Pearson Education, New Delhi, 2003.
3 Edmund G. Seebauer and Robert L. Barry, 'Fundamentals of Ethics for Scientists and Engineers', Oxford University of Press, Oxford, 2001.

SIXTH SEMESTER

Course Code	:	**CS351**
Course Title	:	**Programme Core - XV /Software Engineering**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1	Discuss the impact of software engineering in contemporary business, economic, environmental and societal context.
CO2	Interpret the flow of different modules in terms of DFD, UML and ER diagrams.
CO3	Assess the software modules with various testing techniques.
CO4	Develop the software project management skills.
CO5	Employ validation and verification techniques to assure software quality.

Course Content:

Introduction and Software Development Life Cycle Models: Role of Software Engineer, Software Components, Software Characteristics, Software Crisis, Software Engineering Processes, Similarity and Differences from Conventional Engineering Processes, Quality Attributes.
Assessment*:* How Software Engineering Changes? Software Development Life Cycle (SDLC) Models: Water Fall Model, Prototype Model, Spiral Model, Evolutionary Development Models, Iterative Enhancement Models, Choosing a social relevant problem-Summary Team Report.

Requirement and Design: Requirement Engineering Process: Elicitation, Analysis, Documentation, Review and Management of User Needs, Feasibility Study, Information Modeling, Data Flow Diagrams, UML diagrams**,** Entity Relationship Diagrams, Designing the architecture, Design concepts, Design Patterns.
Assessment: Impact of Requirement Engineering in their problem. Decision Tables, SRS Document, IEEE Standards for SRS, Architectural design, component level design, user interface design, WebApp Design. Submission of SRS Document for Team Project.

Testing: Testing Objectives, Unit Testing, Integration Testing, Acceptance Testing, Regression Testing, Testing for Functionality and Testing for Performance, Top-Down and Bottom-Up Testing, Software Testing Strategies - Strategies: Test Drivers and Test Stubs, Structural Testing (White Box Testing), Functional Testing (Black Box Testing), Testing conventional applications, object oriented applications, and Web applications, Formal modeling and verification, Software configuration management, Product metrics.
Assessment: Team Analysis in Metrics Calculation.

Software Management: Project Management Concepts, Process and Project Metrics, Estimation

for Software projects, Project Scheduling, Risk Management, Maintenance and Reengineering.
Assessment: Preparation of Risk mitigation plan

Software Quality Assurance: Quality concepts, Review techniques, Software Quality Assurance (SQA): Verification and Validation, SQA Plans, Software Quality Frameworks.

Assessment: Framing SQA Plan. ISO 9000 Models, SEI-CMM Model and their relevance to project Management-other emerging models like People CMM.

Text Books:

1 R. S. Pressman, "Software Engineering: A Practitioners Approach", McGraw Hill, 8th edition, 2014
2 Ian Sommerville, "Software Engineering", Tenth Edition, Pearson Education, 2015.
3 PankajJalote, "Software Project Management in practice", Pearson Education, New Delhi, 2002

Reference Books:

1 Rajib Mall, "Fundamentals of Software Engineering", PHI Publication, 4th edition, 2014
2 Jalote Pankaj, "An Integrated Approach to Software Engineering", Third Edition, Springer, 2010.
3 Shari Lawrence Pfleeger and Joanne M. Atlee, "Software Engineering: Theory and Practice", Fourth Edition, Prentice Hall, 2010.

Web link(s):

1 Research in Software Engineering (RiSE): https://www.microsoft.com/en-us/research/group/research-software-engineering-rise/
2 https://www2.cs.siu.edu/~mengxia/Courses%20PPT/435/435ppt.htm
3 https://www.educba.com/software-development/software-development-tutorials/software-engineering-tutorial/

Course Code	:	**CS352**
Course Title	:	**Programme Core - XVI / Internetworking Protocols**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**Data Communication**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1 Review the networks, topologies, and layered communication architecture.
CO2 Explain various concepts of IPv4 comprehensively.
CO3 Distinguish between IPv4 and IPv6.
CO4 Apply TCP for efficient communication.
CO5 Design and develop Mobile IP.

Course Content:

Internet Address Architecture: Review of TCP/IP Reference Model, Topology and switching, IEEE Standard 802 from Ethernet, Token Bus, Token Ring and Wireless LAN, Connecting Devices, Internet Address Architecture, Link Layer, ARP: Address Resolution Protocol.

IPV4: IPv4 headers, IP forwarding, Mobile IP, Host Processing of IP datagrams, DHCP and Autoconfiguration, Firewalls and NAT, ICMPv4, Broadcasting and Local Multicasting (IGMP and MLD), User Datagram Protocol (UDP) and IP Fragmentation, DNS.

IPV6: IPv6 Transition issues, IP Security Protocol (Ipsec), Protocol basics, IPv6 Addressing, IPv6 Options and Extension Headers, IPv6 Multicast, IPv6 Anycast, IPv6 Internet Control Message Protocol (ICMPv6), Neighbor Discovery, Routing, Quality of Service, Auto configuration, Mobile IPv6, Multicast Listener Discovery (MLD), IPv6 and DNS, Next Generation Protocols.

TCP: TCP Preliminaries, TCP Connection Management, TCP Timeout and Retransmission, TCP Data Flow and Window Management, TCP Congestion Control, TCP Keepalive, Stream Control Transmission Protocol (SCTP), Services, SCTP Association management, SCTP flow and error control.

Overview of Mobile IP: Need for Mobile IP, Overview of Mobile IP, Details of Mobile IP, Tunneling, and Mobility for IPv6, Applications of Mobile IP – Security primer, Campus Mobility, Internet wide mobility, A service provider perspective.

Text Books:

1 W. Richard Stevens and G. Gabrani, “TCP/IP Illustrated: The Protocols”, Pearson, 2011

2 Peter Loshin, Morgan Kaufmann, ”IPv6: Theory, Protocol, and Practice”, 2nd Ed,2003
3 James Solomon, “Mobile IP: The Internet Unplugged”, 1st Ed, Pearson Education, 2008

Reference Books:

1 Kevin R. Fall and W. Richard Stevens, “TCP/IP Illustrated, Vol. 1- The Protocols”, 2nd Edition, Addison-Wesley, 2012
2 Silvia Hagen, “IPv6 Essentials, 2nd Edition, O'Reilly Media, 2006
3 Charles E. Perkins, “Mobile IP: Design Principles and Practices”, Pearson Education, 2008

Web link(s):

1 https://nptel.ac.in/courses/106/105/106105183/
2 https://people.kth.se/~maguire/courses/IK1550/Coursepage-Spring-2013.html

Course Code	:	**CS353**
Course Title	:	**Programme Core - XVII / Web Technology**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1 Design a basic website using HTML and Cascading Style Sheets.

CO2 Construct dynamic and interactive web sites using appropriate technologies.

CO3 Write server side programs for real time applications.

CO4 Develop real client applications with Angular JS.

CO5 Create web services and utilize them in web applications.

Course Content:

Website Basics: The Internet – Basic Internet protocols – World wide web – HTTP Request Message – HTTP Response Message – Web Clients – Web Servers -HTML- XHTML - DHTML, Cascading Style sheets(CSS). XML- Document type definition, XML Schemas, Document Object model - Simple API for XML (SAX), Extensible Style sheet Language (XSL)

Client side Programming: JavaScript DOM Model-Date and Objects,- Regular Expressions-Exception Handling-Validation-Built-in objects-Event Handling - DHTML with JavaScript – AJAX - JSON introduction – Syntax – Function Files – Http Request – SQL

Web Servers and its Applications: Web servers –IIS (XAMPP, LAMPP) and Tomcat Servers – Model View Controller (MVC) architecture. Java Web Technologies in Netbeans - Servlets, Java Server Pages (JSP), Java Server Faces (JSF), JSF Components, Session Tracking, Cookies – PHP - Database Connectivity with MySQL

Angular JS: Introduction - Data Binding – Modules – Scopes – Controllers – Expressions – Filters – Directives - Module Loading - Multiple Views and Routing - Dependency Injection – Services – XHR – Server Communication – Testing – Events – Caching – Security – Optimization

Webservices: Introduction- Service Oriented Architecture – UDDI, SOAP - Java web services Basics – Creating, Publishing, Testing and Describing a Web services (WSDL)-Consuming a web service, Database Driven web service from an application, Web 2.0 technologies, Introduction to semantic web.

Text Books:

1 Paul J. Deitel, Harvey M. Deitel, Abbey Deitel, "Internet & World Wide Web How to Program", Deitel series, 5th edition, 2018

2 Ari Lerner, "ng-Books The Complete Books on AngularJS", Fullstack.io, 2013.

3 Ron Schmelzer, Travis Vandersypen, Jason Bloomberg, Madhu Siddalingaiah, Sam hunting, Micheal D.Qualls, David Houlding, Chad Darby, Diane Kennedy, "XML and Web Services", Sams, 2002.

Reference Books:

1 Robert W. Sebesta, "Programming with World Wide Web", Addison Wesley, 7th edition, 2013

2 Jeffrey C and Jackson, — "Web Technologies - A Computer Science Perspective", Pearson Education, 2011.

3 Jason Gilmore, "Beginning PHP and MySQL From Novice to Professional", 4th Edition, Apress Publications, 2010

Web link(s):

1 www.w3schools.com
2 https://web.stanford.edu/class/cs142/lectures.html

Course Code	:	**HM351**
Course Title	:	**Technical English**
Number of Credits	:	**2**
Prerequisites (Course code)	:	**None**
Course Type	:	**GIR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Develop competence in English for independent and effective professional communication.
CO2 Apply thinking strategies to convince people.
CO3 Evaluate the scenario and decide the suitable writing style.
CO4 Identify suitable language to persuade and to reasonably present the analysis of a situation related to his/her profession.

Course Content:

Listening: Barriers to listening: Physical & psychological – Steps to overcome them – Purposive listening practice – Active listening and anticipating the speaker – Use of technology in the professional world - online listening

Speaking: Fluency & accuracy in speech – Positive thinking – Kinds of thinking – Improving self-expression – Tonal variations – Listener oriented speaking – Group discussion practice– Interpersonal Conversation – Developing persuasive speaking skills.

Reading: Speed reading practice – Use of extensive readers –Trans-coding: verbal and nonverbal – Analytical and critical reading practice – Introduction to ethics & values through case-study materials.

Writing: Professional Correspondence – Formal letters – CV/Resume – Argument Writing – Perspectives in writing – Narrative writing – Different registers – Tone in formal writing – Report Writing – Writing SOP - online tools to effective writing - publishing online - blog writing

Study Skills: Reference Skills - Use of dictionary, thesaurus etc. – Importance of contents page, cover & back pages – Bibliography - use of online resources

Text Books:

1 Herta A Murphy, Herbert W Hildebrandt, and Jane P Thomas, "Effective Business Communication", 7th Edition, McGraw Hill, Irwin, 1997.
2 Martin Hewings, "Advanced Grammar in Use", 2nd Edition, Cambridge University Press, 2008.
3 Michae Swan, "Practical English Usage", Oxford University Press, Oxford, 1995.

Reference Books:

1 Perelman, Leslie C, James Paradis, and Edward Barrett, “The Mayfield HandBooks of Technical & Scientific Writing”, Mountain View, Calif: Mayfield Pub. Co, 1998.
2 Robert Gannon, “Best Science Writing: Readings and Insights”, University Press, Hyderabad, 2000.
3 Shirley Taylor, “Communication for Business”, Longman, New Delhi, 1999.

Web link(s):

1 https://nptel.ac.in/courses/109/106/109106094/ (NPTEL Course by Prof. Aysha Iqbal, IITM)
2 https://www.youtube.com/watch?v=lQrj_7xkeNI - Technical Presentation (Part of an NPTEL Course by Prof. Prathap Haridoss, IITM)
3 https://www.youtube.com/watch?v=9SB4tfD0hxM - Technical Writing
4 https://writingcenter.fas.harvard.edu/pages/strategies-essay-writing

Course Code	:	**CS354**
Course Title	:	**Networks Laboratory**
Number of Credits	:	**2**
Prerequisites (Course code)	:	**None**
Course Type	:	**ELR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Practice the analytical studies of Computer Networks through network simulation.
CO2 Design a network using NS-3 toolkit and explain its importance in a real network.
CO3 Measure and analyze the network parameters for a high throughput network.
CO4 Compare various routing algorithms.
CO5 Differentiate the various transport layer protocols.

Course Content:

Exercises on Socket Programming using C and Java

Exercises using NS-3 Network Simulator

Hands on experiments on Network equipments

a. Switches, Routers
b. Hardware firewall

Implementation of error detection and correction techniques

Implementation of Stop and Wait Protocol and sliding window

Implementation of IP address configuration

Implementation of routing algorithms

a. Distance vector

b. Link state routing

Client Server Program using TCP sockets

a. Date and Time Server

b. Chat application

Client Server Program using UDP

a. DNS Implementation

b. Chat application

Course Code	:	**CS355**
Course Title	:	**Web Technology Laboratory**
Number of Credits	:	**2**
Prerequisites (Course code)	:	**None**
Course Type	:	**ELR**

Course outcomes: At the end of the course, the student will be able to:

CO1	Develop web applications with suitable technologies
CO2	Change the layout of web pages according to user needs.
CO3	Establish database access from the web pages.
CO4	Create web services and use them in web applications.
CO5	Integrate advanced technologies easily with the existing web applications.

Course Content:

Designing a static web page using HTML. 3

Designing a dynamic webpage using JAVASCRIPT.

Implement three-tier architecture using Servlets / JSP / PHP with MySQL as database.

Parsing an XML document

Programming using Angular JS.

Programming using AJAX, UDDI, SOAP, WSDL.

Mini Project

SEVENTH SEMESTER

Course Code	:	**CS402**
Course Title	:	**Programme Core - XVIII / Machine Learning**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**PC**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the basic concepts of Machine learning.
CO2 Apply the linear models for regression in Machine learning.
CO3 Use clustering techniques and graphical models of Machine learning algorithms.
CO4 Review the various reinforcement models of Machine learning.
CO5 Employ machine learning algorithms to real data and evaluate their performance.

Course Content:

Introduction – Well defined learning problems - Designing Learning System - Perspectives & Issues in Machine Learning - Types of Machine learning: supervised learning, unsupervised learning and reinforcement learning - The machine learning process.

Linear models for regression–Maximum Likelihood Estimation (MLS)–least squares–regularized least squares–The Bias-Variance Decomposition–Bayesian Linear Regression–Linear models for classification– Discriminant functions–Fisher's linear discriminant–Probabilistic generative models–Probabilistic discriminative models–Bayesian logistic regression- Bayesian learning–maximum a posterior (MAP) estimation.

Clustering - Mixture Densities – K-means Clustering – Expectation- Maximization algorithm – Mixtures of Latent variables models – Supervised Learning after clustering– Hierarchal Clustering – Choosing the number of clusters – Spectral Clustering – Dimensionality Reduction – Principal Component Analysis (PCA) – Linear Discriminant Analysis (LDA) – Factor analysis – Independent Component Analysis (ICA).

Graphical models– Markov random fields – Hidden Markov Models – Representation – learning – Decoding - Inference in graphical models –Monte Carlo models – Sampling.

Reinforcement Learning – Elements of reinforcement learning – Model based– temporal difference learning – Generalization – Partially observable states – The learning task – Q-learning- Deep reinforcement learning.

Text Books:

1 Tom Mitchell, "Machine Learning", McGraw-Hill, 1997
2 Stephen Marsland, "Machine Learning – An Algorithmic Perspective", Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014.

3 E. Alpaydin, “Introduction to Machine Learning”, 2nd edition, Prentice-Hall of India, 2010

Reference Books:

1 R.O. Duda, P.E. Hart and D.G. Stork. “Pattern Classification”, Wiley-Inderscience, 2nd Edition, 2000.
2 T. Hastie, R. Tibshirani and J. Friedman, “The Elements of Statistical Learning”, Springer, 2011
3 Shai Shalev-Shwartz, Shai Ben-David, “Understanding Machine Learning from Theory to Algorithms”, Cambridge University Press, 2014

Web link(s):

1 https://towardsdatascience.com/machine-learning/home
2 https://dzone.com/refcardz/machine-learning-predictive

Course Code	:	**CS403**
Course Title	:	**Machine Learning Laboratory**
Number of Credits	:	**2**
Prerequisites (Course code)	:	**None**
Course Type	:	**ELR**

Course outcomes: At the end of the course, the student will be able to:

CO1 Analyze the performance of supervised learning algorithms.
CO2 Apply clustering techniques on real data.
CO3 Compare the performance of dimensionality reduction techniques.
CO4 Demonstrate reinforcement learning algorithm with real world datasets.

Course Content:

Implementation of supervised learning classification and regression using few datasets.
Implementation of naive bayes classifier.
Implementation of clustering using K-Means algorithm.
Implementation of Dimensionality reduction using LDA.
Implementation of Dimensionality reduction using PDA.
Implementation of Reinforcement learning.

ELECTIVES

Course Code	:	**CS511**
Course Title	:	**Advanced Computer Architecture**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**Computer Organization and Architecture**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the sequential changes in computer architecture. .
CO2 Apply parallelism both in single and multiple processors.
CO3 Describe parallel hardware constructs.
CO4 Develop skills for exploiting thread level parallelism in multiprocessor systems.
CO5 Design various levels of memories and optimize them.

Course Content:

Introduction Fundamentals of computer Architecture, Power, Fabrication, Amdahl's law, Iron's Law, Measuring and reporting performance. Pipelining - Hazards, stalls, data dependencies - Extending the MIPS Pipeline.

Instruction-Level Parallelism and Its Exploitation Instruction-Level Parallelism: Concepts and Challenges, Basic Compiler Techniques for Exposing, Reducing Branch Costs with Prediction, BTB, BHT, Bit predictor, History Predictor, RAS.

Overcoming Data Hazards with Dynamic Scheduling Dynamic Scheduling, Hardware-Based Speculation, Multiple Issue, Advanced Techniques for Instruction Delivery and Speculation, VLIW, Super Scalar Processor, Limits on ILP Hardware versus Software Speculation, Multithreading.

Multiprocessors and Thread-Level Parallelism Symmetric Shared-Memory Architectures, Distributed Shared Memory and Directory-Based Coherence, Synchronization, Models of Memory Consistency, Case studies of recent processors.

Memory Hierarchy Design Eleven Advanced Optimizations of Cache Performance, Memory Technology and Optimizations, Protection: Virtual Memory and Virtual Machines. The Design of Memory Hierarchies, Cache Performance, Cache Optimization Techniques.

Text Books:

1 David Patterson, John L. Hennessy, “Computer Architecture: A Quantitative Approach”, Sixth edition, Morgan Kaufmann, 2017.
2 Kai Hwang, Naresh Jotwani, “Advanced Computer Architecture”, Third edition, TMH, 2016.
3 John Paul Shen, Mikko H. Lipasti, “Modern Processor Design: Fundamentals of Superscalar Processors”, Waveland Press, 2005.

Reference Books:

1 Michael J. Flynn, “Computer Architecture: Pipelined and Parallel Processor Design”, First edition, Jones and Bartlett Publishers, 1995.
2 David A. Patterson, John L. Hennessy, “Computer organization and design”, Fifth edition, Morgan Kaufmann, 2013.
3 William Stallings, Computer Organization and Architecture – Designing for Performance, Eighth Edition, Pearson Education, 2010.

Web link(s):

1 https://www.sciencedirect.com/topics/computer-science/computer-architecture
2 https://www.intel.com/content/www/us/en/programmable/support/literature/lit-tutorials.html

Course Code	:	**CS512**
Course Title	:	**Object Oriented Analysis and Design**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**Object Oriented Programming**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Define the fundamentals of object oriented approach.
CO2 Analyze and devise software specifications.
CO3 Design object oriented applications using design patterns.
CO4 Solve real world problems by applying OOAD principle.
CO5 Develop java program for solving real-time applications.

Course Content:

Object Model Evolution, Elements – Nature of Classes and Objects – Relationships among Classes - Classification – Identification of classes and objects – Key abstractions and mechanisms – Basic and Advanced Modeling techniques.

Methodology Modeling and UML – Rambaugh's Method – Booch Method – Jacobson et al Method – Comparisons – UML – Static-Dynamic Models – Diagrams –Use Cases.

Processes Process of design, design principles, architectural patterns, design document, difficulties and risks in design - Frameworks: reusable subsystem. Design patterns – Singleton, observer, adapter, Façade, proxy with examples. - Pattern Categories - Relationships between patterns - Pattern descriptions – Patterns based Applications – Object Oriented Database.

Java Programming Features – Structure – Elements of Java – Array, String, String Buffer, Vectors –Methods – Object Oriented Features- Classes, Objects – Constructors – Package – Inheritance – Interface – Abstract Class - Special types of classes.

Applet Programming AWT – Graphics - Event Handling – Exception Handling – Utilities and Collections – I/O Streams - Multithreaded Programming - Swings - J2EE Architecture.

Text Books:

1 Grady Booch et al, "Object-Oriented Analysis and Design with Applications", 3rd Edition, Pearson Education, 2007.
2 Michael Blaha and James Rumbaugh, "Object-Oriented Modeling and Design with UML", 2nd Edition, Pearson Education, 2005.
3 Craig Larman, ―Applying UML and Patterns: An Introduction to Object-Oriented

Analysis and Design and Iterative Development‖, Third Edition, Pearson Education, 2005.

Reference Books:

1 Joshua Bloch, "Effective Java", 2nd Edition, Addison-Wesley, 2008.
2 Erich Gamma, Richard Helm, Ralph Johnson & John Vlissides, "Design Patterns: Elements of Reusable Object-oriented Software", Pearson Education India, 2004.
3 Martin Fowler, ―UML Distilled: A Brief Guide to the Standard Object Modeling Language‖, Third edition, Addison Wesley, 2003.

Web link(s):

1 https://www.tutorialspoint.com/object_oriented_analysis_design/index.htm
2 https://sparxsystems.com/resources/tutorials/uml/part1.html

Course Code	:	**CS513**
Course Title	:	**Multimedia Systems**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**-**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Design multimedia components efficiently.
CO2 Perform audio and speech analysis in multimedia systems.
CO3 Apply image and video compression algorithm for saving storage space.
CO4 Employ protocols for multimedia networks.
CO5 Develop security algorithms for specialized multimedia applications.

Course Content:

Multimedia Elements: Introduction – Definitions – Applications – Elements - Text – Image/Graphics Audio – Video – Animation.

Audio and Speech: Data acquisition, sampling and quantization, human speech, digital model of speech production, analysis and synthesis, psychoacoustics, low bit rate speech compression, MPEG audio compression.

Images and Video: Image acquisition and representation, bi-level image compression standards: ITU (formerly CCITT) Group III and IV standards, JPEG image compression standards, MPEG, H.264/AVC video compression standards, Transcoding.

Multimedia Networks: Protocol - QOS Issues - RTP, RTCP, RTSP, SIP - Media on demand –ITV - STB Broadcast Schemes for VoD Buffer Management- Multimedia over wireless networks.

Multimedia Security and Forensics: Multimedia encryption - Digital Watermarking Security Attacks- Digital Forensics taxonomy, goals/requirements - Forensic Data Acquisition - Forensics Analysis and Validation.

Text Books:

1 K. Andleigh, Kiran Thakrar , “Multimedia Systems Design”, PHI, 2007.
2 Ze-Nian Li & Mark S. Drew, “Fundamentals of Multimedia”, Pearson Prentice Hall, 2006.
3 Jerry D. Gibson, Toby Berger, Tom Lookabaugh, Dave Lindergh and Richard L. Baker, “Digital Compression for Multimedia: Principles and Standards”, Elsevier, 2006.

Reference Books:

1 Ralf Steinmetz and Klara, “Multimedia Computing, Communications and Applications”, Pearson Education, 2009.

2 Chun-Shien Lu, “Multimedia Security: Steganography and Digital Watermarking techniques for Protection of Intellectual Property”, Springer Inc 2007.

3 Wenjun Zeng, Heather Yu and Ching, Yung Lin, “Multimedia Security technologies for Digital rights Management”, Elsevier Inc 2006.

Web link(s):

1 https://freevideolectures.com/course/2652/cse-40373-multimedia-systems

2 https://nptel.ac.in/content/storage2/courses/117105083/pdf/ssg_m1l1.pdf

Course Code	:	**CS514**
Course Title	:	**Combinatorics and Graph Theory**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**Discrete Structures**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the fundamentals of combinatorics and apply combinatorial ideas in mathematical problems, queuing theory, etc.

CO2 Analyze time and space complexity of algorithms using counting principles and recurrences.

CO3 Discuss the fundamentals of graph theory and solve problems in dynamic programming and network flows.

CO4 Describe the types of graphs and identify the suitable coloring algorithm.

CO5 Develop solutions for real time application using graph theory.

Course Content:

Advanced Combinatorics Introduction to combinatorics, permutation of multisets. Combinations of Multisets, distribution of distinct objects into distinct cells, distribution of non-distinct objects into distinct cells, Shamire secret sharing. Catalan number. Principle of inclusion and exclusion, Derangement.

Storing and Counting Generating functions, Partitions of integer, Ferrer graph. Solving recurrence relations using generating functions, Generating permutations and combinations. Pigeonhole principle: simple and strong Form, Ramsey's Theorem.

Graphs Simple graph, graph isomorphism, incidence and adjacency matrices, Haveli-Hakimi criterion. Subgraphs Tree, minimum spanning tree, Kruskal, Prims algorithm, Caleys' formula, Kirchoff-Matrix- tree Theorem, Fundamental circuits, Algorithms for fundamental circuits , Cut-sets and Cut-vertices, fundamental cut-sets.

Graph Connectivity and Coloring Euler graph, Fleury's algorithm, Hamiltonian graph, Planar and Dual Graphs, Kuratowski's graphs. Coloring, Greedy coloring algorithm, chromatic polynomial.

Graph Analysis and Applications Mycielski's theorem, Matching, Halls marriage problem. Independent set, Dominating set, Vertex cover, clique, approximation algorithms.

Text Books:

1 Ralph P. Grimaldi, "Discrete and Combinatorial Mathematics", Fifth edition, PHI/Pearson Education, 2004.

2 Gary Chartrand and Ping Zhang, “Introduction to Graph Theory”, First edition, McGraw-Hill, 2006.
3 Kenneth H. Rosen, “Discrete Mathematics and its Applications”, Seventh edition, McGraw- Hill, 2012.

Reference Books:

1 John Harris, Jeffry L. Hirst, Michael Mossinghoff, “Combinatorics and Graph Theory”, Second edition, Springer Science & Business Media, 2008.
2 Dr. D.S. Chandrasekharaiah, "Graph Theory and Combinatorics", Prism, 2005.
3 J. H. Van Lint and R. M. Wilson, “A course in Combinatorics”, 2nd edition, Cambridge Univ. Press, 2001.

Web link(s):

1 https://web.math.princeton.edu/~pds/onlinetalks/talks.html
2 https://www.britannica.com/topic/graph-theory

Course Code	:	**CS515**
Course Title	:	**Unix Programming**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Develop text data processing applications using Unix commands and filters.
CO2	Analyze and manipulate file systems and directories.
CO3	Write shell scripts using filters and pipes.
CO4	Establish communication between users.
CO5	Apply Unix utilities for text searching, parsing, and processing.

Course Content:

Introduction and commands Architecture, Environment, Structure, Basic commands, vi editor - Modes, Commands, Key terms.

File Systems Filenames, File Types, Regular Files and Directories – operations, File System Implementation, Security and File permissions.

Shell Scripting Unix Session, Streams, Redirection, Pipes, tee command, Command line execution ,Job control, Variables, Customization, Filters and pipes, File concatenation and display, Sorting, Character translation and counting, File comparison.

Communications User communication, Electronic mail, Remote access, File transfer.

Filters Regular expressions, grep, pr, head, tail, cut, paste, sort, uniq, tr, introduction to sed and awk.

Text Books:

1 Behrouz A. Forouzan and Richard F. Gilberg, "UNIX and Shell programming : A TextBooks", First edition, Cengage Learning, 2003.
2 SumitabhaDas, "Your Unix/Linux: The Ultimate Guide", TMH. Third Edition, McGraw-Hill Education, 2012.
3 Graham Glass, King Ables, "Unix for programmers and users", Third edition, Pearson, 2003.

Reference Books:

1 Kernighan and Pike, “Unix programming environment”, PHI. / Pearson Education, 1984.
2 Richard Blum, Christine Bresnahan, “Linux Command Line and Shell Scripting Bible”, Second Edition, Wiley, 2014.
3 Terrance Chan, “ Unix System Programming using C++”, Prentice Hall India, 1999.

Web link(s):

1 www.tldp.org (The Linux Documentation Project)
2 https://www.shellscript.sh/

Course Code	:	**CS516**
Course Title	:	**Parallel Architectures and Programming**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**Computer Organisation and Architecture**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain parallel architecture and its importance in solving engineering problems.
CO2 Design parallel programs to enhance machine performance in parallel hardware environment.
CO3 Develop programs for the efficient use of multiple cores, multiple networked processors and GPU Processing power.
CO4 Differentiate among various parallel programming strategies.
CO5 Employ parallel programs in modern environments such as CUDA, OpenMP, etc.

Course Content:

Introduction: Overview of Parallelism, Flynn's Classical Taxonomy, von Neumann Computer Architecture, Parallel Computers, Communication Architecture and their Models.

Large Cache Design: Shared vs. Private, Centralized vs. Decentralized, Cache Coherence Protocol, Uniform Cache Access, Non-Uniform Cache Access, D-NUCA, S-NUCA, Transactional Memories.

Graphics Processing Unit: GPUs as Parallel Computers, Architecture of a modern GPU, Evolution of Graphics Pipelines, GPGPUs, Scalable GPUs, Architectural characteristics of Future Systems, Implication of Technology and Architecture for users, Vector addition, Applications of GPU.

Parallel Programming: Strategies, Mechanism, Performance theory, Parallel Programming Patterns, Parallel Data Management, Map, Reduce, Fusing Map and Reduce, Scan, Fusing Map and Scan, Data Recognition, Fork-Join, Pipeline.

Parallel Programming Languages: Parallel Programming with MPI and OpenMP, CUDA: Parallel programming in CUDA C, Thread management, Constant memory and Event, Graphics Interoperability, Atomics, Streams.

Text Books:

1 D. E. Culler, J. P. Singh, and A. Gupta, “Parallel Computer Architecture”, Morgan-Kaufmann, 2004.

2 Rajeev Balasubramonian, Norman P. Jouppi, and Naveen Muralimanohar, “Multi-Core Cache Hierarchies”, Morgan & Claypool Publishers, 2011.

3 Peter and Pach Eco, “An Introduction to Parallel Programming”, Elsevier, 2011.

Reference Books:

1 David B. Kirk, Wen-mei W. Hwu, “Programming Massively Parallel Processors: A Hands-on Approach”, 2010.

2 Michael McCool, James Reinders, Arch Robison, “Structured Parallel Programming: Patterns for Efficient Computation”, 2012.

3 Jason Sanders, Edward Kandrot, “CUDA by Example: An Introduction to General-Purpose GPU Programming”, 2011.

Web link(s):

1 https://www.cs.princeton.edu/courses/archive/spr07/cos598A/

2 https://computing.llnl.gov/tutorials/parallel_comp/

3 http://15418.courses.cs.cmu.edu/spring2015/

4 https://princetonuniversity.github.io/PUbootcamp/sessions/parallel-programming/Intro_PP_bootcamp_2018.pdf

Course Code	:	**CS517**
Course Title	:	**Software Testing**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Define the criteria for test cases.
CO2 Design test cases.
CO3 Apply test management and test automation techniques.
CO4 Develop a test tool to support test automation.
CO5 Assess test metrics and measurements to analyze the algorithm efficiency.

Course Content:

Introduction Testing as an Engineering Activity – Testing as a Process – Testing axioms – Basic definitions – Software Testing Principles – Defects – Developer/Tester Support of Developing A Defect Repository – Defect Prevention strategies.
Test case Design Strategies – Black Bod Approach – Random and Requirements testing – Boundary Value Analysis – Equivalence Class Partitioning – State based testing – Cause-effect graphing – Compatibility, Documentation, domain testing – White Box – Test Adequacy – Static vs. structural – Code coverage and Complexity.
Levels of Testing Need – Unit, Integration, Scenario, Acceptance, Performance, Regression Testing' Internationalization, and Ad-hoc testing – Alpha, Beta Tests – OO systems – Usability, Accessibility, Configuration, Compatibility, Documentation, and Website testing.
Test Management People and organizational issues - Test Planning – Test management – Test process – Reporting Test Results – The role of three groups - Test specialist – Skills needed by a test specialist – Building a Testing Group.
Test Automation Software test automation – requirements for a test tool – challenges in automation – Test metrics and measurements – project, progress and productivity metrics – Case study using latest frameworks.

Text Books:

1 Srinivasan Desikan and Gopalaswamy Ramesh, "Software Testing – Principles and Practices", First edition, Pearson Education, 2006.
2 Ron Patton, "Software Testing", Second Edition, Sams Publishing, Pearson Education, 2007.
3 Ilene Burnstein, "Practical Software Testing", Springer International Edition, 2003.

Reference Books:

1 Boris Beizer," Software Testing Techniques" – 2nd Edition, Van Nostrand Reinhold, New York, 1990.
2 Paul Ammann and Jeff Offutt, "Introduction to Software Testing", Second edition, Cambridge University Press, 2016.
3 Aditya P. Mathur, ―Foundations of Software Testing _ Fundamental Algorithms and Techniques‖, Dorling Kindersley (India) Pvt. Ltd., Pearson Education, 2008.

Web link(s):

1 https://www.w3schools.in/category/software-testing/
2 https://www.softwaretestingmaterial.com/manual-testing-tutorial/

Course Code	:	**CS518**
Course Title	:	**Data Mining and Data Warehousing**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**DBMS**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe data mining principles and techniques.
CO2 Analyze large sets of data to gain useful business understanding.
CO3 Create a quantitative analysis report to take decisions.
CO4 Apply basic data mining algorithms to extract useful patterns hidden in the data.
CO5 Use mining tools for various data extraction.

Course Content:

Data Warehousing and Business Analysis: Data warehousing Components –Building a Data warehouse –Data Warehouse Architecture – Data Warehouse Schemas for Decision Support – Data Extraction, Cleanup, and Transformation Tools –Metadata – reporting – Query tools and Applications – Online Analytical Processing (OLAP) – OLAP and Multidimensional Data Analysis.

Data Mining: Databases – Steps in Data mining process- Data Mining Functionalities- Architecture of a Typical Data Mining Systems- Classification of Data Mining Systems. Data Pre-processing – Data Cleaning – Data Integration and Transformation – Data Reduction – Data Discretization and Concept Hierarchy Generation.

Classification and Prediction: Classification by Decision Tree Introduction – Bayesian Classification – Rule Based Classification – Classification by Back propagation – Support Vector Machines – Lazy Learners – Other Classification Methods – Prediction – Accuracy and Error Measures – Evaluating the Accuracy of a Classifier or Predictor – Ensemble Methods – Model Section.

Association and Clustering: Association Rule Mining: - Efficient and Scalable Frequent Item set Mining Methods – Mining Various Kinds of Association Rules – Association Mining to Correlation Analysis – Constraint- Based Association Mining. Cluster Analysis: - Types of Data in Cluster Analysis – Partitioning Methods – Hierarchical methods.

Applications of Data mining: Social Impacts of Data mining-Tools- Mining the World Wide Web– Spatial Data Mining – Multimedia Data Mining – Text Mining.

Text Books:

1 Alex Berson and Stephen J. Smith “Data Warehousing, Data Mining & OLAP”,

Second Edition, Tata McGraw – Hill, Tenth Reprint 2007.
2 Jiawei Han, Micheline Kamber, and Jian Pei, “Data Mining Concepts and Techniques”, Third Edition, Elsevier, 2011.
3 G. K. Gupta “Introduction to Data Mining with Case Studies”, Easter Economy Edition, Prentice Hall of India, 2006.

Reference Books:

1 K.P. Soman, ShyamDiwakar and V. Ajay “Insight into Data mining Theory and Practice”, Easter Economy Edition, Prentice Hall of India, 2006.
2 Pang-Ning Tan, Michael Steinbach and Vipin Kumar “Introduction to Data Mining”, Pearson Education, 2007.
3 Sam Anahory and Dennis Murray, “Data Warehousing in the Real World”, Pearson Edition Asia, 2000.

Web link(s):

1 www.towardsdatascience.com
2 https://nptel.ac.in/courses/106/105/106105174/

Course Code	:	**CS519**
Course Title	:	**Advanced Java Programming**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Develop interactive web pages using Applet.
CO2 Design application with advanced GUI programming using Swing and Java Beans.
CO3 Create applications to access remote functions using RMI.
CO4 Establish database access with JDBC connectivity.
CO5 Write server side programs using Servlets.

Course Content:

Applet: Basics – Applet architecture – HTML APPLET tag – Passing parameter to AppletgetDocumentBase() and getCodeBase() – AWT classes and Graphics – AWT ControlsEvent Handling – Event Classes – Event Listener Interfaces – Layout Managers – Menus.

Swing and Java Beans: Exploring Swing – JLabel and ImageIcon, JTextField – The Swing Buttons – JTabbedPane -JScrollPane, JList&JcomboBox – Trees &JTables – What Is a Java Bean? – Advantages of Java Beans – Introspection, Bound and Constrained Properties – Persistence & Customizers.

RMI and Networking: Remote Method Invocation – Settingup Remote Method Invocation – RMI with Applets -Networking Basics – The Networking Classes and Interfaces – InetAddress – Inet4Address and Inet6Address -TCP/IP Client sockets – URL – URL Connection – HttpURLConnection.

JDBC: Presentation to JDBC CONNECTION settings – The Concept of JDBC – JDBC Driver Types – JDBC Packages – A Brief Overview of the JDBC Process – Database Connection – Associating the JDBC/ODBC Bridge with the Database – Statement Objects – Result Set.

Servlets: Background, The Life Cycle of a Servlet & The JSDK-A Simple Servlet – The Servlet API -RolePlay-Servlet Concept – The javax.servlet Package – Reading Servlet Parameters, The javax.servlet.http Package – Handling HTTP Request and Responses – Using Cookies – Session Tracking.

Text Books:

1 Naughton and H.Schildt, “Java 2-The complete reference”, Fifth Edition McGraw Hil, 2007.

2 Jim Keogh, “The Complete Reference J2EE”, Tata McGraw Hill Edition, New Delhi, 2002.
3 Marty Hall, Larry Brown, “Core Servlets and Java Server Pages”, 2nd Edition, Pearson Education, 2004.

Reference Books:

1 Java 6 Programming, Black Books, Dreamtech, 2012.
2 Java Server Programming, Java EE6 (J2EE 1.6), Black Books, Dreamtech,2013.
3 M.T. Savaliya, “Advanced Java Technology”, Dreamtech, 2011.

Web link(s):

1 https://freevideolectures.com/course/3690/advanced-java
2 wwww3schools.com

Course Code	:	**CS520**
Course Title	:	**Embedded Systems**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the architecture and programming of ARM processor.
CO2 Explain the concept of embedded computing platform.
CO3 Discuss the concepts of peripherals and interfacing of sensors.
CO4 Apply system design techniques to develop firmware.
CO5 Develop the code to construct embedded systems.

Course Content:

Introduction Complex systems – Design process – Model train controller- Instruction sets – ARM Processor – CPU: input and output - supervisor mode, exceptions – Co-processors- Memory system mechanisms – CPU performance- CPU power consumption.

Embedded Computing Platform Design Bus-Memory devices – consumer electronics – performance analysis – Components - Models of programs – Compilation – Performance and Optimization.

Sensor Interfacing with Arduino Basics of hardware design and functions of basic passive components-sensors and actuators Arduino code – library file for sensor interfacing-construction of basic applications.

Embedded Firmware Reset Circuit, Brown-out Protection Circuit-Oscillator Unit – Real Time Clock-Watchdog Timer -Embedded Firmware Design Approaches and Development Languages.

Embedded C Programming Introduction – Creating _hardware delays – Adding Structure to the code – Minimum and maximum delay – Loop timeouts – Hardware timeouts – Testing timeouts.

Text Books:

1 Marilyn Wolf, "Computers as Components – Principles of Embedded Computing System Design", Third Edition, Morgan Kaufmann Publisher, 2012.
2 Michael J. Pont, "Embedded C", Second edition, Pearson Education, 2008
3 Rajesh Singh, Anita Gehlot, Bhupendra Singh, Sushabhan Choudhury, "Arduino-Based Embedded Systems: Interfacing, Simulation, and LabVIEW GUI", First edition, CRC Press, 2017.

Reference Books:

1 Shibu K.V, “Introduction to Embedded Systems”, McGraw Hill, 2014.
2 Jonathan W.Valvano, “Embedded Microcomputer Systems Real Time Interfacing”, Third edition, Cengage Learning, 2012.
3 Raj Kamal, “Embedded Systems-Architecture,programming and design”, 3 edition,TMH, 2015.

Web link(s):

1 https://www.coursera.org/learn/interface-with-arduino#syllabus

Course Code	:	**CS521**
Course Title	:	**Real Time Systems**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Apply Real–time programming environment tasks to solve practical problems.
CO2 Analyze task assignment and scheduling problems.
CO3 Establish real time communication systems.
CO4 Solve concurrency control issues using scheduling algorithms.
CO5 Illustrate the code to construct real-time system.

Course Content:

Introduction: Introduction to real-time computing, Structure of a real-time system, Characterization of real-time systems and tasks, Applications, Performance measures.

Task Assignment and Scheduling: Real time OS, Structure of Microkernel, Scheduling Mechanisms, Uniprocessor scheduling algorithms, Task assignment, Mode changes, Fault tolerant scheduling.

Real-time Communication: Network topologies and architecture issues, Protocols, Contention-based, token-based, polled bus, Fault tolerant routing.

Real–time Databases: Transaction priorities and aborts, Concurrency control issues, Scheduling algorithms, Two–phase approach to improve predictability.

Programming Languages and Tools: Hierarchical decomposition, Run–time error handling, Overloading, Timing specification, Recent trends and developments.

Text Books:

1 C. M. Krishna and Kang G. Shin, "Real–Time Systems", International Edition, McGraw Hill Companies, Inc., New York, 1997.

Reference Books:

1 Jane Liu, “Real–Time Systems”, First edition, Prentice Hall, 2002.

2 Rajib Mall, "Real–Time Systems: Theory and Practice", First edition, Pearson Education, 2012.

Web link(s):

1 https://users.ece.cmu.edu/~koopman/des_s99/real_time/

2 https://nptel.ac.in/courses/106/105/106105036/

Course Code	:	**CS522**
Course Title	:	**Advanced DBMS**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**DBMS**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Apply the complex query processing techniques.
CO2 Analyze system issues related to distributed database systems.
CO3 Discuss object oriented database techniques.
CO4 Develop skills to handle enhanced data models.
CO5 Design multimedia databases and create query structure.

Course Content:

Relational Model Issues: ER Model, Normalization, Query Processing, Query Optimization, Transaction Processing, Concurrency Control, Recovery, Database Tuning.

Distributed Databases: Parallel Databases – Inter and Intra Query Parallelism – Distributed Database Features, Distributed Database Architecture, Fragmentation, Distributed Query Processing, Distributed Transactions Processing, Concurrency Control, Recovery, Commit Protocols.

Object Oriented Databases: Introduction to Object Oriented Data Bases, Approaches Modelling and Design, Persistence, Query Languages, Transaction, Concurrency, Multi Version Locks, Recovery, POSTGRES, JASMINE, GEMSTONE, ODMG Model.

Emerging Systems: Enhanced Data Models, Client/Server Model, Data Warehousing and Data Mining, Web Databases, Mobile Databases, XML and Web Databases.

Current Issues: Rules, Knowledge Bases, Active and Deductive Databases, Multimedia Databases, Multimedia Data Structures, Multimedia Query languages, Spatial Databases.

Text Books:

1 Thomas Connolly and CarlolynBegg, “Database Systems: A Practical Approach to Design, Implementation, and Management”, fifth Edition, Addison-Wesley, 2009.

2 R. Elmasri and S. B. Navathe, “Fundamentals of Database Systems”, Fifth Edition, Pearson/Addison Wesley, 2006.

Reference Books:

1 Abraham Silberschatz, Henry F. Korth, and S. Sudharshan, “Database System Concepts”,Fifth Edition, Tata McGraw Hill, 2006.

2 C. J. Date, A. Kannan, and S. Swamynathan, “An Introduction to Database Systems”, Eighth Edition, Pearson Education, 2006.

Web link(s):

1 https://15721.courses.cs.cmu.edu/spring2020/

2 https://www2.cs.duke.edu/courses/spring05/cps216/index.html

Course Code	:	**CS523**
Course Title	:	**Cloud Computing**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the main concepts, key technologies, strengths, and limitations of cloud computing.
CO2 Describe the architecture and infrastructure of cloud computing.
CO3 Identify suitable computing mechanisms to establish a virtual cloud environment.
CO4 Use cloud storage facilities efficiently.
CO5 Interpret cloud computing solutions and recommendations appropriate for real world applications.

Course Content:

Introduction: Definition and evolution of Cloud Computing, Enabling Technologies, Service and Deployment Models, Popular Cloud Stacks and Use Cases, Benefits, Risks, and Challenges of Cloud Computing, Economic Models and SLAs, Topics in Cloud Security.

Cloud Infrastructure: Historical Perspective of Data Centers, Datacenter Components: IT Equipment and Facilities, Design Considerations: Requirements, Power, Efficiency and Redundancy, Power Calculations, PUE and Challenges in Cloud Data Centers, Cloud Management and Cloud Software Deployment Considerations.

Virtualization: Virtualization (CPU, Memory, I/O), Case Study: Amazon EC2, Software Defined Networks (SDN), Software Defined Storage (SDS).

Cloud Storage: Introduction to Storage Systems, Cloud Storage Concepts, Distributed File Systems (HDFS, Ceph FS), Cloud Databases (HBase, MongoDB, Cassandra, DynamoDB), Cloud Object Storage (Amazon S3, OpenStack Swift, Ceph).

Programming Models: Distributed Programming for the Cloud, Data-Parallel Analytics with Hadoop MapReduce (YARN), Iterative Data-Parallel Iterative Analytics (Spark), Graph-Parallel Analytics with GraphLab 2.0 (PowerGraph), Stream Processing (Samza).

Text Books:

1 Kai Hwang, Geoffrey C. Fox and Jack J. Dongarra, “Distributed and cloud computing from Parallel Processing to the Internet of Things”, Morgan Kaufmann, Elsevier, 2012.

Reference Books:

1 Barrie Sosinsky, " Cloud Computing Bible", John Wiley & Sons, 2010.
2 Tim Mather, Subra Kumaraswamy, and Shahed Latif, "Cloud Security and Privacy An Enterprise Perspective on Risks and Compliance", O'Reilly, 2009.

Web link(s):

1 http://web.stanford.edu/class/cs349d/

2 https://web2.qatar.cmu.edu/~msakr/15319-s12/lectures.html

3 https://nptel.ac.in/courses/106/105/106105167/

Course Code	:	**CS524**
Course Title	:	**Principles of Processor Design :Systems**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**Digital System Design**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Design digital circuits with Verilog.
CO2 Simulate timing and concurrency using Verilog model.
CO3 Develop combinational and sequential circuits using gate level logic.
CO4 Explain instruction execution, internal functions of processor and control unit design.
CO5 Use Verilog description to exploit the full capability of a CPU.

Course Content:

Digital Design with Verilog Design Flow –Design entry –Test bench in Verilog - Design validation - Compilation and synthesis –Post synthesis simulation - Timing analysis - Verilog HDL.

Hardware languages Verilog Language Concepts – Timing- Concurrency- Timing and concurrency example – Module basics – Verilog simulation model – Continuous assignments – Procedural assignments- Compiler directives – System task and function.

Combinational and Sequential Circuits Module wires – Gate level logic – Hierarchical logic- Expressions- Behavioural Combinational Descriptions- Sequential models – Memory components – Registers – State machine coding – Combinational and sequential synthesis.

I**nterfaces and Design Examples** Bus structure – Simple processor – Timer – SRAM – Cache – Clock synchronization, Digital filters and signal processors-Pipelined Architectures-Halftone Pixel Image Converter.

RTL Design Sequential multiplier –Multiplier testing- Von Neumann model – Processor and memory model - Processor model specification- Design of datapath - Control part design-Adding CPU Verilog description- Testing adding CPU design and test.

Text Books:

1 Zainalabedin Navabi, “Verilog Digital System Design”, Second edition, McGraw Hill, 2008
2 Michael D. Ciletti, “Advanced Digital Design with the Verilog HDL” Second edition, Pearson Edition, 2009.
3 David A. Patterson, John L. Hennessy, “Computer organization and design”, Fifth edition, Morgan Kaufmann, 2013.

Reference Books:

1 JP Shen and MH Lipasti, “Modern Processor Design - Fundamentals of Superscalar Processors”, Second Edition, MC Graw Hill, Crowfordsville, 2005.

Web link(s):

1 https://www.chipverify.com/verilog/verilog-tutorial

Course Code	:	**CS525**
Course Title	:	**Soft Computing**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Apply soft computing techniques to solve machine learning applications.
CO2 Construct various neural network models to learn the characteristics of input data.
CO3 Illustrate image classification task using various deep learning models.
CO4 Develop evolutionary algorithms to find optimal solution for a given problem.
CO5 Design fuzzy inference model for decision making.

Course Content:

Introduction: Introduction of soft computing - soft computing vs. hard computing- various types of soft computing techniques- applications of soft computing-Neuron- Nerve structure and synapse-Artificial Neuron and its model- activation functions- Neural network architecture- single layer and multilayer feed forward networks- McCullochPitts neuron model- perceptron model- MLP-back propagation learning methods- effect of learning rule coefficient.

Advanced Neural Networks: Counter propagation network - Hopfield/ Recurrent network-configuration- stability constraints-associative memory- and characteristics- limitations and applications- Hopfield v/s Boltzman machine- Adaptive Resonance Theory- Architecture-classifications-Implementation and training-Associative Memory.

Deep Learning Techniques: Introduction, L-Layer Neural Network, Gradient Descent learning, Parameters - Hyperparameters, Convolutional Neural Network (CNN) - AlexNet, VGG Net, ResNet**.**

Optimization Algorithm: Basic concept of Genetic algorithm and detail algorithmic steps-adjustment of free Parameters-Solution of typical control problems using genetic algorithm-Concept on some other search techniques like tabu search and ant colony search techniques for solving optimization problems.

Fuzzy Systems: Different faces of imprecision - inexactness, Ambiguity, Undecidability, Fuzziness and certainty, Fuzzy sets and crisp sets. Intersections of Fuzzy sets, Union of Fuzzy sets, the complement of Fuzzy sets - Fuzzy reasoning. Linguistic variables, Fuzzy propositions, Fuzzy compositional rules of inference - Methods of decompositions and defuzzification.

Text Books:

1 Laurene V. Fausett, “Fundamentals of Neural Networks: Architectures, Algorithms, And Applications”, 1st edition, Pearson Education, 1993.
2 Zimmermann H. J. "Fuzzy set theory and its Applications" Springer international edition, 2011
3 David E. Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning”, Pearson Education, 2009.

Reference Books:

1 Timothy J. Ross, “Fuzzy Logic with Engineering Applications”, 3rd edition, Wiley India, 2012.
2 W. T. Miller, R. S. Sutton and P. J. Webros, “Neural Networks for Control”, MIT Press, 1996.
3 Herniter, Marc E. Programming in MATLAB. Brooks/Cole-Thomson Learning, 2001.

Web link(s):

1 www. towardsdatascience.com
2 https://nptel.ac.in/courses/106/105/106105215/

Course Code	:	**CS526**
Course Title	:	**Social Network Analysis**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Develop semantic web related applications.
CO2 Describe and represent knowledge using ontology.
CO3 Examine web social networks to detect and extract communities.
CO4 Employ tools to predict human behavior in social web and related communities.
CO5 Visualize online social networks with matrix representation.

Course Content:

Introduction: Semantic Web, Development of Semantic Web, Emergence of the Social Web, Social Network analysis, Key concepts and measures in network analysis, Web-based networks, Applications of Social Network Analysis.

Modelling, Aggregating and Knowledge Representation: Ontology and their role in the Semantic Web, Ontology languages: Resource Description Framework, Web Ontology Language, Modelling and aggregating social network data, Ontological representation of social, social relationships, Aggregating and reasoning with social network data, Advanced representations.

Extraction and Mining Communities in Web Social Networks: Extracting evolution of Web Community from a Series of Web Archive, Definition of community, Evaluating communities, Methods for community detection and mining, Applications of community mining algorithms, Tools for detecting communities social network infrastructures and communities, Decentralized online social networks, Multi-Relational characterization of dynamic social network communities.

Predicting Human Behavior and Privacy Issues: Understanding and predicting human behavior for social communities, User data management, Inference and Distribution, Enabling new human experiences, Reality mining, Privacy in online social networks, Trust in online environment, Trust network analysis, Trust transitivity analysis, Combining trust and reputation, Trust derivation based on trust comparisons, Attack spectrum and counter measures.

Visualization and Applications of Social Networks: Graph theory, Centrality, Clustering, Node-Edge Diagrams, Matrix representation, Visualizing online social networks, Visualizing social networks with matrix-based representations, Matrix and Node-Link Diagrams, Hybrid representations, Applications, Cover networks, Community welfare, Collaboration networks, Co-Citation networks

Text Books:

1 Peter Mika, "Social Networks and the Semantic Web", First Edition, Springer, 2007.

2 Borko Furht, "HandBooks of Social Network Technologies and Applications", First Edition, Springer Science & Business Media, 2010.

Reference Books:

1 Guandong Xu ,Yanchun Zhang and Lin Li, "Web Mining and Social Networking – Techniques and applications", First Edition, Springer, 2011.

2 Dion Goh and Schubert Foo, "Social information Retrieval Systems: Emerging Technologies and Applications for Searching the Web Effectively", IGI Global Snippet, 2008.

3 Max Chevalier, Christine Julien and Chantal Soulé-Dupuy, "Collaborative and Social Information Retrieval and Access: Techniques for Improved user Modelling", IGI Global Snippet, 2009.

Web link(s):

1 http://www.leonidzhukov.net/hse/2015/sna/

2 https://www.microsoft.com/en-us/research/video/social-network-analysis/

Course Code	:	**CS527**
Course Title	:	**Mobile Computing**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the fundamentals of mobile communication.
CO2 State different data transmission standards.
CO3 Explain the architecture of various wireless networks.
CO4 Evaluate the significance of different layers in mobile system.
CO5 Analyze the methods to achieve wireless security.

Course Content:

Introduction Challenges in mobile computing, coping with uncertainties, resource poorness, bandwidth, etc. Cellular architecture, co-channel interference, frequency reuse, capacity increase by cell splitting.

Medium Access Control Motivation, SDMA, FDMA, TDMA: Fixed TDM, Aloha, CSMA, Demand assigned multiple access, PRMA, Reservation TDMA, Collision avoidance, Polling, Inhibit sense multiple access; CDMA: Spread Aloha multiple access.

Wireless LAN, HIPERLAN, and Bluetooth Infrared vs. Radio transmission, Ad hoc Networks, IEEE 802.11, HIPERLAN, Bluetooth - Standards, Layers, Security.

Mobile Network and Transport Layers Mobile IP, Packet delivery, Agent discovery, Registration, Tunneling and Encapsulation, Optimizations, Reverse tunneling, IPv6, DHCP, Ad hoc networks: Routing, TCP- Congestion control, Implications on mobility; Indirect, Snooping, Mobile TCP, Retransmission, Transaction oriented TCP.

Ubiquitous computing and Wireless Security Context aware computing and applications, middleware support, Service discovery, adaptation, mobile agents, Wireless security- Mobile and wireless security issues, Problems in ad hoc networks.

Text Books:

1 Frank Adelstein, S.K.S. Gupta, Golden G. Richard III and Loren Schwiebert, “Fundamentals of Mobile and Pervasive Computing”, First edition, McGraw-Hill Professional, 2005.
2 Jochen Schiller, “Mobile Communication”, Second Edition, Pearson Education, 2008.
3 Charles Perkins, “Ad hoc Networking”, First edition, Addison Wesley, 2001.

Reference Books:

1 Asoke. K Talukder, Roopa R. Yavagal, Asoke K. Talukder, “Mobile Computing”, Second edition, TMH, 2010.
2 Theodore and S. Rappaport, “Wireless Communications, Principles, Practice”, Second Edition, PHI, 2010.
3 William Stallings, “Wireless Communications and Networks”, Second Edition, Pearson Education, 2009.

Web link(s):

1 https://www.classcentral.com/course/wireless-communications-7503
2 https://freevideolectures.com/course/2329/wireless-communication

Course Code	:	**CS528**
Course Title	:	**Randomized Algorithms**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Apply the basics of probability theory to analyze algorithms.
CO2 Compare randomized algorithms and its advantages to traditional algorithm.
CO3 Describe Chernoff Bound and packet routing in sparse networks.
CO4 Explain hashing and random graph models.
CO5 Employ Markov Chain and Random Walk on real world problems.

Course Content:

Elementary Probability Theory Elements of probability theory, Verification of strings, poly identities, matrix multiplication Las Vegas and Monte Carlo algorithms, Expectations, Jensen's Inequality, Coupon collector's problem, geometric distribution.

Random Variable and Chebyshev Inequality Randomized Quick Sort and its expected run-time, Variance and moments, Chebyshev's inequality, Coupon collector's problem, randomized median finding, analysis, moment generating functions.

Chernoff Bound and packet routing in sparse networks Derivation and application of Chernoff's bounds, Sum of Poisson Trials, Coin flips, Set balancing, Packet routing in sparse networks, permutation routing on the hypercube, butterfly.

Hashing and random graphs Birthday paradox, balls and bins model, application to bucket sort, Poisson distribution, Application to hashing, random graph models, Hamiltonian cycles in random graphs.

Markov Chain and Random Walk Markov chains, representations, randomized algorithm for 2-satisfiability and 3-satisfiability, classification of states, gambler's ruin, random walks on undirected graphs, s-t connectivity algorithm.

Text Books:

1 Michael Mitzenmacher and Eli Upfal, “Probability and computing: Randomized algorithms and Probabilistic analysis”, Second edition, Cambridge University Press, 2017.
2 Motwani R, “Randomized Algorithms”, Cambridge University Press, 1995.
3 Vazirani V., “Approximation Algorithms”, Springer, First Edition, 2004.

Reference Books:

1 Prabhakar Raghavan and Rajeev Motwani, “Randomized algorithms”, Cambridge University Press, 1995.
2 Sanjeev Arora and Boaz Barak, “Computational Complexity: A Modern Approach”, Cambridge University, 2009.
3 Feller, William. “*An Introduction to Probability Theory and Its Applications” v*ol. 1. New York, NY: John Wiley, 1968.

Web link(s):

1 https://www.wolframscience.com/nks/notes-10-9--randomized-algorithms/
2 https://brilliant.org/wiki/randomized-algorithms-overview/

Course Code	:	**CS529**
Course Title	:	**GPU Computing**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the basics of GPUs and GPU architecture.
CO2 Write parallel programs for GPUs using OpenCL.
CO3 Develop programs to achieve data parallelism with CUDA.
CO4 Examine performance considerations for efficient GPU programming.
CO5 Discuss the architecture evolution of GPU computing.

Course Content:

Introduction Graphics Processing Units (GPU) as Parallel Computers - Architecture of a modern GPU - Why more speed or parallelism? - Parallel Programming Languages and Models - Overarching Goals – History - Evolution of Graphics Pipelines - GPU Computing.

Parallel Programming Goals of Parallel Programming - Problem Decomposition - Algorithm Selection - Computational Thinking – OPENCL: Background – Data Parallelism Model – Device Architecture – Kernel Functions - Device Management & Kernel Launch.

Introduction to CUDA Data Parallelism - CUDA Structure - Matrix Multiplication - Device Memories and Data Transfer - Kernel Functions and Threading - Function declarations - Kernel launch - Predefined variables - Runtime API – CUDA Threads – CUDA Memories.

Performance considerations Thread execution – Memory bandwidth – Dynamic partitioning – Data prefetching - Instruction mix – Thread Granularity- Floating Point considerations – Algorithm considerations – Debugging and Profiling.

Architecture Evolution Memory Architecture – Kernel Execution and Control Evolution – Core Performance – Programming Environment – Application Case Study: Advanced MRI Reconstruction**.**

Text Books:

1 David Kirk, Wen-mei Hwu, “Programming Massively Parallel Processors: A Hands-on Approach”,Third Edition, Morgan Kaufmann, 2017.
2 Mete Yurtoglu and Duane Storti, “Cuda For Engineers An Introduction To High-Performance Parallel Computing”, Pearson India, 2016.
3 Aaftab Munshi , Benedict Gaster, Timothy G. Mattson, “OpenCL Programming Guide”, First edition, Addison Wesley, 2011.

Reference Books:

1 Shane Cook, " CUDA Programming: A Developer's Guide to Parallel Computing with GPUs (Applications of Gpu Computing)", First edition, Morgan Kaufmann, 2012

Web link(s):

1 http://docs.nvidia.com/cuda/cuda-c-programming-guide/index.html
2 https://devblogs.nvidia.com/even-easier-introduction-cuda/

Course Code	:	**CS530**
Course Title	:	**Computer Graphics**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Differentiate various computer graphics hardware and display technologies.
CO2 Discuss different output primitives and draw 2D and 3D objects using OpenGL.
CO3 Apply 2D transformation and clipping algorithms for point, line and polygon
CO4 Describe curves and surfaces using interpolation methods and perform 3D transformation on objects.
CO5 Develop applications using animation and morphing techniques.

Course Content:

Introduction: Basics and applications of Computer Graphics, Graphics software and standards, Interaction (sample- and event-driven) and Graphics user Interface (GUI) features, **Display Systems:** Raster and Random displays, CRT basics, Flat panel displays, 3D display systems. Hardcopy devices – Printers and Plotters, Various File formats and Colour models.

Output Primitives: Point, Line, Circle, Ellipse. Scan conversion algorithms for primitives, Fill area primitives – scanline polygon filling, inside-outside test, boundary and floodfill, character generation, line attributes, area-fill attributes, character attributers. **OpenGL primitives**: Functions, pipeline, sample programs for drawing 2-D, 3-D objects; event handling and view manipulation.

2D Transformations and Viewing: Rotation, Translation, Scale, Reflection and Shear Transform, Matrix representation, homogeneous coordinates, composite transformations, Clipping algorithms for point, line and polygon, Text.

3D object representation: 3D display methods, polygon surfaces, tables, equations, meshes. **Curves and Surfaces:** curved lines and surfaces, quadric surfaces, spline representation, cubic spline interpolation methods, Bezier curves and surfaces, B-spline curves and surfaces.**3D transformation and viewing**: 3D translation, rotation and scaling, composite transformation, viewing pipeline and coordinates, parallel and perspective transformation, view volume and general (parallel and perspective) projection transformations.

H**idden Surface Removal:** Back face detection, Z-buffer method, Painter's algorithm, scan-line algorithm, BSP-trees, Area sub-division method, Ray tracing. Animation, Morphing.

Text Books:

1 D. Hearn and M. P. Baker, "Computer Graphics with OpenGL", 4th edition, Pearson

Education, 2013.
2 J. D. Foley, A. Van Dam, S. K. Feiner and J. F. Hughes, “Computer Graphics; Principles and practice in C”, Second Edition, Addison Wesley, 1997.
3 D. F. Rogers and J. A. Adams, “Mathematical elements for Computer Graphics”, 2nd edition, McGraw-Hill International. Edn., 1990.

Reference Books:

1 F. S. Hill Jr., “Computer Graphics using OpenGL”, 2nd edn., Pearson Education, 2003.
2 Shreiner, Woo, Neider, Davis, “OpenGL Programming Guide”, 6th. Edition, Pearson Education, 2008.
3 Peter Shirley, Steve Marschner and others, “Fundamentals of Computer Graphics”, 3rd Edition, A K Peters/CRC Press, 2009.

Web link(s):

1 https://nptel.ac.in/courses/106/106/106106090/

2 https://nptel.ac.in/courses/106/102/106102063/

Course Code	:	**CS531**
Course Title	:	**Principles of Cryptography**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the mathematics behind cryptographic algorithms.
CO2 Describe the functions of different cryptographic algorithms.
CO3 Analyze and compare different symmetric-key encryption based on different security models.
CO4 Demonstrate the Conventional Encryption Principles and the Public key cryptography principles.
CO5 Apply cryptographic techniques to secure e-Commerce and other secret transactions.

Course Content:

Algebra: Group, cyclic group, cyclic subgroup, field, probability. Number Theory: Fermat's theorem , Cauchy 's theorem, Chinese remainder theorem, primality testing algorithm, Euclid's algorithm for integers, quadratic residues, Legendre symbol, Jacobi symbol etc.

Cryptography and cryptanalysis: Classical Cryptography, substitution cipher, different type of attack: CMA,CPA,CCA etc, Shannon perfect secrecy, OTP, Pseudo random bit generators, stream ciphers and RC4.

Block ciphers: Modes of operation, DES and its variants, AES, linear and differential cryptanalysis.

One-way function: trapdoor one-way function, Public key cryptography, RSA cryptosystem, Diffie-Hellman key exchange algorithm, Elgamal Cryptosystem.

Hash functions: Secure hash algorithm, Message authentication, digital signature, RSA digital signature, ElGamal digital signature.

Text Books:

1 Doug Stinson, “Cryptography: Theory and Practice”, Third edition, Chapman & Hall/CRC, 2010.
2 Behrouz A. Forouzan and Debdeep Mukhopadhyay, “Cryptography and Network Security”, Second edition, Tata McGraw Hill, 2011.
3 William Stallings, “Cryptography and Network Security Principles and practice”, Sixth edition, Pearson Education Asia, 2014.

Reference Books:

1 Thomas Koshy, “Elementary Number Theory with applications”, Elsevier India, 2005.

Web link(s):

1 https://crypto.stanford.edu/~dabo/courses/OnlineCrypto/
2 https://www.classcentral.com/course/basic-cryptography-and-crypto-api-9531

Course Code	:	**CS532**
Course Title	:	**Mobile Application Development**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain system requirements for mobile applications.
CO2 Create suitable design using specific mobile development frameworks.
CO3 Integrate advanced design features in mobile applications.
CO4 Develop mobile application design using Android Platform.
CO5 Experiment various application design using cross platform techniques.

Course Content:

Introduction Introduction to mobile applications, embedded systems, Market and business drivers for mobile applications, Publishing and delivery of mobile applications, Requirements gathering and validation for mobile applications.

Basic Design Introduction to embedded systems design, Embedded OS, Design constraints for mobile applications, Architecting mobile applications, User interfaces for mobile applications, Quality, performance, usability, security, availability and modifiability.

Advanced Design Designing applications with multimedia and web access capabilities, Integration with GPS and social media networking applications, accessing applications hosted in a cloud computing environment, Design patterns for mobile applications.

Android Platform Environment, Android architecture, Activities and views, Interacting with UI, Persisting data using SQLite, Packaging and deployment, Server side applications, Using Google Maps, GPS and Wi-Fi, Integration with social media applications.

Cross platform application development Installation and features of Cordova, Ionic and React Native. Cross-platform application development (Cordova, HTML5, CSS3, Javascript). Developing apps using React Native and Javascript.

Text Books:

1 Jeff McWherter and Scott Gowell, “Professional Mobile Application Development”, Wrox, 2012.
2 Charlie Collins, Michael Galpin and Matthias Kappler, “Android in Practice”, DreamTech, 2012.
3 Anubhav Pradhan, Anil V Deshpande, “Composing Mobile Apps Learn|Explore|Apply

using Android", First Edition, Wiley Publications, 2014.

Reference Books:

1 Erica Sadun, "The Core iOS Developer's CookBooks", Fifth edition, Addison-Wesley 2014.
2 David Mark, Jack Nutting, Jeff LaMarche and Frederic Olsson, "Beginning iOS 6 Development: Exploring the iOS SDK", First edition, Apress, 2013.

Web link(s):

1 https://developer.android.com/docs/
2 https://techbeacon.com/app-dev-testing/ultimate-android-development-guide-50-beginner-expert-resources

Course Code	:	**CS533**
Course Title	:	**Quantum Computing**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the basic principles of quantum computing.
CO2 Distinguish between conventional computing and quantum computing.
CO3 Apply basic quantum computing algorithms.
CO4 Explain the use of quantum parallelism in simple quantum algorithms.
CO5 Apply cryptography techniques in quantum computing.

Course Content:

Computer organization and theory of computation: Binary system, Boolean algebra, logic gates, quantum logic gates, algorithms, Turing machines and effective computability.

Quantum mechanics and computers: From bits to qubits, superposition, measurement, classical and quantum coin-tosses, uncertainty principle.

Quantum algorithms: Quantum parallelism, Discrete Fourier Transform, phase estimation, Shor's factoring and Grover's searching algorithms.

Physical realization of quantum computation: ion trap, cavity QED, nuclear magnetic resonance (NMR) and solid-state-based quantum computers.

Quantum Information: Quantum cryptography, quantum teleportation and quantum error correction.

Text Books:

1 Michael A. Nielsen and Isaac L. Chuang, “Quantum Computation and Quantum Information”, Tenth Anniversary Edition, Cambridge Univesrity Press, 2010.

Reference Books:

1 Benenti, Giuliano, Giulio Casati, and Giuliano Strini, “Principles of quantum computation and information: Volume II: Basic Tools and Special Topics”, World Scientific Publishing Company, 2007.

2 Pittenger, Arthur O, “An introduction to quantum computing algorithms”, Vol. 19, Springer Science & Business Media, 2012.

Web link(s):

1 https://nptel.ac.in/courses/115/101/115101092/

2 https://homepages.cwi.nl/~rdewolf/qcnotes.pdf

Course Code	:	**CS534**
Course Title	:	**Natural Language Processing**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the mathematical and linguistic foundations in NLP.
CO2 Describe N-gram language models in NLP.
CO3 Apply neural network algorithms for learning patterns in NLP.
CO4 Employ different parsing techniques and perform semantic analysis.
CO5 Analyze machine translation techniques.

Course Content:

Introduction: NLP tasks in syntax, semantics, and pragmatics, Applications, The problem of ambiguity, The role of machine learning, Brief history of the field.

N-gram Language Models: The role of language models, Simple N-gram models, Estimating parameters and smoothing, Evaluating language models, Lexical syntax, Hidden Markov Models (Forward and Viterbi algorithms and EM training).

Basic Neural Networks: Any basic introduction to perceptron and backpropagation, Pattern Recognition and Machine Learning, LSTM Recurrent Neural Networks.

Syntactic parsing and Semantic Analysis:: Grammar formalisms and treebanks, Efficient parsing for context-free grammars (CFGs), Statistical parsing and probabilistic CFGs (PCFGs), Lexicalized PCFGs, Neural shift-reduce dependency parsing, Lexical semantics and word-sense disambiguation, Compositional semantics, Semantic Role Labeling and Semantic Parsing.

Information Extraction (IE)and Machine Translation (MT): Named entity recognition and relation extraction, IE using sequence labeling, Basic issues in MT, Statistical translation, word alignment, phrase-based translation, and synchronous grammars.

Text Books:

1 Jurafsky, Dan and Martin, James, "Speech and Language Processing", second Edition, Pearson Education,Tenth Impression, 2018.
2 Christopher Manning and SchutzeHeinrich, "Foundations of Statistical Natural Language Processing", MIT Press, 1999.

Reference Books:

1 Allen James, “Natural Language Understanding”, second edition, Benjamin Cumming, 1995.

2 Charniack, Eugene, “Statistical Language Learning”, MIT Press,1993.

Web link(s):

1 https://www.cs.utexas.edu/~mooney/cs388/

2 http://www1.cs.columbia.edu/~kathy/NLP/

3 https://people.cs.umass.edu/~mccallum/courses/inlp2007/index.html

Course Code	:	**CS535**
Course Title	:	**Big Data Analytics**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the characteristics of big data and its management architecture.
CO2 Analyze data with Hadoop.
CO3 Apply MapReduce programming model to process big data.
CO4 Use Spark and SCALA for big data processing.
CO5 Develop programs for big data applications with NoSQL database.

Course Content:

Introduction: Big Data - Characteristics of Big Data – Big data management architecture- Examining Big Data Types – Big Data Technology Components - Big data analytics – Big data analytics examples - Web Data Overview – Web Data in Action.

Hadoop: Introduction – History of Hadoop - Hadoop Ecosystem- Analyzing data with Hadoop - Hadoop Distributed File System- Design - HDFS concepts - Hadoop filesystem – Data flow –Hadoop I / O - Data integrity – Serialization - Setting up a Hadoop cluster - Cluster specification - cluster setup and installation – YARN.

MapReduce: Introduction – Understanding Map, Reduce functions - Scaling out - Anatomy of a MapReduce Job Run - Failures – Shuffle and sort - Mapreduce types and formats - features – counters - sorting - Mapreduce Applications – Configuring and setting the environment - Unit test with MR unit- local test.

Spark: Installing spark – Spark applications, Jobs, Stages and Tasks –Resilient Distributed databases - Anatomy of a Spark Job Run – Spark on YARN - SCALA: Introduction- Classes and objects- Basic types and operators- built-in control structures- functions and closures- inheritance.

NoSQL Databases: Introduction to NoSQL - MongoDB: Introduction – Data types –- Creating, Updating and deleing documents -Querying – Introduction to indexing – Capped collections. Hbase: Concepts - Hbase Vs RDBMS - Creating records- Accessing data – Updating and deleting data –Modifying data- exporting and importing data.

Text Books:

1 EMC Education Services, “Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data”, Wiley publishers, 2015.
2 Simon Walkowiak, “Big Data Analytics with R”, PackT Publishers, 2016.

3 David Loshin, “Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph”, Morgan Kaufmann/Elsevier Publishers, 2013.

Reference Books:

1 Bart Baesens, “Analytics in a , World: The Essential Guide to Data Science and its Applications”, Wiley Publishers, 2015.
2 Kim H. Pries and Robert Dunnigan, “Big Data Analytics: A Practical Guide for Managers” CRC Press, 2015.
3 Anand Rajaraman and Jeffrey David Ullman, "Mining of Massive Datasets", Cambridge University Press, 2012.

Web link(s):

1 https://nptel.ac.in/courses/106/104/106104189/

2 https://www.guru99.com/bigdata-tutorials.html

Course Code	:	**CS536**
Course Title	:	**Network Security**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Distinguish between conventional and modern encryption techniques.
CO2 Describe different public key encryption algorithms.
CO3 Employ various hashing functions for authentication.
CO4 Compare different IEEE standards and electronic mail security.
CO5 Explain intrusion detection system and firewall design principles.

Course Content:

Conventional and Modern Encryption Model of network security – Security attacks, OSI – SDES – Block cipher - DES – Mode of operation – AES – RC4 - Differential and linear cryptanalysis – Placement of encryption function – traffic confidentiality.

Public Key Encryption Number Theory – Euclid's algorithm - Fermet's and Euler's theorem – Primality – CRT – Discrete logarithm – RSA – Key distribution – Key management – Diffie Hellman key exchange – Elliptic curve cryptography.

Authentication Authentication requirement – Authentication function – MAC – Hash function – Security of hash function and MAC – SHA –MD5- HMAC – CMAC - Digital signature and authentication protocols – DSS.

Security Practice Authentication applications – Kerberos – X.509 Authentication services - E-mail security – IP security - Web security.

System Security Introduction to distributed ledgers - Intruder – Intrusion detection system – Virus and related threats – Countermeasures – Firewalls design principles – Trusted systems – Practical implementation of cryptography and security.

Text Books:

1 William Stallings, "Cryptography & Network Security", Sixth Edition, Pearson Education, 2014.
2 Behrouz A. Forouzan and Debdeep Mukhopadhyay, Cryptography and Network Security, Second edition, Tata McGraw Hill, 2011.
3 V. K. Pachghare, "Cryptography and Information Security", Third edition, PHI Learning, 2019.

Reference Books:

1 Charlie Kaufman, Radia Perlman, Mike Speciner, “Network Security, Private communication in public world”, PHI Second Edition, 2002.
2 BruceSchneier, Neils Ferguson, “Practical Cryptography”, Wiley Dreamtech India Pvt Ltd, First Edition, 2003.
3 Douglas R Simson, “Cryptography – Theory and practice”, CRC Press, First Edition, 1995.

Web link(s):

1 https://online.stanford.edu/courses/xacs255-network-security
2 https://www.futurelearn.com/courses/introduction-to-cyber-security

Course Code	:	**CS537**
Course Title	:	**Architecture of High Performance Computers**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**Computer Organization and Architecture**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the fundamental issues and tradeoffs involved in the design and evaluation of modern computers.
CO2 Interpret the execution of instructions through pipelining in a processor.
CO3 Employ optimization algorithms to manage memory efficiently.
CO4 Explain the methods of improving performance in a processor using software and hardware constructs.
CO5 Design advanced architectures for specific application domains.

Course Content:

Introduction Measuring Performance - Instruction Set Architecture - MIPS ISA Processor.

Pipelining Instruction Pipelining - Hazards - Software Pipelining - Dynamic Scheduling - Speculation - Multi Threading.

Memory Hierarchy and Multiprocessing Memory Technology and Optimizations - Cache Performance - Advanced Cache Optimizations - Virtual Memory.

Data and Thread Level Parallelism Vector Architecture - SIMD Instruction Set - Graphics Processing Units - Detecting and Enhancing Loop Level Parallelism - Thread Level Parallelism - Centralized Shared Memory Architecture - Distributed Shared Memory Architecture - Coherency and Consistency.

Domain Specific Architectures Guidelines - Example Domain: Neural Networks - Case Studies: Google's Tensor Processing Unit - Microsoft Catapult - Intel Crest - Pixel Visual Core.

Text Books:

1 David Patterson, John L. Hennessy, "Computer Architecture: A Quantitative Approach", Sixth Edition, Morgan Kaufmann, 2017.
2 R. Ibbett ,"The Architecture of High Performance Computers" , Second edition, Springer, 1989.
3 R. Ibbett ,"Architecture of High Performance Computers Volume II", First edition, Springer, 1989.

Reference Books:

1 Harold S. Stone, “High Performance Computer Architecture”, Third edition, Prentice Hall, 1993.
2 Thomas Sterling, Maciej Brodowicz, Matthew Anderson, “High Performance Computing - Modern Systems and Practices”,First edition, Morgan Kaufmann, 2017.

Web link(s):

1 https://nptel.ac.in/courses/106/105/106105033/
2 https://omscs.gatech.edu/cs-6290-high-performance-computer-architecture

Course Code	:	**CS538**
Course Title	:	**Software Project Management**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Develop software projects and manage resources.
CO2 Calculate cost, size and time metrics to develop a software product.
CO3 Employ quality standards and certifications for a software product.
CO4 Assess the cost of risk involved in project management.
CO5 Use tools for software project management.

Course Content:

SPM concepts: Definition, components of SPM, challenges and opportunities, tools and techniques, managing human resource and technical resource, costing and pricing of projects, training and development, project management techniques.

Software Measurements: Monitoring & measurement of SW development, cost, size and time metrics, methods and tools for metrics, issues of metrics in multiple projects.

Software Quality: Quality in SW development, quality assurance, quality standards and certifications, the process and issues in obtaining certifications, the benefits and implications for the organization and its customers, change management.

Risk Issues: The risk issues in SW development and implementation, identification of risks, resolving and avoiding risks, tools and methods for identifying risk management.

SPM Tools: Software project management using Primavera & Redmine and case study on SPM tools.

Text Books:

1 Richard H. Thayer, "Software Engineering Project Management", 2nd edition, John Wiley & Sons, 2001.

2 Royce Walker, "Software Project Management", Pearson Education, 2002.

Reference Books:

1 Kelker, S. A., “Software Project Management”, Prentice Hall, 2003.

2 Galin, Daniel. Software quality assurance: from theory to implementation. Pearson Education India, 2004.

Web link(s):

1 https://cs.uwaterloo.ca/~apidduck/se362/

2 https://ocw.mit.edu/courses/engineering-systems-division/esd-36-system-project-management-fall-2012/index.htm

Course Code	:	**CS539**
Course Title	:	**Data Science**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the data science concepts, techniques and models.
CO2 Apply various supervised machine learning algorithms to classify the data.
CO3 Describe unsupervised machine learning algorithm and evaluate its performance.
CO4 Construct model for recommendation system.
CO5 Analyze the time series data.

Course Content:

Introduction to data science- case for data science-data science classification-data science algorithms, Data Science Process- prior Knowledge-Data Preparation-Modeling-Application-Knowledge, Data Exploration-Objectives of data Exploration-Datasets-Descriptive Statistics-Data Visualization-Roadmap for data exploration.

Supervised Machine learning: Classification-Decision Trees-Rule Induction-K-Nearest Neighbors-Naïve Bayesian-Artificial Neural Networks-Support Vector Machines-Ensemble learners, Regression Methods-Linear Regression-Logistic regression.

Unsupervised Machine Learning: Association Analysis-Mining Association rules-Apriori Algorithm-Frequent pattern growth algorithm, Clustering-K-means clustering-DBSCAN Clustering-Self organizing maps, Model Evaluation-Confusion matrix-ROC and AUC-Lift Curves-How to implement.

Advanced Learning: Text Mining- Deep Learning-Foundations of Deep Learning-Methods and Models, Recommendation Engines-Recommendation Engine Concepts-Collaborative Filtering-Content based Filtering-Hybrid recommenders.

Time Series Analysis: Forecasting-Time series Decomposition-Smoothing based Methods-Regression based Methods-Machine Learning Methods-Performance evaluation, Outlier Detection, Feature Selection.

Text Books:

1 Vijay Kotu, Bala Deshpande, "Data Science: Concepts and Practice", 2nd Edition , Elsevier publications, 2019.

2 Brandon Reagen, Robert Adolf, Paul Whatmough, Gu-Yeon Wei, David Brooks," Deep Learning for Computer Architects", Morgan ClayPool Publishers, 2017.

Reference Books:

1 Ethem Alpaydin, ―Introduction to Machine Learning 3e (Adaptive Computation and Machine Learning Series), Third Edition, MIT Press, 2014.
2 Stephen Marsland, ―Machine Learning – An Algorithmic Perspective, Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014.

Web link(s):

1 www.towardsdatascience.com

2 https://nptel.ac.in/courses/106/106/106106179/

Course Code	:	**CS540**
Course Title	:	**Information Security**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Discuss the basics of Information Security.
CO2 Describe the legal, ethical and professional issues in Information Security.
CO3 Analyze the aspects of risk management.
CO4 State the various standards for Information Security.
CO5 Explain the technological aspects to ensure Information Security.

Course Content:

Introduction Information Security-Critical Characteristics of Information-NSTISSC Security Model-Components of an Information System-Securing the Components-Balancing Security and Access-The SDLC-The Security SDLC.

Security Investigation Need for Security-Business Needs-Threats-Attacks-Legal-Ethical and Professional Issues – An Overview of Computer Security – Access Control Matrix-Policy-Security Policies-Confidentiality policies- Integrity policies and Hybrid policies.

Security Analysis Risk Management: Identifying and Assessing Risk-Assessing and Controlling Risk – Systems: Access Control Mechanisms-Information Flow and Confinement Problem.

Logical Design Blueprint for Security-Information Security Policy-Standards and Practices-ISO 17799/BS 7799-NIST Models-VISA International Security Model-Design of Security Architecture-Planning for Continuity.

Physical Design Security Technology-IDS-Scanning and Analysis Tools-Cryptography-Access Control Devices-Physical Security-Security and Personnel.

Text Books:

1 Michael E Whitman and Herbert J Mattord, “Principles of Information Security”, Vikas Publishing House, New Delhi, 2003.
2 Micki Krause, Harold F. Tipton, “HandBooks of Information Security Management”, Vol 1-3 CRCPress LLC, 2004.
3 Mark Stamp, “Information Security: Principles and Practice”, Second edition, Wiley, 2011.

Reference Books:

1 Stuart McClure, Joel Scrambray, George Kurtz, “Hacking Exposed”, Tata McGraw- Hill, 2003.
2 Matt Bishop, “Computer Security Art and Science”, Pearson/PHI, 2002.

Web link(s):

1 https://www.cybrary.it/
2 https://www.lynda.com/Security-training-tutorials/2069-0.html

Course Code	:	**CS541**
Course Title	:	**Virtual Reality**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the basic concept and framework of virtual reality.
CO2 State the computer-human interaction.
CO3 Apply computer graphics techniques to virtual reality programs.
CO4 Use tools and frameworks to create virtual reality applications.
CO5 Apply virtual reality technology in film and digital entertainment industry.

Course Content:

Introduction: Fundamental Concept and Components of Virtual Reality, Primary Features and Present Development on Virtual Reality.

Interface: Multiple Models of Input and Output Interface in Virtual Reality: Input -- Tracker, Sensor, Digital Glove, Movement Capture, Video-based Input, 3D Menus & 3DScanner etc. Output -- Visual /Auditory / Haptic Devices.

Visual Computation: Fundamentals of Computer Graphics, Software and Hardware Technology on Stereoscopic Display, Advanced Techniques: Management of Large Scale Environments & Real Time Rendering.

Techniques: Interactive Techniques in Virtual Reality: Body Track, Hand Gesture, 3D Manus, Object Grasp, Development Tools and Frameworks in Virtual Reality: Frameworks of Software Development Tools in VR. X3D Standard, Vega, MultiGen, Virtools etc.

Applications: Virtual Reality Technology in Film & TV Production. Virtual Reality Technology in Physical Exercises and Games, Demonstration of Digital Entertainment by Virtual Reality.

Text Books:

1 Burdea, G. C. and P. Coffet, "Virtual Reality Technology", Second Edition, Wiley-IEEE Press, 2006.

Reference Books:

1 Alan B Craig, William R Sherman and Jeffrey D Will, "Developing Virtual Reality Applications: Foundations of Effective Design", Morgan Kaufmann, 2009.

2 William R Sherman and Alan B Craig, “Understanding Virtual Reality: Interface, Application and Design (The Morgan Kaufmann Series in Computer Graphics)”. Morgan Kaufmann Publishers, San Francisco, CA, 2002.

Web link(s):

1 https://stanford.edu/class/ee267/

2 https://nptel.ac.in/courses/106/106/106106138/

Course Code	:	**CS542**
Course Title	:	**Pattern Recognition**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Determine classifiers based on Bayes theory for pattern recognition.
CO2 Use linear classifiers to identify the patterns of data.
CO3 Categorize the data using nonlinear classifier algorithms.
CO4 Employ statistical analysis to select optimal feature set.
CO5 Develop template matching module to recognize the patterns.

Course Content:

Classifiers Based on Bayes Decision Theory: Introduction, Bayes Decision Theory, Discriminant Functions and Decision Surfaces, Bayesian Classification, Maximum Likelihood Parameter Estimation, Maximum a Posteriori Probability Estimation, Bayesian Inference, Maximum Entropy Estimation, Mixture Models, Nonparametric Estimation, The Naive-Bayes Classifier, The Nearest Neighbor Rule, Bayesian Networks.

Linear Classifiers: Linear Discriminant Functions and Decision Hyperplanes, The Perceptron Algorithm, Least Squares Methods, Mean Square Estimation Revisited: , Logistic Discrimination, Support Vector Machines.

Non Linear Classifiers: XOR Problem, Two-Layer and Three Layer Perceptrons, Backpropagation Algorithm , Hyperparameters, Generalized Linear Classifiers, Capacity of the l-Dimensional Space in Linear Dichotomies, Polynomial Classifiers, Radial Basis Function Networks, Universal Approximators, Nonlinear SVM, Decision Trees, Boosting Approach to Combine Classifiers.

Feature Selection: Preprocessing, Statistical Hypothesis Testing, The Receiver Operating Characterisitcs (ROC) Curve, Class Separability Measures, Feature Subset selection, Optimal Feature Generation, Neural Networks and Feature Generation / Selection, The Bayesian Information Criterion.

Feature Generation: Linear Transforms, Regional Features, Features for Shape and Size Characterization, Typical Features for Speech and Audio Classification Template Matching: Introduction, Similarity Measures Based on Optimal Path Searching Techniques, Measures Based on Correlations, Deformable Template Models.

Text Books:

1 S Theodoridis and K Koutroumbas – Pattern Recognition, 4th Edition, Academic Press,

2009.
2 C Bishop – Pattern Recognition and Machine Learning – Springer, 2006.
3 R. O. Duda and P. E. Hart, D. G. Stork, “Pattern Classification”, Wiley Interscience, Second Edition, 2007.

Reference Books:

1 R. O. Duda and P. E. Hart, D. G. Stork, “Pattern Classification”, Wiley Interscience, Second Edition, 2007.
2 J. P. Marques de Sá, “Pattern Recognition”, Springer Science & Business Media , 2001.

Web link(s):

1 https://nptel.ac.in/courses/106/106/106106046/

2 https://nptel.ac.in/courses/106/108/106108057/

Course Code	:	**CS543**
Course Title	:	**Design Thinking**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Analyze real-life problems in terms of methodical problems.
CO2 Apply various visualization principles for problem and solution representation.·
CO3 Design solutions by applying an integrated approach to design thinking.
CO4 Employ prototype solutions to problems
CO5 Develop solutions according to user needs.

Course Content:

Introduction: Design Thinking – What , How, Why – Design Process – Four Questions – Ten Tools – Identify an Opportunity – Scope your opportunity – Draft your design brief.

Visualization: Three visualizations – Visualization basics - Journey mapping – Value Chain analysis – Mind mapping.

Concept Creation: Design Criteria – Design thinking brainstorming – Concepts development – develop concepts – napkin pitches.

Prototyping: Assumption testing – Rapid Prototyping – Surface Key assumptions – make prototypes.

Redesigning: Customer co-creation – learning launch – Feedback from stake holders – Design the on-ramp - Case study.

Text Books:

1 Jeanne Liedtka, Tim Ogilvie, and Rachel Brozenske, The Designing for Growth Field Books: A Step-by Step Project Guide, New York: Columbia University Press, 2014.
2 Jeanne Liedtka and Tim Ogilvie, Designing for Growth: A Design Thinking Tool Kit for Managers, New York: Columbia University Press, 2011.
3 Nigel Cross, "Design Thinking: Understanding How Designers Think and Work", Bloomsbury Academic, 2011

Reference Books:

1 Jeanne Liedtka, Randy Salzman, and Daisy Azer, "Design Thinking for the Greater Good: Innovation in the Social Sector", Columbia Business School Publishing, 2017.

2 Don Norman, “The Design of Everyday Things”, Basic Bookss, 2013.
3 IDEO.org, “The Field Guide to Human Centered Design”, IDEO.org, 2015.

Web link(s):

1 Design Thinking Boot Camp Bootleg (Stanford D-School); https://dschool.stanford.edu/resources/the-bootcamp-bootleg
2 Design Thinking for Educators (IDEO); https://designthinkingforeducators.com/

Course Code	:	**CS544**
Course Title	:	**Malware Analysis and Detection**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Describe different types of malware in computer system.
CO2	Apply standard methodology for detecting, analyzing, reverse engineering, and eradicating malware.
CO3	Detect malware and employ anti-dynamic analysis technique.
CO4	Observe malware behavior and apply data encoding methods.
CO5	Explain signature and non-signature based malware detection techniques.

Course Content:

Basic Analysis: Introduction to malware, Operating system security concepts, malware threats, evolution of malware, malware types - viruses, worms, rootkits, trojans, bots, spyware, adwares, logic bombs, malware analysis, static malware analysis, dynamic malware analysis.

Advanced Static Analysis: x86 Disassembly: Levels of Abstraction, Reverse-Engineering, x86 Architecture: Main Memory, Instructions, Opcodes and Endianness, Operands, Registers, Simple Instructions, The Stack, Conditionals, Branching, Rep Instructions, C Main Method and Offsets, Analyzing Malicious Windows programs, Portable executable file format, disassembling malicious executable programs. Antistatic analysis techniques-obfuscation, packing, metamorphism, polymorphism.

Advanced Dynamic Analysis: Debugging malware, OllyDbg, Kernel Debugging with WinDbg, setting virtual environments-sandboxes, emulators, hypervisors, virtual machines, live malware analysis, dead malware analysis, analyzing traces of malware-systemcalls, api calls, registries, network activities. Anti dynamic analysis techniques-antivm, runtime evasion techniques.

Malware Functionality: Malware Behavior: Downloaders, Backdoors, Credential Stealers, Persistence Mechanisms, Privilege Escalation, Covert malware launching: Launchers, Process Injection, Process Replacement, Hook Injection, Detours, APC Injection, Data encoding: Simple Ciphers, Common Cryptographic Algorithms, Custom Encoding, Decoding, Malware-Focused Network Signatures: Network Countermeasures, Safely Investigate an Attacker

Online, Content-Based Network Countermeasures, Combining Dynamic and Static Analysis Techniques.

Malware Detection Techniques: Signature based techniques: malware signatures, packed malware signature, metamorphic and polymorphic malware signature, Non signature based techniques: similarity based techniques, machine learning methods, invariant inferences.

Text Books:

1 Michael Sikorski, Andrew Honig, "Practical Malware Analysis: The Hands-On Guide to Dissecting Malicious Software", 1st Edition, No Starch Press, 2012.

2 Eric Filiol, "Computer viruses: from theory to applications", 1st edition, Springer-Verlag Paris, 2006

3 Michael Hale Ligh, Andrew Case, Jamie Levy, AAron Walters, "The Art of Memory Forensics: Detecting Malware and Threats in Windows, Linux, and Mac Memory", 1st edition, Wiley, 2014.

Reference Bookss:

1 Michael Hale Ligh, Steven Adair, Blake Hartstein, Matthew Richard, "Malware Analyst's CookBooks and DVD: Tools and Techniques for Fighting Malicious Code", 1st Edition, Wiley, 2010.

2 Christodorescu, M.,Jha, S.,Maughan, D.,Song, D.,Wang, C, "Malware Detection", 1st edition, Springer US, 2007

3 Cameron H. Malin, Eoghan Casey, and James M. Aquilina , "Malware Forensics: Investigating and Analyzing Malicious Code", 1st edition, Syngress Publications, 2008.

Web links

1 https://www.cybrary.it/course/malware-analysis/

2 https://www.udemy.com/course/malware-analysis-and-reverse-engineering/

3 https://digital-forensics.sans.org/certification/grem

Course Code	:	**CS545**
Course Title	:	**Block Chain Techniques**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the functional/operational aspects of cryptocurrency ecosystem.
CO2 Apply cryptographic techniques to blockchain.
CO3 Discuss the functionalities of Bitcoin and other crypto currencies.
CO4 Explain some attacks on smart contracts.
CO5 Perform mining task in Bitcoin transaction.

Course Content:

Introduction: Basic ideas behind blockchain, how it is changing the landscape of digitalization, introduction to cryptographic concepts.

Blockchain: Hashing, public key cryptosystems, private vs public blockchain and use cases, Hash Puzzles, Introduction to Bitcoin Blockchain.

Bitcoin Blockchain: Bitcoin Blockchain and scripts, Use cases of Bitcoin Blockchain scripting language in micropayment, escrow etc., Downside of Bitcoin mining.

Ethereum: Ethereum Virtual Machine (EVM), Wallets for Ethereum - Solidity - Smart Contracts - some attacks on smart contracts, IOTA.

Mining: The real need for mining – consensus, Byzantine Generals Problem, Consensus as a distributed coordination problem, Coming to private or permissioned blockchains, use cases – Hyperledger and Corda.

Applications: Uses of Blockchain in E-Governance, Land Registration, Medical Information Systems, and others.

Text Books:

1 Narayanan, A., Bonneau, J., Felten, E., Miller, A., and Goldfeder, S, “Bitcoin and cryptocurrency technologies: a comprehensive introduction”, Princeton University Press, 2016.

Reference Books:

1 Bonneau, Joseph, Andrew Miller, Jeremy Clark, Arvind Narayanan, Joshua A. Kroll, and Edward W. Felten, "Sok: Research perspectives and challenges for bitcoin and cryptocurrencies.", In 2015 IEEE Symposium on Security and Privacy, pp. 104-121. IEEE, 2015.

2 Garay, Juan, Aggelos Kiayias, and Nikos Leonardos, "The bitcoin backbone protocol: Analysis and applications.", In Annual International Conference on the Theory and Applications of Cryptographic Techniques, pp. 281-310. Springer, Berlin, Heidelberg, 2015.

3 Pass, Rafael, Lior Seeman, and Abhi Shelat, "Analysis of the blockchain protocol in asynchronous networks.", In Annual International Conference on the Theory and Applications of Cryptographic Techniques, pp. 643-673. Springer, Cham, 2017.

Web link(s):

1 https://ocw.mit.edu/courses/sloan-school-of-management/15-s12-blockchain-and-money-fall-2018/index.htm

2 https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-cs01/

Course Code	:	**HM611**
Course Title	:	**Intellectual Property Rights**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 State the importance of intellectual property rights.

CO2 Describe the various aspects of patents to understand the process of patent filing.

CO3 Explain the scope of trademark and related features.

CO4 Analyze the importance of copyrights in reproduction and distribution.

CO5 Evaluate the significance of trade secret and its legal implications.

Course Content:

Introduction, Types and Importance of Intellectual Property Rights (IPR) – The Evolutionary Past - The IPR Tool - Legal and Ethical Tasks in Intellectual Property Law– New developments in IPR, Technological research, Innovations and Inventions, International Organizations, Agencies and treaties, IPR in India.

Patents: Need, subject matter, Classification of patents in India, Rights of a patent, Patent Searching, Patent Drafting, filing of a patent, applying and granting of patents, types of patent application, infringement and defences, limitations of patent rights, the international patent system.

Introduction, to Trade mark: Types and Importance– Purpose, Duration and function of Trade mark, Registration and acquisition Process, – Trade mark maintenance - Transfer of Rights - Infringement – Dilution, Ownership of Trade mark – Likelihood of confusion - Trademarks claims and Litigations – International Trade mark Law.

Introduction and Importance of Copyrights: Fundamentals of Copyrights Law, Copyright Ownership and issues, Originality of Material, Transfer and duration, Rights to Reproduction and Distribution, Rights to Perform the Work Publicly, Copyright Formalities and Registration, Copyright disputes and International Copyright law.

Introduction to Trade Secret: Determination of trade Secrets Status, Maintaining Trade Secret – Physical Security – Employee Limitation and confidentiality agreement - Trade Secret Law - Unfair Competition – Trade Secret Litigation – Breach of Contract, Geographic

indication, managing intellectual property in a knowledge-based society. IPR and technology transfer, famous IPR case studies.

Text Books:

1 Debirag E.Bouchoux: “Intellectual Property”. Cengage learning, New Delhi.

2 M.Ashok Kumar and Mohd.Iqbal Ali: “Intellectual Property Right” Serials Pub. Cyber Law. Texts & Cases, South-Western’s Special Topics Collections.

3 Prabhuddha Ganguli: ‘Intellectual Property Rights” Tata Mc-Graw –Hill, New Delhi.

Reference Books:

1 Jayashree, Watal, “Intellectual Property Rights In The WTO And Developing Contries”, Oxford University Press.

2 T. Ramappa, “Intellectual Property Rights under WTO” S. Chand.

3 Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, 4e Revised, ASPEN publishers, 2007.

Web link(s):

1 https://nptel.ac.in/courses/109/106/109106137/

2 https://nptel.ac.in/courses/110/105/110105139/

Course Code	:	**HM612**
Course Title	:	**Economics of Information Technology**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the economic characteristics of IT industry.

CO2 Employ various pricing strategies for products.

CO3 Perform switching cost analysis.

CO4 Analyze the effect of network in IT industry.

CO5 Create awareness about copyrights and patents.

Course Content:

Introduction: Overview of Information Technology Economics, Economic characteristics of the IT industry, Technology and market structure, Information Technology as Intellectual property, The Internet Boom, Combinatorial Innovation, Demand (Schumpeter), Supply side, Development of complements, Internet revolution, financial speculations, Moore's Law, the new economy of IT.

Pricing strategies: Personalization and Differentiation of product and prices, versioning, degrees of price discrimination, conditioning on purchase history, search good, bundling, dispersion of willingness to pay and barriers to entry.

Switching cost: Lock-in, Simple analytics of Lock-in, Klemperer (1995) model, Competition to acquire customers, Analytics to acquire customers, Switching cost and price discrimination, Supply and Demand side Economies of Scale, Competition and Welfare, Competing for Monopoly, Duopoly, the currency of competition and rules of games.

Network effect, Exploitation of network effect, Standards: Standard wars, Negotiations, Leaders, Cost advantages of Standardization, Windows versus Linux Case, the Napster case Economics of piracy, Reproduction and Degradation cost, System effects, Computer mediated transactions.

Intellectual Property Rights: Intellectual Property Right in Information Technology sector, Competition in IPR for Information Technology, Copyrights, Patents (offensive and defensive portfolio) and Trade secrets, secrecy to protect software programs, need for reform in patent.

system in IT.

Text Books:

1 Hal R. Varian, “Economics of Information Technology”, University of California, Berkeley, 2004.

2 Hal R. Varian, Joseph Farrell, Carl Shapiro, “The Economics of Information Technology: An Introduction”, Cambridge University press, 2004.

Reference Books:

1 Shapiro and Varian , “Information rules”, Harvard Business School Press,1999.

Course Code	:	**HM613**
Course Title	:	**Health Economics and Health Technology Assessment**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Discuss the need for Health Economics.

CO2 Describe the infrastructure of Health Economics system.

CO3 Explain different ways of delivering health care schemes.

CO4 Analyze cost-utility for health technology assessment and its contribution in policy making.

CO5 Summarize systematic reviews and construct guidelines for health economics research.

Course Content:

Introduction: Basic introduction to Health Economics, Consumer Behaviour, Problems in health care Market, Demand and Supply, Measuring Elasticity, Determinants of demand, Supply and costs of health service, Marginal analysis and opportunity cost, Grossman's Demand for Healthcare.

Production, Cost and Market for Health care: Behaviour models, Managed Care, Health Care Professionals, Hospitals Services, Health Insurance, Demand for Insurance: Expected Utility, Information, Complexity, Impact Evaluation, and Decision-Making, Basic market model in different aspects of health care, Market Imperfections, Cases of market failure, Akerlof Model, Asymmetric information, Adverse Selection: Graphical Analysis, Moral Hazard, Externalities, Health as Public and Private Goods.

Delivery of Health Care: The Labor Market for Physicians, The Hospital Industry, Why are Costs so High? Roles and limitations of market and Government in finance and organization of health care, Healthcare Financing, Equity and efficiency, Social Determinants of Health, Population, Health and Development, Population Aging, International Health Care Systems, Alternative Designs, Health Planning and Policies (Especially India).

Health Technology Assessment and Health System Policy-Making, Fundamentals of HTA, Economic, Social and Epidemiological Contexts, Choosing HTA topic, Primary data methods,

Assessing quality, validity, strength and limitations, Methods of economic evaluation, collecting cost data, key attributes of Cost analysis, Measurement of costs and benefits, cost-effectiveness, cost-utility analysis, Budget impact, Statistics in health economic evaluation including Quality of life, QALY's and DALY's.

Evidence-Based Healthcare: tools and databases, international resources, Issues of Data, integrative methods: Systematic Reviews and Critical Appraisal (Simple), guidelines for reporting primary and secondary research, modelling, Information and Knowledge in HTA, Technology Growth and Innovation, Pharmaceutical Markets and Innovation in HTA.

Text Books:

1 Folland, Goodmand, and Stano (FSG), "The Economics of Health and Health Care", 5th Edition, Pearson Prentice Hall Press, 2012.

2 Stephen Morris, Nancy Devlin, David Parkin, " Economic Analysis in Health Care", John Wiley & Sons, 2007.

3 Jay Bhattacharya, Timothy Hyde, Peter Tu., "Health Economics", Palgrave MacMillan, 2013.

Reference Books:

1 James W. Henderson, "Health Economics and Policy", Thomson-South-Western, (Indian edition by Akash Press, New Delhi) 2010.

2 Peter Bo Poulsen, "Health Technology Assessment and Diffiusion of Health Technology" Odense University Press, Paperback Edition, 1999.

3 Michael F. Drummond , "Methods for the Economic Evaluation of Health Care Programmes" (Paperback), 1987

Web link(s):

1 https://www.nlm.nih.gov/nichsr/hta101/HTA_101_FINAL_7-23-14.pdf

2 https://swayam.gov.in/nd1_noc19_mg50/preview

Course Code	:	**HM614**
Course Title	:	**Managerial Economics**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Discuss the importance of economics in engineering.

CO2 Analyze demand and supply to understand consumer behavior.

CO3 Estimate production related variables for cost analysis and maximize profit.

CO4 Evaluate market structure for suitable price determination.

CO5 Discuss the impact of inflation and business cycles on Indian economy.

Course Content

Basic economic concept – Importance of economic in engineering; Introduction to Managerial Economics; Applications of Economics in Managerial Decisions; Basic Techniques in Managerial Economics: Opportunity Cost; Role of the Managerial Economists.

The Theory of Consumer Behavior: Demand Analysis and Supply Analysis; Law of Demand and supply; Shifts in demand and supply, Determinants of Demand and supply; Elasticity of Demand and supply &Types, and Measurement, Determinants of Elasticity, uses and importance, Demand Forecasting; Methods or Techniques, Criteria for Good Demand Forecasting, The Meaning of Utility and Marginal Utility Analysis; Law of Diminishing Marginal Utility; Indifference Curve Analysis; Consumer's Equilibrium.

Production and Costs Analysis: Theory of production; Law of Variable Proportions; General Applicability of Law of Diminishing Returns; Types of Costs, Determinants of Costs; Cost-Output Relationship, Cost Forecasting; law of returns; Economies of scale: Internal and external; Profit Analysis: Theories of Profit; Depreciation; Profit Maximization and Planning; Cost-Volume-Profit (CVP) Relations; Break Even Analysis

Market Structure and Price Determination: Various Forms of Market Structures; Price and Output Determination by the firm and Industry under various market structures e.g., Perfect Competition, Monopoly; Monopolistic Competition; Oligopoly; duopoly sorbent features of price determination and various market conditions. Business Decision Making under Risk and Uncertainty: Insurable and Non-Insurable Risk.

Nature and characteristics of Indian economy, concepts of LPG, elementary concepts of National Income, Inflation and Business Cycles ,Concept of N.I. and Measurement., Meaning of Inflation, Types and causes , Phases of business cycle Investment decisions for boosting economy(National income and per capital income).

Text Books:

1 Dominick Salvatore, "Managerial Economics: Principles and Worldwide Applications", Oxford University Press, 2008.
2 Keat, Young and Banerjee, " Managerial Economics", Pearson Education, New Delhi, 2007.
3 Mote, Samuel Paul and G.S. Gupta, "Managerial Economics: Concepts and Cases", Tata Mgraw Hill, 1977.

Reference Books:

1 Ghosh Geetika. Managerial Economics, Tata Mgraw Hill
2 Varshney and Maheswari, Managerial Economics.
3 Dwivedi DN, "Principles of Microeconomics", Pearson Education.

Web link(s):

1 https://nptel.ac.in/courses/110/101/110101005/

2 https://nptel.ac.in/courses/110/105/110105075/

Course Code	:	**HM615**
Course Title	:	**Management Information Systems**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Discuss key terminologies and concepts of major areas of management.
CO2 Design, develop and apply information technology solutions for business problems.
CO3 Analyze computing systems and telecommunication networks suitable for business information systems.
CO4 Identify ethical issues that occur in business and evaluate alternative courses of actions.
CO5 Combine analytical thinking and creativity to solve management related problems.

Course Content:

Introduction: Information Systems in Global Business Today, Global E-Business and collaboration, Information Systems, Organization and Strategy, Ethical and social issues in Information Systems.

Emerging Technologies and Information Management: IT infrastructure and Emerging Technologies, Foundations of Business Intelligence: Databases and Information Management.

Technologies in Enterprises: Telecommunications, the internet and Wireless Technology, Securing Information Systems, Achieving Operational Excellence and Customer Intimacy: Enterprise Applications.

Introduction to E-commerce: E – Commerce: Digital Markets, Digital Goods, Managing Knowledge, Enhancing Decision Making.

Project Management and Global Systems: Building Information Systems, Managing Projects, Managing Global Systems.

Text Books:

1 Kenneth J Laudon and Jane P. Laudon, "Management Information Systems", Fourteenth Edition, Pearson PHI, 2016.

2 Lucey, Terry; Lucey, Terence, "Management Information Systems", Cengage Learning EMEA,2004.

Reference Books:

1 W. S. Jawadekar, “Management Information Systems”, Third Edition, Tata McGraw Hill, 2004.

2 Kroenke, D. M., Boyle, R. J., Gemino, A., & Tingling, P., “*Experiencing MIS”,* 5th Canadian Edition), Toronto: Pearson, 2019.

Web link(s):

1 https://nptel.ac.in/courses/122/105/122105022/

Course Code	:	**MA611**
Course Title	:	**Numerical Solution of Differential Equations**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Solve ordinary differential equations and conduct stability analysis.
CO2 Apply finite difference methods for derivatives.
CO3 Classify partial differential equations and analyze boundary value problems.
CO4 Employ explicit and implicit methods for solving hyperbolic equations.
CO5 Analyze elliptic equations in one space and two space dimensions.

Course Content:

Ordinary Differential Equations: Multistep (explicit and implicit) methods for initial value problems, Stability and Convergence analysis, Linear nonlinear boundary value problems, Quazilinearization, Shooting methods

Finite difference methods: Finite difference approximations for derivatives, boundary value problems with explicit boundary conditions, implicit boundary conditions, error analysis, stability analysis, convergence analysis.

Partial Differential Equations: Classification of partial differential equations, finite difference approximations for partial derivatives and finite difference schemes for: Parabolic equations: Schmidt's two level, multilevel explicit methods, Crank-Nicolson's two level, multilevel implicit methods, Dirichlet's problem, Neumann problem, mixed boundary value problem, stability analysis.

Hyperbolic Equations: Explicit methods, implicit methods, one space dimension, two space dimensions, ADI methods.

Elliptic equations: Laplace equation, Poisson equation, iterative schemes, Dirichlet's problem, Neumann problem, mixed boundary value problem, ADI methods.

Text Books:

1 M.K.Jain, "Numerical Solution of Differential Equations", Wiley Eastern, 1984.
2 G.D.Smith, "Numerical Solution of Partial Differential Equations" , Oxford Univ. Press, 2004.

Reference Books:

1 C.F. Gerald, P.O. Wheatle, " Applied Numerical Analysis", Addison- Wesley, 1989.

2 M.K.Jain, S.R.K.Iyengar, R.K.Jain, “Computational methods for partial differential equations”, Wiley Eastern, 2005.
3 B.S. Grewal, “Higher Engineering Mathematics”, Khanna Publications, 44nd ed, 2015.

Web link(s):

1 https://nptel.ac.in/courses/111/106/111106101/
2 https://nptel.ac.in/courses/111/105/111105038/

Course Code	:	**CS646**
Course Title	:	**Internet of Things**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Discuss the architecture of IoT network.
CO2 Analyze various protocols of IoT for efficient network communication.
CO3 Design and develop an IoT system using Rasperry Pi/Arduino.
CO4 Evaluate the security constraints in IoT applications.
CO5 Demonstrate applications of IoT in real time scenario.

Course Content:

Introduction: What Is IoT?: Genesis of IoT, IoT and Digitization, IoT Impact, Convergence of IT and OT, IoT Challenges, IoT Network Architecture and Design: Drivers Behind New Network Architectures, Comparing IoT Architectures, A Simplified IoT Architecture, Core IoT Functional Stack, IoT Data Management and Compute Stack, Smart Objects, Connecting Smart Objects.

IoT Protocols: IoT Access Technologies: IEEE 802.15.4, IEEE 802.15.4g, IEEE 802.15.4e, IEEE 1901.2a, IEEE 802.11ah, LoRaWAN. Network Layer: Need for Optimization, Optimizing IP for IoT, From 6LoWPAN to 6Lo, Profiles and Compliances, Transport Layer, Application Transport Methods: Supervisory Control and Data Acquisition (SCADA), Application Layer: CoAP, Message Queuing Telemetry Transport (MQTT)

Design and Develop: Design Methodology - Embedded computing logic - Microcontroller, System on Chips - IoT system building blocks - Arduino Basics, Internet Connectivity, Communication Protocols, Complex Flows: Node-RED, Realtime Clients, Remote Control, Installing Raspbian on the Raspberry Pi, Writing Python Programs Using Raspberry Pi, Using the GPIO to Connect to the Outside World, Subscribing to Web Services, Controlling a Servo with Python, Tinkercad, Cayenne cloud / ThingSpeak.

IoT Security: History of OT Security, Common Challenges in OT Security, Insecure Operational Protocols, Modbus, DNP3, ICCP, OPC, IEC Protocols, Purdue Model for Control Hierarchy, OT Network Characteristics Impacting Security, Formal Risk Analysis Structures: OCTAVE and FAIR, Phased Application of Security in an Operational Environment. Multiple security levels, Security and Privacy Issues in IoT, Privacy preserving algorithms in IoT, Complexity Analysis of the cryptographic algorithms in IoT.

Applications: Manufacturing: An Architecture for the Connected Factory - Edge Computing in the Connected Factory, Utilities- Smart grid, Electrical Vehicle Charging, Smart and Connected Cities: An IoT Strategy for Smarter Cities - Smart City Use-Case Examples,

Transportation: Transportation Challenges - Extending Bus IoT Architecture to Railways, Mining: An IoT Strategy for Mining, An Architecture for IoT in Mining, Public Safety: An IoT Blueprint for Public Safety - IoT Public Safety Information Processing, Case Studies: IoT in Disaster Management System, Agriculture, Healthcare, Activity Monitoring.

Text Books:

1 David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things", 1st edition, Cisco Press, 2017

2 Adeel Javed, "Building Arduino Projects for the Internet of Things: Experiments with Real-World Applications", 1st Edition, Apress, 2016.

3 Colin Dow,"Internet of Things Programming Projects: Build modern IoT solutions with the Raspberry Pi 3 and Python", 1st edition, Packt Publishing, 2018.

Reference Books:

1 Arshdeep Bahga, Vijay Madisetti, "Internet of Things – A hands-on approach", Universities Press, 2015.

2 Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle,"From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence",1st Edition, Academic Press, 2014.

3 Tom Igoe, "Making Things Talk, Second Edition, O'Reilly Media, Inc, 2011.

Web link(s):

1 IoT: https://onlinecourses.nptel.ac.in/noc20_cs66/preview

2 Arduino: https://www.arduino.cc/, Raspberry Pi: https://www.raspberrypi.org/

3 Arduino Tutorials: https://www.programmingelectronics.com/arduino-tutorials-all/

Course Code	:	**CS647**
Course Title	:	**Digital Image Processing**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the characteristics of a digital image and analyze the image in frequency domain.
CO2 Differentiate and interpret various image enhancement techniques.
CO3 Identify noise models and employ suitable filter to remove noise.
CO4 Analyze and use appropriate image compression techniques.
CO5 Apply suitable techniques to segment different regions of an image.

Course Content:

Introduction: Digital Image Processing – Characteristics of Digital Image - Basic relationship between pixels - Image sampling and quantization - Color models. Basic Geometric Transformations - Fourier Transform – Cosine, Sine and Hartley Transform – Hadamard, Haar, Slant Transform – Discrete Fourier Transform.

Image Enhancement Techniques: Spatial Domain Methods - Basic Grey Level Transformation – Histogram Processing – Image subtraction – Image averaging – Spatial filtering - Smoothing, Sharpening filters – Laplacian filters – Frequency domain filters - Smoothing – Sharpening filters – Homomorphic filtering.

Image Restoration: Model of Image Degradation/restoration process – Noise models – Spatial and Frequency Filters- Inverse filtering & Wiener Filtering - Least mean square filtering – Constrained least mean square filtering.

Image Compression Fundamentals: Image Compression Models - Lossless compression: Variable length coding – LZW coding – Bit plane coding- predictive coding-DPCM. Lossy Compression: Lossy Predictive Coding - Transform coding – Wavelet coding.

Image Segmentation & Analysis: Image Segmentation techniques - Edge detection – Thresholding – Region - Boundary Extraction & Representation – Region, Moment representation, chain codes- Polygonal approximation, Texture, Pattern Recognition. Applications - Finger print/iris recognition - Remote sensing - Automatic character recognition - Medical image processing.

Text Books:

1 Rafael C Gonzalez, Richard E Woods,"Digital Image Processing", Pearson Education, 4th edition, 2010.

2 A.K. Jain, “Fundamentals of Digital Image Processing”, PHI, New Delhi, 1995.

3 William K Pratt, “Digital Image Processing”, 4rd Edition, John Willey, 2007.

Reference Books:

1 SE Umbaugh, “Digital Image Processing and Analysis: Application with MATLAB and CVIP tools”, 3rd Edition , Taylor & Francis, CRC Press, 2018.

2 Frank Y. Shih, “Image processing and Pattern Recognition”, Wiley – IEEE press, 2010.

Web link(s):

1 https://nptel.ac.in/courses/117/105/117105135/(NPTEL Course by Prof. P.K. Biswas from IIT Kharagpur)

2 https://nptel.ac.in/courses/117/104/117104069/(NPTEL Course by Prof. Sumana Gupta from IIT Kanpur)

Course Code	:	**CS648**
Course Title	:	**Network Processors Design**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the basic components of embedded network system.
CO2 Explain the instruction set of Ti320C67xx and Ti320C55xx processors.
CO3 Develop applications using cisco network processor.
CO4 Discuss the architecture of digital signal processors.
CO5 Design DSP for audio / video applications.

Course Content:

Embedded System: Embedded system design life cycle – selection process – partitioning decision – development environment – special software techniques – basic toolset – BDM, joint text action group and Nexus – ICE an integrated solution – testing.

Instruction Set: Ti320C67xx and Ti320C55xx processors - instruction set - programming examples – pipelining of instructions – special features of Ti320C67xx and Ti320C55xx processor.

Applications: Case Study - 67xx processor in image / video applications – applications with IXP1200 network processors, single chip OC-12 network processor, CISCO network processor.

Special Processors: Ti320C55xx digital signal processor - architecture of Ti320C55xx processor – instruction set and programming examples - Ti320C67xx digital signal processor - introduction to very large instruction word architecture - arithmetic computation – memory accessing.

Case Study of DSP: Case Study- digital signal processor for audio/video applications – architecture of digital signal processors – digital signal processor versus conventional processors – fixed point arithmetic versus floating point arithmetic – digital signal processor for embedded systems.

Text Books:

1 Rulph Chassing Wiley, DSP Applications Using C and the TMS320C6x DSK, 2005.
2 Arnold S Berger Embedded System Design, CMP Bookss, 2005.
3 Sen M Kuo and Bob H Lee, Real Time Signal Processing, John Wiley and Sons, 2005.

Reference Books:

1 Raj Kamal, Embedded Systems – Architecture, Programming and Design, Tata McGraw Hill, New Delhi, 2006.

Web link(s):

1 https://www.embedded.com/network-processor-programming/

Course Code	:	**CS649**
Course Title	:	**Information Theory and Coding**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Design the channel performance using Information theory.
CO2 Apply asymptotic equipartition property theorem.
CO3 Construct efficient codes for data on imperfect communication channels.
CO4 Explain the properties of differential entropy and apply coding theorem for Gaussian channels.
CO5 Use linear block codes for error detection and correction.

Course Content:

Entropy, Relative Entropy, and Mutual Information: Entropy, Joint Entropy and Conditional Entropy, Relative Entropy and Mutual Information, Chain Rules, Data-Processing Inequality, Fano's Inequality.

Typical Sequences and Asymptotic Equipartition Property: Asymptotic Equipartition Property Theorem, Consequences of the AEP: Data Compression, High-Probability Sets and the Typical Set.

Source Coding and Data Compression: Kraft Inequality, Huffman Codes, Optimality of Huffman Codes. Channel Capacity: Symmetric Channels, Properties of Channel Capacity, Jointly Typical Sequences, Channel Coding Theorem, Fano's Inequality and the Converse to the Coding Theorem.

Differential Entropy and Gaussian Channel: Differential Entropy, AEP for Continuous Random Variables, Properties of Differential Entropy, Relative Entropy, and Mutual Information, Coding Theorem for Gaussian Channels.

Linear Binary Block Codes: Introduction, Generator and Parity-Check Matrices, Repetition and Single-Parity-Check Codes, Binary Hamming Codes, Error Detection with Linear Block Codes, Weight Distribution and Minimum Hamming Distance of a Linear Block Code, Hard-decision and Soft-decision Decoding of Linear Block Codes, Cyclic Codes, Parameters of BCH and RS Codes, Interleaved and Concatenated Codes, Convolutional Codes.

Text Books:

1 Thomas Cover and Joy Thomas, "Elements of Information Theory", Second Edition, Wiley-Interscience publication, 2006.

2 William Ryan and Shu Lin, “Channel Codes: Classical and Modern”, Cambridge University Press, 2009.

Reference Books:

1 Robert Gallager, “Information Theory and Reliable Communication”, 1969

2 N. Abramson, “Information and Coding”, McGraw Hill, 1963

3 M. Mansurpur, “Introduction to Information Theory”, McGraw Hill, 1987

Web link(s):

1 https://nptel.ac.in/courses/108/108/108108168/ (NPTEL Video by Prof. Himanshu from IISC Bangalore)
2 https://nptel.ac.in/courses/117/106/117106031/ (NPTEL Video by Dr.AndrewThangaraj from IIT Madras)

Course Code	:	**CS650**
Course Title	:	**Robotics**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the working principles of Robots.
CO2 Analyze the kinematics of Robots.
CO3 Discuss various sensors of Robots.
CO4 Apply suitable mechanisms to control movements of Robots.
CO5 Employ computer vision techniques for robot vision.

Course Content:

Introduction: Introduction to robotics-origin of automation, Classification of robots, Rotations and translation of vectors. Transformations and Euler angle representations, Homogenous transformations, Problems.

Robot Kinematics: Direct kinematics , Inverse kinematics. Problems. Velocity kinematics and Jacobian, Statics, singularity and Manipulability.

Sensors: Trajectory planning. Actuators, Velocity and position sensors. Range, proximity, touch sensors.

Controller: Control basics, Linear control basics, Model based control. Fore control, Impedance control. Basic mechanical design concepts.

Vision: Robot Vision, Image segmentation, Template matching, Polyhedral objects, Shape analysis. Motion planning – potential fields, projective path planning. Grasping and industrial automation.

Text Books:

1 D.K. Pratihar, “Fundamentals of Robotics”, Narosa Publishing House, New-Delhi, 2017.
2 K.S. Fu, R.C. Gonzalez, C.S.G. Lee, “Robotics”, McGraw-Hill Books Company, 1987.
3 J.J. Craig, “Introduction to Robotics”, Addison-Wesley Publishing Company, 1986.

Reference Books:

1 Mikell P Groover, Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, “Industrial Robotics, Technology programming and Applications", McGraw Hill, 2012.
2 Carl D. Crane and Joseph Duffy, "Kinematic Analysis of Robot manipulators",

Cambridge University press, 2008.
3 Fu. K. S., Gonzalez. R. C. & Lee C.S.G., “Robotics control, sensing, vision and intelligence”, McGraw Hill Books co, 1987.

Web link(s):

1 http://engineering.nyu.edu/mechatronics/smart/Archive/intro_to_rob/Intro2Robotics.pdf
2 https://see.stanford.edu/Course/CS223A

Course Code	:	**CS651**
Course Title	:	**Wireless Sensor Networks**
Number of Credits	:	**3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1 Review the basics of wireless sensor networks.
CO2 Explain the fundamentals of MAC protocols in WSN.
CO3 Identify the design issues in WSN and resolve them using routing protocols.
CO4 Measure the performance of transfer control protocols in WSN.
CO5 Describe the requirements of network management.

Course Content:

Sensor networks overview: Introduction, Applications of WSN, Range of Applications, Design issues, Basic Wireless Sensor Technology: Sensor node architecture, Hardware and Software, Sensor Taxonomy, WSN Operating Environment, Wireless Transmission Technology and Systems.

Fundamentals of MAC Protocols: Performance Requirements, Common Protocols, MAC Protocols for WSNs, Schedule-Based Protocols, Random Access-Based Protocols, Sensor-MAC Case Study, Protocol Overview, Periodic Listen and Sleep Operations, Schedule Selection and Coordination, Schedule Synchronization, Adaptive Listening, Access Control and Data Exchange.

Routing Protocols: Routing Challenges and Design Issues in Wireless, Sensor Networks, Routing Strategies in Wireless Sensor Networks, WSN Routing Techniques, Flooding and Its Variants, Sensor Protocols for Information via Negotiation, LowEnergy Adaptive Clustering Hierarchy, Power-Efficient Gathering in Sensor Information Systems, Directed Diffusion, Geographical Routing.

Transport Control Protocols: Transport Protocol Design Issues, Examples of Existing Transport Control Protocols, CODA, ESRT, RMST, PSFQ, GARUDA, ATP, Problems with Transport Control Protocols, Performance of Transport Control Protocols, Congestion, Packet Loss Recovery.

Middleware: Introduction, Network Management Requirements, Traditional Network Management Models, Simple Network Management Protocol, Telecom Operation Map, Network Management Design Issues, Example of Management Architecture: MANNA, Other Issues Related to Network Management, Naming, Localization, Performance and Traffic Management

Text Books:

1 Sohraby, Kazem, Daniel Minoli, and Taieb Znati, “Wireless sensor networks: technology, protocols, and applications”, John wiley & sons, 2007.

2 Raghavendra, Cauligi S., Krishna M. Sivalingam, and Taieb Znati, “Wireless sensor networks”, Springer, 2006.

Reference Books:

1 Faludi, Robert, “Building wireless sensor networks: with ZigBee, XBee, arduino, and processing” , O'Reilly Media, Inc., 2010.

2 Zhao, Feng, Leonidas J. Guibas, and Leonidas Guibas, “Wireless sensor networks: an information processing approach”, Morgan Kaufmann, 2004.

Web link(s):

1 https://www3.nd.edu/~cpoellab/teaching/cse40815/

2 http://web.cse.ohio-state.edu/~arora.9/788-12.html

3 http://www.inf.tu-dresden.de/index.php?node_id=2568&ln=en&lv_id=45