Indian Institute of Information Technology Bhagalpur

B.Tech in Mathematics and Computing (MAC)

Syllabus First Semester onwards

Course Code	Course name	L	T	P	C	Year	Semester
MA101	Engineering Mathematics I	3	1	0	4	1st	1st
Topic	Contents						No. of Lectures
Module-I	Matrices and solving system of linear equations: Gauss elimination method, Elementary Row operations, Elementary matrices, Invertible matrices, Gauss-Jordon method for finding the inverse of a matrix; the Determinant method for finding the inverse of a matrix, Vector space, Subspace, Linear span, Linear independence and dependence, Basis, Dimension, Extension of a basis of a subspace, Intersection, and the sum of two subspaces. The rank of a matrix, Row and column spaces, Solvability of a system of linear equations.						09
Module-II	Inner Product Space, Orthogonal projection, Orthogonal complement, Orthogonal basis of a Vector Space, Gram-Schmidt orthogonalization process. Least Square Method; Eigenvalue, Eigen Vectors, Matrix Diagonalization, Similarity Transformation.						08
Module-III	Co-ordinate of a Vector, Change of Basis; Linear transformation, Kernel, and Range of a linear map, Rank-Nullity Theorem, Matrix of a Linear Transformation; Point set Theory: Real Number system, Open and Closed Set, Intervals; Sequences of Real Numbers: Monotonicity, Convergence tests, Cauchy Criterion, Subsequences; Limits and Continuity of a real function, Boundedness of a continuous function on a closed interval, Uniform continuity.						08
Module-IV	Taylor's theorem, Increasing and decreasing function, Convexity, Second derivative test for max and min, Point of Inflection; Series of real Numbers: Partial Sum Sequence, Convergence of series, Geometric and Harmonic Series, Absolute convergence, Comparison test, Ratio test, Root test, Cauchy Condensation test; Power series, Radius of convergence, Taylor Series, Maclaurin Series.						09
Module-V	Introduction to Riemann Integration, Integrability, The Integral existence theorem for continuous functions and monotone functions, Elementary properties of integral, Fundamental theorems of Calculus; Improper integral of the first and the second kind, Comparison test, Absolute convergence. Introduction to Beta and Gamma Function; Application of Integration to length, area, volume and surface area of revolution						08
						Total	42
Text	1. B S Grewal, J S Grewal, J K Dhanoa, Higher Engineering Mathematics, Khanna Publishers, 44th edition, 2017. 2. E. Kreyszig, H. Kreyszig, E. J. Norminton, Advanced Engineering Mathematics, 10th, Wiley India Pvt. Ltd., 2017						
Reference	1. D. Poole, Linear Algebra: A Modern Introduction, 4th edition, Brooks Cole, 2014. 2. S. R. Ghorpade and B. V. Limaye, A Course in Calculus and Real Analysis, 1st edition, Springer India, 2006.						

Course Code	Course name	L	T	P	C	Year	Semester
PH101	Engineering Physics	3	1	0	4	1st	1st
Topic	Contents						No. of Lectures
Module-I	Laws of thermodynamics- Statement, Discussion and Significance of Zeroth, First and Second law, Isothermal and Adiabatic change &Carnot cycle.						08
Module-II	Concept of Entropy-Clausius inequality and the physical significance of Entropy; Matter Waves, Wave and Group Velocities, Heisenberg Uncertainty Principle						08
Module-III	Wave Function, its Interpretation and Normalization, Superposition of Amplitudes, Dynamical Variables as Operators, Expectation Values, Schrodinger Equation and its Simple Applications like Particle in a Box.						10

Module-IV	Semiconductor materials, insulators, intrinsic and extrinsic semiconductor, Carrier transport in a semiconductor: diffusion current, drift current, mobility, and resistivity. Generation and recombination of carriers in semiconductors.	08
Module-V	Electrons and Holes in semiconductors: Donors and acceptors in the band model, electron effective mass, Density of states, Thermal equilibrium, Fermi-Dirac distribution function for electrons and holes, Fermi energy. Equilibrium distribution of electrons & holes.	08
	Total	42
Text	1. Dattu R Joshi, Engineering Physics, Tata McGraw Hill Education, 1st edition, 2015. 2. D K Bhattacharya, Poonam Tandon, Engineering Physics, Oxford University Press India; 2017.	
Reference	1. Arthur Beiser, Shobhit Mahajan, S Rai Choudhury, Concepts of Modern Physics, Tata McGraw Hill Education, 7th edition, 2017. 2. David J Griffiths, Introduction to Quantum Mechanics, Pearson India Education Services Pvt. Ltd, 2nd edition, 2018.	

Course Code	Course name	L	T	P	C	Year	Semester
EC101	Electrical Science	3	0	0	3	1st	1st
Course objective: The main objective of this course is to analysis of resistive circuits and solution of resistive circuits with independent sources, two terminal element relationships for inductors and capacitors and analysis of magnetic circuits, analysis of single phase AC circuits, the representation of alternating quantities and determining the power in these circuits, etc.							
Topic	Contents						No. of Lectures
Module-I	Basic components and electric circuits, Ohm's law,nodes, paths, loops and branches, Kirchhoff's current law, Kirchhoff's voltage law, dependent and independent sources, voltage and current division,Basic nodal and mesh analysis; supernode, supermesh						04
Module-II	Network theorems: linearity and superposition, source transformations, Thevenin and Norton equivalent circuits, maximum power transfer; RL and RC circuits: source-free RL circuit, source-free RC circuit, unit-step function, driven RL circuits, natural and forced response, driven RC circuits						10
Module-III	RLC circuit: source-free parallel circuit, overdamped parallel RLC circuit, critical damping, underdamped parallel RLC circuit, source-free series RLC circuit, complete response of the RLC circuit						09
Module-IV	Sinusoidal steady-state analysis: forced response to sinusoidal functions, complex forcing function, phasor, phasor relationship for R, L and C, impedance, admittance, phasor diagrams, instantaneous power, average power, apparent power and power factor, complex power; Polyphase circuits: polyphase systems, single-phase three-wire systems, three-phase Y-Y connection, delta connection, power measurement in three-phase systems						10
Module-V	Magnetically coupled circuits: mutual inductance, energy considerations, Transformers, Principle of transformers and rotating machine, D. C machine: D. C. Motor and generator; Two-port networks: one-port networks, admittance parameters, impedance parameters, hybrid parameters, transmission parameters.						09
	Total						42
Text	1. W. H. Hayt, J. E. Kemmerly, S. M. Durbin, Engineering Circuit Analysis, Tata-McGraw-Hill Publishing Company Limited, 8th edition,2012. 2. E. Hughes, J. Hiley, I. McKenzie-Smith, K. Brown, Electrical And Electronic Technology, Pearson Education India, 10thedition, 2010.						
Reference	1. Bruce Carlson, Circuits: Engineering Concepts and Analysis of Linear Electric Circuits, Thomson Asia Pvt. Ltd., 2nd edition Reprint, 2006.						

Course Code	Course name	L	T	P	C	Year	Semester
CS101	Computer Programming	3	0	0	3	1st	1st

Course objective: This course aims to teach everyone the basics of programming computers using C Programming Language. We cover the basics of how one constructs a program from a series of simple instructions in C language.

Topic	Contents	No. of Lectures
Module-I	Introduction to Computing: Historical perspective, Early computers, the von Neumann architecture. Problems, Pseudo code, and Flowchart. Memory, Variables, Values, Instructions, Programs. Assembly language, High level language, Compiler, Assembler, Operating Systems.	08
Module-II	Introduction to C: The C language. Phases of developing a running computer program in C; Data Concepts in C: Constants, Variables, Expressions, Operators, and operator precedence in C. Managing input and output statements, Sequential control statements, Decision making statements (If Else constructs), Loop control statements (While construct, Do While construct, For construct).	08
Module-III	Data Types in C: Different basic data types and their sizes. One-dimensional Arrays: Declaration and initialization, Two-dimensional Arrays: Declaration and initialization, Multidimensional Arrays. String variables, Reading and writing strings, Arithmetic operations on characters, Putting strings together, Comparison of two strings.	09
Module-IV	Modular Programming and Example Programs: Functions: The prototype declaration, Function definition. Function call: Passing arguments to a function (by value, by reference). Scope of variables. Recursive function calls, Tail recursion, Tree of recursion. Sorting problems: Selection sort, Insertion sort. Sorting in arrays. Search problems: Linear search and binary search. Recursive and iterative formulations; More Data Types in C: Pointers: Declaring and dereferencing pointer variables. Pointer arithmetic. Accessing arrays. through pointers. Pointer types, Pointer and strings.	10
Module-V	Structures in C: Motivation, examples, declaration, and use. Operations on structures. Passing structures as function arguments. Type defining structures. Self-referential structures, Linked lists with examples. File operations in C: Input, output, and error streams. Opening, closing, and reading from files. Searching through files using functions such as fseek(), ftell(), and rewind(). Programming for command line arguments.	07
	Total	42
Text	1. Bryon Gottfried, Programming with C, Tata-McGraw-Hill, 3rdedition, 2015.	
Reference	1. Kernighan and Ritchie, The C Programming Language, PHI, 2nd edition, 2017. 2. H. M. Deitel, P. J. Deitel, C: How to program, Pearson Education, 7th edition, 2010.	

Course Code	Course name	L	T	P	C	Year	Semester
HS101	Professional Communication	2	0	0	2	1st	1st

Topic	Contents	No. of Lectures
Module-I	Communication Fundamentals: Using Verbal and Non- verbal Communication	03
Module-II	Interviewing Principles And Skills: Fundamental principles of interviewing, Success in an interview, Types of Interviews, Important Non-verbal aspects	04
Module-III	GROUP DISCUSSIONS: Methodology of GD, Improving Group performance	04
Module-IV	Professional Writing: Kinds of business letters, Job Applications and Resume Writing, Report Writing, Proposal layout and design, E-mail etiquette, Notices, Agenda and Minutes	05
Module-V	Delivering Professional Presentations: Elements of effective English, Effective paragraphs, The power of reading, Punctuation and Capitalization	04
	Total	20
Text	1. Business Correspondence and Report Writing - R. C. Sharma 2. Business Communication - M. Balasubramanyam 3. Essentials of Business Communication - R. Pal and Kolahalli 4. Business Communication and Report Writing - Sharma, Mohan 5. Lesikar's Basic Business Communication – Lesikar	

Course Code	Course name	L	T	P	C	Year	Semester
ME102	Engineering Graphics	2	0	3	4	1st	1st

Course objective:

1. To understand the drawing importance in engineering
2. To describe the 3D objects into different 2D views.
3. To understand the application of company standards and techniques applied in engineering graphic
4. To represent engineered parts by use of auxiliary or sectional views.

Topic	Contents	No. of Lectures
Module-I	Introduction and importance of engineering drawing, Drawing techniques: manual drawing and computer-aided drawing, Drawing instruments and their uses; Conventions of ISO and BIS, Layout of drawing sheets, Border lines, Title block, Folding of drawing sheets, Lines; Scales: Requirements, Plane scale, Diagonal and Vernier scales; Geometrical construction and curves: Definitions of ellipse, Parabola and hyperbola, Various methods of drawing Ellipse, parabola and hyperbola and drawing tangents and normal at any point on the conic.	06
Module-II	Cycloids, Construction of cycloids, Epicycloids & hypocycloid; Involutes, Spirals and Helices and their construction; Orthographic projection: Introduction, Methods of projection, Orthographic projection, Projection planes and four quadrants, First and third angle projections; Projection of points: Introduction, A point is situated in the first, second, third and fourth quadrant; Projection of straight lines: Introduction, Line parallel to one or both of the planes, Line perpendicular to one of the planes, Line inclined to one and perpendicular to other, Line inclined to both of the planes, True lengths and its inclination, Traces of a line.	06
Module-III	Projection of planes: Introduction, Types of planes, Traces of planes and its calculations, Projection of planes parallel to one of the reference planes, Projection of planes inclined to one reference planes and perpendicular to other, Projection of oblique planes; Projection of lines and plane by auxiliary planes; Projection of solids: Introduction, Types of solids, Projections of solids in simple positions, Projections of solids with axes inclined to one of the reference planes and parallel to other, Projections of solids with axes inclined to both of the planes, Projection of spheres.	06
Module-IV	Projection of sectioned solids: Introduction, Conventions in sectional view drawings, True shape of a section, Sections of prisms, pyramids, cylinders, cones and spheres; Intersection of solids: Introduction, Classification, Line of intersection, Line/generator method and section plane method, Intersection of two prisms, two cylinders, cone and cylinder, pyramid and cylinder, pyramid and prism, etc; Development of surfaces: Introduction, Method of development, Development of lateral surfaces of right solids, Development of transition pieces, Development of spheres.	06
Module-V	Isometric: Introduction, Isometric scale, Box method, Coordinate or offset method, Four center method, Isometric projection of arcs, Construction of isometric projection of different solids; Perspective projection: Introduction, Terminology and Principles of perspective projection. Methods of perspective projection of various objects.	04
	Total	28

Text	1. N D Bhatt and V M Panchal, Engineering Drawing, Charator Publishing House, 53rd edition, 2001 2. M B Shah and B C Rana, Engineering Drawing, Pearson Education, 2nd edition, 2009.
Reference	1. T E French, C J Vierck and R J Foster, Graphic Science and Design, Tata McGraw Hill, 4th edition, 1984. 2. W J Luzadder and J M Duff, Fundamentals of Engineering Drawing, PHI, 11th edition, 1995. 3. K Venugopal, Engineering Drawing and Graphics, New Age International, 3rd edition,1998.

Course Code	Course name	L	T	P	C	Year	Semester
MA102	Engineering Mathematics II	3	1	0	4	1st	2nd
Topic	Contents						No. of Lectures
Module-I	Vector functions of one variable – continuity, differentiation and integration; Functions of several variables - continuity, partial derivatives, directional derivatives, gradient, differentiability, chain rule; tangent planes and normal; Concavity-Convexity, Maxima and minima, Saddle Pont, Lagrange multiplier method.						09
Module-II	Repeated and Multiple integrals with applications to volume, surface area, Moments of Inertia, change of variables, Vector Fields, Line and Surface Integrals.						08
Module-III	Green's, Gauss' and Stokes' theorems and their applications; First order differential equations - exact differential equations, integrating factors,Bernoulli equations, existence and uniqueness theorem, applications						08
Module-IV	Higher-order linear differential equations, solutions of homogeneous and non-homogeneous equations, method of variation of parameters. Series solutions of linear differential equations. Legendre equation and Legendre polynomials. Bessel equation and Bessel functions of first and second kinds.						09
Module-V	Systems of first-order equations, two-dimensional linear autonomous system, phase plane, critical points, stability.						08
						Total	42
Text	1. B S Grewal, J S Grewal, J K Dhanoa, Higher Engineering Mathematics, Khanna Publishers, 44th edition, 2017. 2. E. Kreyszig, H. Kreyszig, E. J. Norminton, Advanced Engineering Mathematics, 10th, Wiley India Pvt. Ltd., 2017						
Reference	1. D. Poole, Linear Algebra: A Modern Introduction, 4th edition, Brooks Cole, 2014. 2. S. R. Ghorpade and B. V. Limaye, A Course in Calculus and Real Analysis, 1st edition, Springer India, 2006.						

Course Code	Course Name	L	T	P	C	Year	Semester
CS201	Design and Analysis of Algorithms	3	1	0	4	2nd	3rd
Course Objective: The objective of this course is to teach different algorithm techniques for effective problem solving. The use of different paradigms of problem solving will be used to illustrate clever and efficient ways to solve a given problem. In each case emphasis will be placed on rigorously proving correctness of the algorithm. In addition, the analysis of the algorithm will be used to show the efficiency of the algorithm over the naive techniques.							
Topic	Contents						No. of Lectures
Module I	Introduction and Recursion: Algorithm Phases, Asymptotic Notations and Analysis-space and time complexity measures, lower and upper bounds; Various Algorithm Design Techniques, Pseudo code, Models of Computation- Turing Machine Model and Random Access Machine Model. Classification of Recursion, Application of Recursion, Various Solution Methodology for recurrence relations.						7
Module II	Divide-and-conquer and Dynamic Programming: Binary Searching, Quick Sort, Merge Sort, Matrix Chain Multiplication Problem, Travelling Salesman Problem, Shortest Path Problems.						10
Module III	Greedy Method: 0/1 knapsack Problem, Job Sequencing with Deadlines, Minimum Spanning Trees, Optimal Sub-Structure.						8
Module IV	Backtracking, Branch and Bound and Lower Bound Theory: N–Queens Problem, Hamiltonian Cycle Problem, and Graph Coloring Problem. Backtracking vs Branch and Bound, 15-Puzzle Problem. Computational Model - Comparison Tree, Oracles and Adversary Arguments. Lower Bound for Sorting; Selection algorithms.						8
Module V	Graph Algorithms and NP completeness: Connectivity, Topological Sort, Shortest Paths Network Flow; Disjoint Set Union Problem; String Matching, Disjoint Set Manipulation, Classification of Problems- Decision Problems, Optimisation Problems, Classification of Algorithms- Deterministic Algorithms, Non-deterministic Algorithms, Classes of Problems- P, NP, NP–Complete, and NP-Hard. Relationship among Classes of Problems, Reducibility, Cook's Theorem, Satisfiability, C-SAT Problem, Clique Decision Problem.						9
						Total	42

Text	1. Introduction to Algorithms; Thomas H Cormen, Charles E Leiserson, Ronald L Rivest; 3rd, PHI Learning Private Limited; 2018. 2. Design and Analysis of Computer Algorithms; A Aho, J E Hopcroft, J D Ullman; , Addison-Wesley; 1974.
Reference	1. Algorithm Design; Jon Kleinberg, Eva Tardos; 14th, Pearson India Education Services Pvt.Ltd; 2017. 2. Fundamentals of Computer Algorithms; Ellis Horowitz, Sartaj Sahni, S Rajasekaran; 2nd Edition, University Press; 2011. 3. Algorith Design: Foundations, Analysis and internet Examples; M T Goodrich, R Tamassia ; , John Wiley & Sons; 2001.

Course Code	Course name	L	T	P	C	Year	Semester
EC102	Digital Design	3	0	0	3	1st	2nd

Course objective: The main objective of this course is to introduce the number system, elements of digital system abstractions such as digital representations of information, logic gates, combinational and sequential circuits, Boolean algebra, state elements and finite state machine (FSMs).

Topic	Contents	No. of Lectures
Module-I	Number Systems and Codes, Positional number system, Binary, octal and hexadecimal number systems; Methods of base conversions; Binary, octal and hexadecimal arithmetic; Representation of signed numbers; Fixed and floating point numbers; Binary coded decimal codes; Gray codes; Error detection and correction codes - parity check codes and Hamming code	08
Module-II	Combinatorial Logic Systems: Definition and specification; Truth table; Basic logic operation and logic gates; Boolean Algebra and Switching Functions: Basic postulates and fundamental theorems of Boolean algebra; Standard representation of logic functions - SOP and POS forms; Simplification of switching functions using K-map upto five variables, Synthesis of combinational logic circuits	09
Module-III	Logic Gates, Two-level realizations using gates; AND-OR, OR-AND, NAND-NAND and NOR-NOR structures; Multifunction gates, Multi-bit serial & parallel adder and subtractor, comparator, Multiplexers, Multiplexer-based realization of K-maps; Combinational circuit design using multiplexers and gates, DE-multiplexers, Encode, Decoders,	09
Module-IV	Sequential Logic systems: Latches and Flip-flops, Timing hazards and races; Analysis of state machines using D flip-flops and JK flip-flops; Sequence generator using flip-flops; Design of state machines-state table, state assignment, transition/excitation table, excitation maps and equations, logic realization	10
Module-V	Synchronous and Asynchronous counters; Registers; Memory: Read-only memory, RAM, ROM, PAL, PLA.	06
	Total	42
Text	1. M. Morris Mano, Digital Logic and Computer Design, Pearson Education, 11thedition, 2009. 2. R. Tokheim, Digital Electronics: Principles and Applications, Tata McGraw Hill, 6th edition, 2017.	
Reference	1. R. J. Tocci, N. S. Wisdmer and G. L. Moss, Digital Systems: Principle and Applications, Pearson Education, 10th edition, 2011. 2. John F Wakerly, Digital Design: Principles And Practices, Pearson Education, 4th edition, 2008.	

Course Code	Course name	L	T	P	C	Year	Semester
EC103	Semiconductor Devices & Circuits	3	0	0	3	1st	2nd

Course objective: The main objective of this course is to study semiconductor materials and transport mechanism, semiconductor diodes, bipolar transistors, field effect devices and transistors. More particularly, the course objectives are to:
1. Introduce students to the physics of semiconductors and the inner working of semiconductor devices.
2. Provide students the insight useful for understanding new semiconductor devices and technologies.

Topic	Contents	No. of Lectures
Module-I	Introduction of semiconductors, equilibrium and carrier concentration in semiconductors; Bond model and band model of intrinsic semiconductors, Density of state, Fermi-dirac distribution function; Carrier transport in semiconductors, Mobilty, resistivity and conductivity; Excess carrier, method of generating excess carrier inside extrinsic semiconductors. Doping and diffusion process.	08

Module-II	P-N Junction: Simplified device structure and physical operation of diode;depletion region, forward and reverse-bias, depletion and diffusion capacitances, switching characteristics; breakdown mechanisms; Zener diode, Tunnel diode; Diode Applications: Half Wave and Full Wave Rectifier, Clippers and Clampers, and Zener Regulators	09
Module-III	Simplified device structure and physical operation of BJT, I-V characteristics of BJT, carrier distribution; current gain, transit time, secondary effects; SPICE model. Metal-semiconductor junctions, Breakdown of the junction with the non-impact and impact ionization, β-I_C characteristics curve, variation of α with I_c; Small signal equivalent circuit, BJT Amplifiers: Transistor Configuration analysis, Common base, Common emitter and Common collector	08
Module-IV	MOS structure, Energy band diagrams, Flat-band condition and flat-band voltage, Surface accumulation, surface depletion, Threshold condition and threshold voltage, MOS C-V characteristics, MOS Q-V Characteristics.	08
Module-V	Introduction to Field effect transistors, Construction and characteristics of Junction Field effect transistors; N-channel and p-channel JFET characteristics; MOSFETS: Enhancement type and depletion type of MOSFET, Basic Operation and Characteristics; N-channel and P-channel MOSFET characteristics	09
	Total	42
Text	1. R. F. Pierret, Semiconductor Device Fundamentals, Pearson Education, 1st edition, 2006. 2. B. G. Streetman and S. K. Banerjee, Solid State Electronic Devices, Pearson Education, 7th edition, 2015. 3. A. S. Sedra, K. C. Smith and A. N. Chandorkar, Microelectronics circuits, Oxford university Press India, International Version 7th edition, 2017.	
Reference	1. J. Singh, Semiconductor Devices - Basic Principles, John Wiley & Sons Inc., 1st edition, 2001.	

Course Code	Course name	L	T	P	C	Year	Semester
ME102	Engineering Mechanics	3	1	0	4	1st	2nd
Topic	Contents						No. of Lectures
Module-I	Equivalent force systems; free-body diagrams; degrees of freedom; equilibrium equations;						10
Module-II	Analysis of determinate trusses and frames; properties of surfaces friction.						8
Module-III	Centroids and centres of gravity, Moment of Inertia; Virtual work principal						8
Module-IV	Equations of motion; work-energy and impulse-momentum principles; Generalized coordinates; Lagrangian mechanics.						9
Module-V	Plane kinematics and kinetics of rigid bodies including work-energy and impulse-momentum principles; single degree of freedom rigid body systems.						8
	Total						43
Text	1. H. Shames, "Engineering Mechanics: Statics and Dynamics", 4th Ed., PHI, 2002. 2. F. P. Beer and E. R. Johnston, "Vector Mechanics for Engineers, Vol I –Statics", Vol II -Dynamics, 3rd Ed., Tata McGraw Hill, 2000.						
Reference	1. S. Timoshenko, D.H. Young, J.V. Rao and S. Pat, "Engineering Mechanics", Paperback –1 Jul 2017. 2. 1. J. L. Meriam and L. G. Kraige, "Engineering Mechanics, Vol I -Statics, Vol II –Dynamics", 5th Ed., John Wiley, 2002.						

Course Code	Course name	L	T	P	C	Year	Semester
MA201	Engineering Mathematics III	3	1	0	4	2nd	3rd
Topic	Contents						No. of Lectures
Module-I	Complex numbers and elementary properties. Complex functions - limits, continuity and differentiation. Cauchy-Riemann equations. Analytic and harmonic functions.						08
Module-II	Elementary functions. Anti-derivatives and path (contour) integrals. Cauchy-Goursat Theorem. Cauchy's integral formula, Morera's Theorem. Liouville's Theorem, Fundamental Theorem of Algebra and Maximum Modulus Principle. Taylor series. Power series. Singularities and Laurent series.						09
Module-III	Cauchy's Residue Theorem and applications. Mobius transformations; Partial Differential Equations: First order PDEs; solutions of linear and nonlinear first order PDEs; classification of second-order PDEs.						08
Module-IV	Method of characteristics Iin PDE; boundary and initial value problems (Dirichlet and Neumann type) involving wave equation, heat conduction equation, Laplace's equations and solutions by method of separation of variables; initial boundary value problems.						08
Module-V	Solution of PDE by Laplace transform; Fourier series, Fourier integrals; Fourier transforms, sine and cosine transforms; solution of PDE by Fourier transform.						10
						Total	43
Text	1. B S Grewal, J S Grewal, J K Dhanoa, Higher Engineering Mathematics, Khanna Publishers, 44th edition, 2017. 2. E. Kreyszig, H. Kreyszig, E. J. Norminton, Advanced Engineering Mathematics, 10th, Wiley India Pvt. Ltd., 2017						
Reference	1. Ian N Sneddon, Elements of Partial Differential Equations, Dover Publications; 2006. 2. John H Mathews, Russell W Howell, Complex Ananlysis for Mathematics and Engineering, Jones and Bartlett India Pvt.Ltd, 6th edition, 2011. 3. James Ward Brown, Ruel V Churchill, Complex Variables and Applications, Tata McGraw Hill Education, 8th edition, 2016.						

Course Code	Course name	L	T	P	C	Year	Semester
CS201	Object Oriented Programming	3	0	0	3	2nd	3rd
Course objective:The course is designed to provide students with complete knowledge of Object Oriented. Programming through C++ and to enhance the programming skills of the students by giving practical assignments to be done in labs. The course also aims to provide students with requisite knowledge about Object Oriented Programming through C++ so that they make their own Applications/Projects using C++.							
Topic	Contents						No. of Lectures
Module-I	Principles of OOPs, Basics of C++, Functions in c++ : Basic Concepts of OOP, Benefits of OOP, OOP Languages, Applications of OOP. C++ program basics, data types, operators in c++, scope resolution, type cast operators, operator overloading, operator precedence. Main function, function prototyping, call by reference, inline functions, default arguments, constant arguments, function overloading, friend and virtual functions, maths library functions.						08
Module-II	Classes, objects, constructors and destructors – C structures revisited, specifying a class, defining a member function, private member functions, memory allocation for objects, static data members and member functions, array of objects, objects as function arguments, friendly functions, returning objects, pointers to members, constructors, Parametrized constructors, Multiple constructors, Copy constructor, Destructors.						08
Module-III	Operator overloading, inheritance, virtual functions and polymorphism – Overloading unary operators, overloading binary operators, rules for overloading operators, type conversions. Derived classes, single inheritance, multilevel inheritance, multiple inheritance, hierarchical inheritance, hybrid inheritance, virtual base classes, abstract classes, nesting of classes. Pointers, pointer to objects, this pointer, pointer to derived classes, virtual functions, pure virtual functions.						09

Module-IV	Console I/O operations, working with files and templates – C++ streams and stream classes, unformatted I/O operations, formatted console I/O operations, managing output with manipulators. Classes for file stream operations, opening/closing of file, file pointers and their manipulation, error handling during file operation, command line arguments. Class templates, class template with multiple parameters, function templates, overloading template functions, member function templates, non-type template arguments.	09
Module-V	Exception handling and Standard template library – Basics of exception handling, exception handling mechanism, throwing mechanism, catching mechanism, rethrowing exception, specifying exception. Components of STL, Containers, Algorithms, Iterators, Application of Container classes, Functions objects.	08
	Total	42
Text	1. E. Balagurusamy, Object Oriented Programming with C++,Tata McGraw Hill. 2. Herbert Schildt, C++: The Complete Reference, Osborne, 1991.	
Reference	1. Bjarne Stroustrup, 1. The C++ programming language, Pearson Education, 2017.	

Course Code	Course name	L	T	P	C	Year	Semester
CS202	Discrete Mathematics	3	1	0	4	2nd	3rd

A course designed to prepare computer science and engineering students for a background in abstraction, notation and critical thinking for the mathematics most directly related to computer science. Topics include: logic, relations, functions, basic set theory, countability and counting arguments, proof techniques, mathematical induction, graph theory, Combinatorics, recursion, recurrence relations, elementary number theory and graph theory.

Topic	Contents	No. of Lectures
Module-I	Set Notations, Basic Operations on a Set, Subset, Power Set, Product of Sets, and Partition on a set. Relation: equivalence relation, Closures. Functions: composition, injective-bijective functions. Poset, Lattice, Boolean Algebra, and Groups as Algebraic Structures.	9
Module-II	Propositions and Logical Operators, Tautologies, logical equivalence of Statements. Normal Forms CNF & DNF. Predicate Logic, Quantifiers and Nested Quantifiers. Proofs and Logical Inference, Prenex Normal Form (PNF). Induction Based Proofs.	8
Module-III	Counting: Inclusion and Exclusion Principles, Product and Sum Rules, Permutation and combination, BInomial and Multinominal Coefficient. Derrangements. Stirling numbers of the 1st and 2nd kind. Bell's Number, Catalan Number. Recursion: Solving First and Second order Non Homogeneous Linear Recurrence Relations. Generating Functions and its application in solving Recurrence Relations.	9
Module-IV	Number Theory: Division Algorithm, Euclid's Algorithm. Fundamental Theorem of Algebra. Congruence. Solving Linear Diophantine Equations. Chinese Remainder Theorem. Graphs, Subgraphs, Graph Representation. Isomorphism of graphs. Walks, paths, circuits. Eulerian and Hamiltonian Paths. Connectedness and Components, Cut Set. Trees, Spanning tree in a graph. Shortest Path.	9
Module-V	Planar Graph: Matching and Bipartite Graph Coloring of a graph	9
	Total	44
Text	1. Discrete Mathematics and its Applications; Kenneth H Rosen, Kamala Krithivasan; 7th, McGraw Hill Education; 2011.	
Reference	1. Discrete Mathematics for Computer Scientists and Mathematicians; Joe L Mott, Abraham Kandel, Theodore P Baker; 2nd, Pearson India Education Services Pvt.Ltd; 2018. 2. Discrete Mathematical Structures with Applications to Computer Science; J P Tremblay, R Manohar; McGraw Hill Education; 2016.	

Course Code	Course name	L	T	P	C	Year	Semester
CS201	Design and Analysis of Algorithms	3	1	0	4	2nd	3rd
Course Objective: The objective of this course is to teach different algorithm techniques for effective problem solving. The use of different paradigms of problem solving will be used to illustrate clever and efficient ways to solve a given problem. In each case emphasis will be placed on rigorously proving correctness of the algorithm. In addition, the analysis of the algorithm will be used to show the efficiency of the algorithm over the naive techniques.							
Topic	Contents						No. of Lectures
Module-I	Introduction and Recursion: Algorithm Phases, Asymptotic Notations and Analysis- space and time complexity measures, lower and upper bounds; Various Algorithm Design Techniques, Pseudo code, Models of Computation- Turing Machine Model and Random Access Machine Model. Classification of Recursion, Application of Recursion, Various Solution Methodology for recurrence relations.						7
Module-II	Divide-and-conquer and Dynamic Programming: Binary Searching, Quick Sort, Merge Sort, Matrix Chain Multiplication Problem, Travelling Salesman Problem, Shortest Path Problems.						10
Module-III	Greedy Method: 0/1 knapsack Problem, Job Sequencing with Deadlines, Minimum Spanning Trees, Optimal Sub-Structure.						8
Module-IV	Backtracking, Branch and Bound and Lower Bound Theory: N– Queens Problem, Hamiltonian Cycle Problem, and Graph Coloring Problem. Backtracking vs Branch and Bound, 15-Puzzle Problem. Computational Model - Comparison Tree, Oracles and Adversary Arguments. Lower Bound for Sorting; Selection algorithms.						8
Module-V	Graph Algorithms and NP completeness: Connectivity, Topological Sort, Shortest Paths Network Flow; Disjoint Set Union Problem; String Matching, Disjoint Set Manipulation, Classification of Problems- Decision Problems, Optimisation Problems, Classification of Algorithms- Deterministic Algorithms, Non-deterministic Algorithms, Classes of Problems- P, NP, NP–Complete, and NP-Hard. Relationship among Classes of Problems, Reducibility, Cook's Theorem, Satisfiability, C-SAT Problem, Clique Decision Problem.						9
						Total	42
Text	1. Introduction to Algorithms; Thomas H Cormen, Charles E Leiserson, Ronald L Rivest; 3rd, PHI Learning Private Limited; 2018. 2. Design and Analysis of Computer Algorithms; A Aho, J E Hopcroft, J D Ullman; , Addison-Wesley; 1974.						
Reference	1. Algorithm Design; Jon Kleinberg, Eva Tardos; 14th, Pearson India Education Services Pvt.Ltd; 2017. 2. Fundamentals of Computer Algorithms; Ellis Horowitz, Sartaj Sahni, S Rajasekaran; 2nd Edition, University Press; 2011. 3. Algorithm Design: Foundations, Analysis and internet Examples; M T Goodrich, R Tamassia ; , John Wiley & Sons; 2001.						

Course Code	Course Name	L	T	P	C	Year	Semester
CS207	Computer Organization and Architecture	3	1	0	4	2nd	3rd
Course Objective: This course will introduce students to the fundamental concepts underlying modern computer organization and architecture. Main objective of the course is to familiarize students about hardware design including logic design, basic structure and behavior of the various functional modules of the computer and how they interact to provide the processing needs of the user. It will cover machine level representation of data, instruction sets, computer arithmetic, CPU structure and functions, memory system organization and system input/output devices.							
Topic							Hour
Module I	Basic structure of computers: Functional units, Basic operational concepts, Technologies for building processors and memory, Performance measures.						5
Module II	Instruction and Arithmetic for computers: Language of the computer: MIPS instruction set, addressing modes, and assembly language programming. Signed and unsigned numbers, addition, subtraction, multiplication- Booth's Algorithm, integer division- Restoring division and non-restoring division, floating point representation.						12
Module III	Processor Design: Single cycle, multi-cycle, pipelined processor design.						8

Module IV	Memory architecture: Basic Concepts, Main Memory, Internal and External Memory, Virtual Memory, Read-Only Memory, Cache Memory – basics of Caches (direct, set-associative, multi-way set associative), measuring and Improving Cache Performance.	8
Module V	Input–Output Design: Basic Concepts, Programmed I/O, Interrupt-Driven I/O, Direct Memory Access (DMA), Buses, Input–Output Interfaces.	8
	Total	41
Text	1. D. A. Patterson and J. L. Hennessy, Computer Organization and Design, 5th Ed., Morgan Kaufmann, 2017. 2. W. Stallings, Computer Organization and Architecture: Designing for Performance, 8th Ed., Pearson Education India. 2010.	
Reference	1. V. C. Hamacher, Z. G. Vranesic and S. G. Zaky, Computer Organization, 5th Ed., McGraw Hill, 2017. 2. David Money Harris and Sarah L. Harris, Digital Design and Computer Architecture, second edition, Morgan Kaufmann, 2017.	

Course Code	Course name	L	T	P	C	Year	Semester
HS201	Management Concepts and Technology	2	0	0	2	2nd	3rd
Topic	Contents						No. of Lectures
Module-I	Principles of Management: Concept of Management, Functions of Management, Planning and its Nature &Organising, Designing organizational Structure, Authority relationships,						04
Module-II	Delegation of Authority. Staffing: Motivation and its Theory, Leadership Communication. Directing, Controlling& its techniques. Coordinating; Principles of Economic: Microeconomics: Concept of consumption, production, exchange, distribution.						05
Module-III	Demand analysis: Concept, kind of demand, change in demand, law of demand; Utility analysis: Marginal, total, consumer surplus, consumer equilibrium; Production analysis: Law of supply, different factors of production, law of returns, economies of scale.						06
Module-IV	Cost analysis: Cost concept, importance of cost behaviour, cost classification; Pricing analysis: Different kinds of markets, pricing & equilibrium in different markets - perfect, imperfect, monopoly.						05
Module-V	Income distribution: Briefing them about rent, wages, interest and profit. The international economics: Changing scenario, globalization, structural adjustment programme, stabilization policy, the multinational corporation. IBRD, IMF, GATT, WTO, ITO, IDA, IFC, MIGA.						05
	Total						25
Text	1. Business Organisation& Management - C.R Basu. 2. Essentials of Management - Harold Koontz, HeingWerhrich. 3. An introduction to Positive Economics; Lipsey. 4. Modern Microeconomics; A. Koutsoyiannis. 5. Managerial Economics - Analysis, Problems and Cases; P.L. Mehta. 6. Business Economics; ManabAdhikary.						

Course Code	Course name	L	T	P	C	Year	Semester
MA204	Optimization	3	1	0	4	2nd	4th
Topic	Contents						No. of Lectures
Module-I	Objective function; Constraints and Constraint surface; Formulation of design problems as mathematical programming problems, Classification of optimization problems, Optimization techniques –classical and advanced techniques.Stationary points; Functions of single and two variables; Global Optimum, Optimization of function of one variable and multiple variables; Gradient vectors; Examples, Optimization of function of multiple variables subject to equality constraints; Lagrangian function Optimization of function of multiple variables subject to equality constraints; Hessian matrix formulation; Eigen values, Kuhn-Tucker Conditions; Examples						10

Module-II	Convex Sets, Polyhedron, Convex and Affine functions, Standard form of linear programming(LP) problem; Canonical form of LP problem; Basic Feasible Solution, Graphical method, Simplex algorithm and construction of simplex tableau; Simplex criterion; Minimization versus maximization problems, Revised simplex method; Duality in LP; Primal-dual relations; Dual Simplex, method; Sensitivity or post optimality analysis, Other algorithms for solving LP problems –Karmarkar's projective scaling method	10
Module-III	Transportation and assignment problems, zero sum games	7
Module-IV	Unimodal function, Unrestricted search, Exhaustive search, Dichotomous search, Interval halving method, Fibonacci method, Golden section method, Direct root methods.	6
Module-V	Sequential optimization; Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and the principle of optimality, Recursive equations –Forward and backward recursions; Computational procedure in dynamic programming(DP), Discrete versus continuous dynamic programming; Multiple state variables; curse of dimensionality in DP	8
		41
Text	1. U. Faigle, W. Kern, and G. Still, Algorithmic Principles of Mathematical Programming, Kluwe, 2002. 2. D.P. Bertsekas, Nonlinear Programming, 2nd Ed., Athena Scientific, 1999.	
Reference	1. N. S. Kambo, Mathematical Programming Techniques, East West Press, 1997 2. M. S. Bazarra, J.J. Jarvis, and H.D. Sherali, Linear Programming and Network Flows, 4th Ed., 2010. (3nd ed. Wiley India 2008). 3. K. Deb, "Optimization for Engineering Design-Algorithms and Examples", Prentice-Hall of India Pvt. Ltd., New Delhi, 1995	

Course Code	Course Name	L	T	P	C	Year	Semester
CS206	Operating Systems	3	0	0	3	2nd	4th
Objective: The objective of this course is to teach the fundamentals of computer Operating Systems. This course allows the students to understand the service provided by the operating system, what a process is and how processes are synchronized and scheduled and different approaches to memory management. It also explains the structure and organization of the file system and different security issues in modern operating systems.							
Topic							Hour
Module I	Introduction: Introduction to operating systems, operating system operations.						5
Module II	Process management: Process concept, multithreaded programming, Process scheduling, Inter process communication and synchronization, Deadlocks; deadlock detection, prevention and avoidance.						10
Module III	Memory Management: Memory management strategies; paging, segmentation, virtual memory management; demand paging, TLB, frame allocation and page replacement algorithms.						8
Module IV	Storage Management: File system, file operation and their implementation, allocation, free space management, directory management, mounting.						6
Module V	I/O Management: disk drives and disk scheduling, basics of security.						5
						Total	34
Text	1. Silberschatz, A., Galvin, P. B., and Gagne G., Operating System Concepts. 8/e. Wiley, 2008. 2. Tanenbaum, A. S. Modern Operating System. 3/e. Pearson, 2007.						
Reference	1. Stalling, W. Operating Systems: Internals and Design Principles. 6/e. Pearson, 2008. 2. Dhamdhere, D. M. Operating SystemsA Concept Based Approach, McGrawHill, 2008.						

Course Code	Course Name	L	T	P	C	Year	Semester
CS205	Formal Language and Automata	3	1	0	4	2nd	4th
Course Objective: The objective of this course is to provide students with an understanding of basic concepts in the theory of computation. The course explains and explores various concepts in automata theory and formal languages such as formal proofs, (non-)deterministic automata, regular expressions, regular languages, context-free grammars, context-free languages, Turing machines. It also aims to explain the power and the limitations of regular languages and context-free languages.							
Topic							Hour

Module I	Basics and Finite Automata: Alphabets, Language, Grammars, NFA, DFA, NFA-DFA, Equivalence of NFA and DFA, Minimization of FA, Myhill-Nerode Theorem.	8
Module II	Finite State Models, Regular Grammar and Language: Basic Definition, Mathematical Representation, Moore versus Mealy M/C, Capability and Limitations of FSM, State Equivalence & Minimization, Machine Equivalence. Regular Expression; Regular Grammar, Regular Language, Pumping Lemma for Regular Languages, Properties of Regular Languages.	10
Module III	Context Free Grammars and Language, Push Down Automata: CFG, CFL, Derivations, Parse Tree, Parsing and Ambiguity, CFG and Programming Languages, Transformation of CFGS, Normal Forms, Membership Algorithms, Pumping Lemma for CFLs, Properties of CFLs. Non-Deterministic PDA, Instantaneous Descriptions, Language Recognized by PDA, PDA and CFL, Deterministic PDA, and Deterministic CFL.	10
Module IV	Turing Machines: Standard Turing Machine, Design of Turing Machine, Universal Turing Machine, Halting Problem, Non-Deterministic Turing Machine.	7
Module V	Hierarchy of Formal Language and Automata: Operations on Formal Language and Their Properties, Chomsky Hierarchy, Context Sensitive Grammars, Linear Bounded Automata, Recursive and Recursively Enumerated Language.	7
	Total	42
Text	1. Introduction to Automata Theory, Languages and Computation; John E Hopcroft, Rajeev Motwani, Jeffrey D Ullman; 3rd, Pearson India Education Services Pvt.Ltd; 2018. 2. An Introduction to Formal Languages and Automata; Peter Linz, ; 6th, Jones and Bartlett India Pvt.Ltd; 2017.	
Reference	1. Elements of the Theory of Computation; H R Lewis, C H papadimitrou; 2nd Edition, Prentice Hall India; 2010. 2. Introduction to the Theory of Computation; Michael Sipser, ; 3rd, Cengage; 2017.	

Course Code	Course Name	L	T	P	C	Year	Semester
CS204	Database Management System	3	0	0	3	2nd	4th

Course Objective: This course provides fundamental knowledge of, and practical experience with, database concepts. In this course, you will create relational databases, write SQL statements to extract information to satisfy business reporting requests, create entity relationship diagrams (ERDs) to design databases, and analyse table designs for excessive redundancy. The course also provides an introductory level understanding of advanced topics such as data mining, information retrieval etc.

Topic		Hour
Module I	Introduction to database management, data abstraction and system structure. Entity relational model, entity set, relationship sets, mapping cardinalities, keys, E-R diagrams.	6
Module II	Relational model, database schema, relational algebra, outer join and manipulation of databases.	5
Module III	Tuple relational calculus: Example queries, formal definitions and safety of expressions; SQL: Query processing and optimization, set operations, aggregate functions, data definition language and views, comparison of queries in relational algebra, SQL, tuple relation calculus and domain relation calculus.	6
Module IV	Relational database design, various normal forms, functional dependencies, canonical cover, lossless join, dependency preservation, multi value dependency and higher normal forms, transaction management, ACID property.	10
Module V	Serializability and testing for serializability, concurrency control schemes, lock-based protocols, two-phase locking protocols, graph-based protocols, time stamp-based	10

	protocols, deadlocks. Recovery systems, log-based recovery, deferred and immediate database modification, object oriented database design.	
	Total	37
Text	1. Database System Concepts; Abraham Silberschatz, Henry F Korth; 6th, McGraw Hill Education (India) Pvt. Limited; 2013. 2. An Introduction to Database Systems; C J Date, A Kannan, S Swamynathan; 8th, Dorling Kindersley (India) Pvt. Ltd.; 2013.	
Reference	1. Abraham, H. and Sudershan, S., "Database System Concepts", 4th Ed., McGraw-Hill, 2002 2. Elmasi, R. and Navathe, S.B., "Fundamentals of Database Systems", 4thEd., Pearson Education., 2005	

Course Code	Course name	L	T	P	C	Year	Semester
MA202	Probability and Statistics	3	1	0	4	2nd	4th
Topic	Contents						No. of Lectures
Module-I	Basic Probability: Sample Space and Events. Conditional Probability, Expectations; Random Variables: Discrete and Continuous Probability Distributions. Moments, Moment Generating Functions.						08
Module-II	Distributions:Binomial-Poisson-Geometric-Uniform-Normal-exponential-Gamma; Two Dimensional Random Variables: Joint Distribution, Marguinal and Conditional Distribution, Covariance, Correlation Coefficient, Linear Regression.						10
Module-III	Transformation of random variables, Sampling Distributions: The Central Limit Theorem, distributions of the sample mean and the sample variance for a normal population, Chi-square, t, F and Z distributions and 2x2 contingency table. Descriptive Statistics: Graphical representation, measures of locations and variability.						09
Module-IV	Estimation: criterion of good estimation, the method of moments and the method of maximum likelihood estimation, confidence intervals for parameters in one sample and two sample problems of normal populations, confidence intervals for proportions.						07
Module-V	Testing of hypotheses: Null and alternative hypotheses, the critical and acceptance regions, two types of error, power of the test, the most powerful test and Neyman-Pearson Fundamental Lemma, tests for one sample and two sample problems for normal populations, tests for proportions, Chi-square goodness of fit test and its applications.						09
	Total						43
Text	1. P G Hoel, S C Port, C J Stone, Introduction to Probability Theory, Universal Book Stall; 2000. 2. J. Medhi, Stochastic Processes, New Age International, 4th edition, 2017.						
Reference	1. R. D. Yates and D. J. Goodman, Probability and Stochastic Processes, Wiley India, 2nd edition, 2012.						

Course Code	Course name	L	T	P	C	Year	Semester
MA301	Mathematical Finance	3	1	0	4	3rd	5th
Topic	Contents						No. of Lectures
Module-I	Introduction to Financial Markets: Bonds, Stocks, Futures & Forwards, Swaps, Options. Interest, Present & Future Values, Annuities, Amortization and Bond Yield, Price Yield Curve and Term Structure of Interest Rates. Markowitz Theory, Return & Risk and Two Asset Portfolio Minimum Variance Portfolio and Feasible Set, Multi Asset Portfolio, Minimum Variance Portfolio, Efficient Frontier and Minimum Variance Line. Market Portfolio, Market Line, Capital Asset Pricing Model.						10
Module-II	No-Arbitrage Principle and Pricing of Forward Contracts, Futures, Options and Put-Call-Parity, Bounds on Options. Derivative Pricing in a Single Period Binomial Model Derivative Pricing in Multiperiod Binomial Model Derivative Pricing in Binomial Model and Path Dependent Options.						07

Module-III	Discrete Probability Spaces Filtrations and Conditional Expectations, Properties of Conditional Expectations. Examples of Conditional Expectations, Martingales-Neutral Pricing of European Derivatives in Binomial Model, Actual and Risk-Neutral Probabilities, Markov Process, American Options.	08
Module-IV	Stochastic Calculus: General Probability Spaces, Expectations, Change of Measure, Filtrations, Independence, Conditional Expectations, Brownian Motion and its Properties, Ito's Integral and its Properties, Ito's Formula, Ito's Processes, Multivariable Stochastic Calculus, Stochastic Differential Equations	09
Module-V	Black-Scholes-Merton (BSM) Model, BSM Equation, BSM Formula, Greeks, Put-Call Parity, Change of Measure, Girsanov Theorem, Risk-Neutral Pricing of Derivatives, BSM Formula. MRT and Hedging, Multidimensional Girsanov and MRT Multidimensional BSM Model, Fundamental Theorems of Asset Pricing Model with Dividend-Paying Stocks.	09
	Total	43
Text	Chandra, Dharmaraja, Mehra, Khemchandani; Financial Mathematics: An Introduction, Narosa Publishing House. Fred Espen Benth, Option Theory with Stochastic Analysis: An introduction to mathematical finance, Springer.	
Reference	S. E. Shreve , Stochastic Calculus for Finance, Vol. I & Vol. II, Springer. Thomas Mikosh, Elementry Stochastic Calculus with Finance in view, World Scientific.	

Course Code	Course name	L	T	P	C	Year	Semester
MA302	Abstract Algebra	3	1	0	4	3rd	5th
Topic	Contents						No. of Lectures
Module-I	Groups - elementary properties including cancellation laws, uniqueness of the identity and inverses; unique solvability of linear equations; subgroups and subgroup tests; orders of elements; cyclic groups; modular systems; abelian groups; permutation groups, including the alternating and symmetric groups, cycle notation, and transpositions; dihedral groups and applications to symmetry.						09
Module-II	Direct products, Finitely generated abelian groups, invariants of a finite abelian group, Group actions, Sylow theorems						08
Module-III	Normal Subgroups and quotient groups, Isomorphism theorems, Auto orphisms, Conjugacy and G-sets, Normal series, Solvable groups, Nilpotent groups.						08
Module-IV	Rings, ideals and quotient rings, Homomorphism, Sum and direct sum of ideals, Maximal and prime ideals, Nilpotent and Nil ideals, Zorn's lemma. Unit IV : Unique factorization domain, Principle ideal domain, Euclidean domain, Polynomial rings over UFD.Definition and examples, Sub modules and direct sums, R-homomorphism and quotient modules, completely reducible modules, free modules.						10
Module-V	Field extensions, Finite fields.						08
						Total	43
Text	1. J. Fraleigh, A First Course in Abstract Algebra, Pearson, 2003. 2. D. Dummit and R. Foote, Abstract Algebra, Wiley, 2004.						
Reference	1. I. N. Herstein, Topics in Algebra, Wiley, 2008. 2. P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra, Cambridge University Press, 1995.						

Course Code	Course name	L	T	P	C	Year	Semester
MA303	Scientific Computing	3	0	2	4	2nd	4th
Course objective: The course provides an overview of the foundations of techniques needed to solve a differential equation in engineering disciplines							
Topic	Contents						No. of Lectures
Module-I	Errors; Iterative methods for nonlinear equations; Polynomial interpolation, spline interpolations; Numerical integration based on interpolation, quadrature methods, Gaussian quadrature						08
Module-II	Initial value problems for ordinary differential equations - Euler method, Runge-Kutta methods, multi-step methods, predictor-corrector method, stability and convergence analysis;						08
Module-III	Finite difference schemes for partial differential equations - Explicit and implicit schemes						09
Module-IV	Consistency, stability and convergence; Stability analysis (matrix method and von Neumann method), Lax equivalence theorem						08
Module-V	Finite difference schemes for initial and boundary value problems (FTCS, Backward Euler and Crank-Nicolson schemes, ADI methods, Lax Wendroff method, upwind scheme).						09
						Total	42
Text	1. D. Kincaid and W. Cheney, Numerical Analysis: Mathematics of Scientific Computing, 3rd Ed., AMS, 2002. 2. G. D. Smith, Numerical Solutions of Partial Differential Equations, 3rd Ed., Calrendorn Press, 1985.						
References	1. K. E. Atkinson, An Introduction to Numerical Analysis, Wiley, 1989. 2. S. D. Conte and C. de Boor, Elementary Numerical Analysis - An Algorithmic Approach, McGraw-Hill, 1981.						

Course Code	Course name	L	T	P	C	Year	Semester
MA304	Real Analysis	3	1	0	4	2nd	3rd
Topic	Contents						No. of Lectures
Module-I	Metrics and norms - metric spaces, normed vector spaces, convergence in metric spaces, completeness, compactness;						06
Module-II	Definition and existence of Riemann Stieltjes integral, properties of the integral, Integration and differentiation. The fundamental theorem of calculus, integral of vector valued function, rectifiable curves.						07
Module-III	Sequences and uniform convergence, Cauchy criterion for uniform convergence, Weierstrass M-test, Abel' s and Dirichlet's tests for uniform convergence, uniform convergence and continuity , uniform convergence and integration, uniform and differentiation, Weierstrass approximation theorem.Rearrangement of terms of a series, Riemann's theorem. Power series, Uniqueness theorem for power series, Abel's limit theorem						08
Module-IV	Functions of several variables, linear transformation, derivatives in an open subset of R^n, chain Rule, partial derivatives, interchange of order of differentiation, Derivatives of higher order, Taylor's theorem. Inverse function theorem. Implicit function theorem, Jacobians, Extremum problems with constraints, Lagrange's multiplier method, Examples on Maxima and Minima, Differentiation of integrals.						10
Module-V	Lebesgue measure and integral - sigma-algebra of sets, measure space, Lebesgue measure, measurable functions, Lebesgue integral, Fatou's lemma, dominated convergence theorem, monotone convergence theorem, Lp spaces.						10
						Total	41

Text	1. Apostol T .M., Mathematical Analysis, Narosa Publishing House,New Delhi, 1985. 2. Robert ,G.Bartle,Donald R.Sherbert:Introduction to Real Analysis Wiley India Edition 2010 3. S.C.Malik and Savita Arora: Mathematical Analysis, Wiley Fastern Ltd., New Delhi. 4. Jain P .K. and Gupta V. P., Lebesque Measure and Integration, New Age international
Reference	1. J. E. Marsden and M. J. Hoffman, Elementary Classical Analysis, 2nd Ed., W. H. Freeman, 1993 2. Walter Rudin; Principles of Mathematical Analysis, Mc Graw HillBooks Company, Third Edition 1976, international student edition

Course Code	Course name	L	T	P	C	Year	Semester
CS303	Artificial Intelligence	3	0	2	4	3rd	5th
Course Objective: The objective of the course is to present an overview of artificial intelligence (AI) principles and approaches. Develop a basic understanding of the building blocks of AI as presented in terms of intelligent agents: Search, Knowledge representation, inference, logic, and learning.							
Topic	Contents						No. of Lectures
Module 1	Fundamental issues in intelligent systems: History of artificial intelligence; philosophical questions; fundamental definitions; philosophical questions; modeling the world; the role of heuristics.						2
Module 2	Search and constraint satisfaction: Problem spaces; brute-force search; best-first search; two-player games; constraint satisfaction.						10
Module 3	Knowledge representation and reasoning: Review of propositional and predicate logic; resolution and theorem proving; non-monotonic inference; probabilistic reasoning; Bayes theorem.						8
Module 4	AI planning systems: Definition and examples of planning systems; planning as search; operator-based planning; propositional planning.						8
Module 5	Sequential decision making: Achieving behaviour by specifying rewards, Markov Decision Problems.						7
	Total						35
Text Books	1. Stuart Russell and Peter Norvig: Artifical Intelligence: A Modern Approach, Pearson; Third edition (2013). 2. Elaine Rich, Kevin Knight and Shivashankar B Nair, Artificial Intelligence, Tata McGraw Hill, 3rd Edition 2009.						
Reference Books	1. N. J. Nilsson, "Principles of Artificial Intelligence", Narosa Publishing House, 1980. 2. Clocksin & Mellish, Programming in PROLOG, Narosa Publ. House.						

Course Code	Course name	L	T	P	C	Year	Semester
MA401	Stochastic Process	3	0	0	3	3rd	6th
Topic	Contents						No. of Lectures
Module-I	Review of random variables, expectations, conditional probabilities, conditional expectations, convergence of a sequence of random variables and limit theorems. Minimum mean square error estimation and the orthogonality principle, building blocks of estimation theory.						09
Module-II	Markov models. Classification and convergence of both discrete-time and continuous-time Markov chains,Martingales.						07
Module-III	Markov processes, orthogonal increment processes, and Brownian motion.						07
Module-IV	Linear stochastic systems and estimation theory. Expectation Maximization (EM) algorithm-maximum likelihood parameter,Innovation sequences and linear stochastic equations are introduced. Kalman Filter.						10
Module-V	State and parameter estimation and applications to queues, communications, finance, biology and manufacturing.						07

	Total	40
Text	1. A. Goswami and B.V. Rao, A Course in Applied Stochastic Processes, Hindustan Book Agency, 2006. 2. U. N. Bhat and G. K. Miller, Elements of Applied Stochastic Processes, 3rd edition, Wiley, 2002.	
Reference	1. S. M. Ross, Stochastic Processes, 2nd edition, Wiley, 1995.	

Course Code	Course name	L	T	P	C	Year	Semester
MA402	Number Theory and Cryptography	3	1	0	4	3rd	6th
Topic	Contents						No. of Lectures
Module-I	The number system and the Well-Ordering Principle, Mathematical InductionDivisibility and Factorization, Divisibility, Greatest Common Divisors, Euclidean Algorithm, Least Common Multiple, Representations of integers (Decimal Representation and Binary Representation of integers). Solving Linear Diophantine Equations, Primes, Prime Numbers, Unique Prime Factorization, Test of Primality by Trial Division						10
Module-II	The concept of congruences, Congruence Classes, applications of Congruences: Check digits. Solving (single) linear congruenceSolving system of linear congruences, the Chinese Remainder Theorem.						07
Module-III	Fermat's Little Theorem, general case: Euler's theorem, Primitive Roots. The multiplicative order Primitive Roots (mod n), The modulus n which does not have primitive roots, The Existence Theorems, The use of primitive roots. Euler's Criterion, The Legendre Symbol and its properties, Examples of computing the Legendre symbol, Jacobi Symbol, Quadratic Residues and Primitive Roots,						10
Module-IV	Continued fractions, Continued fraction method Hash Functions, Public Key cryptography, Diffie-Hellmann key exchange, Discrete logarithm-based crypto-systems, RSA crypto-system, Signature Schemes, Digital signature standard, RSA Signature schemes						08
Module-V	Knapsack problem. Introduction to elliptic curves, Group structure, Rational points on elliptic curves, Elliptic Curve Cryptography. Applications in cryptography and factorization, Known attacks.						08
	Total						43
Text	1. N. Koblitz, A Course in Number Theory and Cryptography, Springer 2006. 2. I. Niven, H.S. Zuckerman, H.L. Montgomery, An Introduction to theory of numbers, Wiley, 2006.						
Reference	1. L. C. Washington, Elliptic curves: number theory and cryptography, Chapman & Hall/CRC, 2003. 2. J. Silverman and J. Tate, Rational Points on Elliptic Curves, Springer-Verlag, 2005.						

Course Code	Course name	L	T	P	C	Year	Semester
MA308	Functional Analysis	3	1	0	4	3rd	5th
Topic	Contents						No. of Lectures
Module-I	Normed Spaces,Norms. Banach spaces and Completeness. Examples, including the spaces Lp [0,1].Linear Maps and ContinuityBounded linear maps. Normed spaces of linear maps. The open mapping and closed graph theorems.						07
Module-II	Spaces of Continuous Functions Dual Spaces. Zorn's Lemma. The Hahn-Banach theorem. The space of continuous functions on a compact metric space and the Stone-Weierstrass theorem.Hilbert SpacesInner product spaces. Associated norms, and the Cauchy-Schwarz inequality. Orthogonal complements and direct sums. Representation of functionals on Hilbert spaces, and adjoints of operators.						10
Module-III	Orthonormal Sets,Orthonormal sets and sequences, and related results. Application to Fourier series and Legendre polynomials.Spectral Theory The spectrum of an operator. Complex analysis on Banach spaces. Non-emptiness and compactness of the spectrum. Self-adjoint and unitary operators. The spectral radius formula, and the spectral mapping theorem for polynomials.						09

Module-IV	Compact Operators, Definition and basic properties of compact operators. The spectral theorem for compact self-adjoint operators. Application to differential equations.The Fredholm Index Definition of a Fredholm operator and its index. Atkinson's theorem. Invariance properties of the index.	09
Module-V	Fourier and Wavelets Analysis The Fourier transform as and its properties. View of the Fourier transform as a unitary operator. Concept of a wavelet. The wavelet series. The integral wavelet transform. Inversion formula.	07
	Total	42
Text	1. B. V. Limaye, Functional Analysis, 2nd edition, Wiley Eastern, 1996. 2. E. Kreyszig, Introduction to Functional Analysis with Applications, John Wiley and Sons, 1978.	
Reference	1. Debnath and Mikusinski; Introduction to Hilbert Spaces with Applications, Academic Press; 3rd edition (2005) 2. J.B. Conway, A Course in Functional Analysis, Springer, 1990.	

Course Code	Course Name	L	T	P	C	Year	Semester
CS307	Machine Learning	3	0	0	3	3rd	6th
Course Objective: Machine learning is the science of getting computers to act without being explicitly programmed. Machine learning is so pervasive today that you probably use it dozens of times a day without knowing it. This course will help the students to learn the necessary details to create next generation applications.							
Topic							Hour
Module I	Introduction: History of machine learning, Basic concepts						3
Module II	Supervised learning: Supervised learning setup, LMS, Logistic regression, Perceptron, Exponential family, Generative learning algorithms, Gaussian discriminant analysis, Naive Bayes, Support vector machines, Model selection and feature selection, Ensemble methods: Bagging, boosting.						10
Module III	Learning theory: Bias/variance trade-off, Union and Chernoff/Hoeffding bounds, VC dimension, Worst case (online) learning.						7
Module IV	Unsupervised learning: Clustering K-means, EM. Mixture of Gaussians, Factor analysis, PCA (Principal components analysis), ICA (Independent components analysis).						8
Module V	Reinforcement learning and control: MDPs. Bellman equations, Value iteration and policy iteration, Linear quadratic regulation (LQR), Q-learning. Value function approximation, Policy search.						7
						Total	35
Text	1. Ethem Alpaydin, Introduction to Machine Learning, Second Edition, PHI, 2010. 2. Marsland, Stephen. Machine learning: an algorithmic perspective. Chapman and Hall/CRC, 2011.						
Reference	1. Murphy, Kevin P. "Machine Learning: A Probabilistic Perspective (Adaptive Computation and Machine Learning series)." (2018), MIT Press. 2. Brownlee, Jason. Machine Learning Mastery With Python: Understand Your Data, Create Accurate Models and Work Projects End-To-End. Jason Brownlee, 2016.						

Course Code	Course name	L	T	P	C	Year	Semester
ME306	Environmental Sciences & Green Technology	2	0	0	2	3rd	6th
Course objective :To bring in the importance and the underlying principles of green and sustainable technology.							
Topic	Contents						No. of Lectures
Module-I	Introduction to Environmental Pollution: Environmental Awareness, Concept of an ecosystem, structure and function of an ecosystem, energy and nutrient flow, biogeochemical cycles, sources, pathways and fate of environmental pollutants.						05
Module-II	Air pollution- Introduction, Segments of environment, Layers of atmosphere and their significance; Mechanism, Causative factors, Consequences and Preventive measures – Ozone depletion, Greenhouse effect and Global warming; Earth's radiation budget, Classification of air pollutants, Indoor air pollution, Smog-						05

	photochemical and sulphurous, Acid rain, Air Quality Standards, Human health effects-Bhopal gas tragedy.	
Module-III	Water Resource; Water Pollution : Definition, Classification , Sources of Contamination, Pollutants & their Detrimental Effects; Water Quality: Portability limit – WHO and PHED Specification; Water Quality Monitoring, Municipal Water Treatment: Slow and Rapid Sand Filter, Disinfection – Methods, Advantages & Disadvantages, Sterilization	05
Module-IV	Soil and Noise pollution: Lithosphere and Soil profile, Soil contamination, sources of soil contamination, Important environmental properties of soil contaminants, Ecological & Health effects, Exposure & Risk Assessment; Noise pollution: Brief introduction to noise pollution, source, measurement and prevention of noise pollution	05
Module-V	Radioactive Pollution & Solid Waste Management: Radioactive pollutant: units of radiation and instruments for their measurements, types of radioactive pollutants and risk factor associated with these radiations Radioactive waste and their disposal, accidental leakage of radiation from nuclear reactors (discuss Chernobyl and Fukushima) Solid waste management different types of solid waste, composting, biological methods of detoxification of hazardous waste Onsite handling and composting, integrated solid waste management,	05
	Total	42
Text	1. Miller, T. G. Jr., Environmental Science, Wadsworth Publishing House, USA. 2. Masters, G.M, Introduction to Environmental Engineering.	

Course Code	Course name	L	T	P	C	Year	Semester
HS401	Professional Ethics in Engineers	2	0	0	2	4th	7th
Course objective: To enable the students to create an awareness on Engineering Ethics and Human Values, to instil Moral and Social Values and Loyalty and to appreciate the rights of others.							
Topic	Contents						No. of Lectures
Module-I	HUMAN VALUES: Morals, Values and Ethics, Integrity, Work ethic, Service learning, Civic virtue, Respect for others, Living peacefully, Caring, Sharing, Honesty, Courage, Valuing time, Cooperation, Commitment, Empathy, Self-confidence, Character- Spirituality, Introduction to Yoga and meditation for professional excellence and Stress management.						05
Module-II	ENGINEERING ETHICS: Senses of Engineering ethics, Variety of moral issues, types of inquiry- Moral dilemmas, Moral Autonomy, Kohlberg's theory, Gilligan's theory, Consensus and Controversy, Models of professional roles, Theories of right action, Self-interest, Customs and Religion, Uses of Ethical theories.						05
Module-III	ENGINEERING AS SOCIAL EXPERIMENTATION: Engineering as Experimentation, Engineers as responsible experimenters, Code of ethics, A Balanced Outlook on Law						04
Module-IV	SAFETY, RERSPONSIBILITIES AND ETHICS: Safety and Risk, Assessment of Safety and risk, Risk Benefit Analysis and Reducing Risk, Respect for authority, Collective Bargaining, Confidentiality, Conflict of interest, Occupational crime, Professional Rights, Employee Rights, Intellectual Property Rights (IPR), Discrimination						05
Module-V	GLOBAL ISSUES: Multinational Corporations, Environmental Ethics, Computer ethics, Weapons Development, Engineers as managers, Consulting engineers, Engineers as Expert Witnesses and Advisors, Moral Leadership, Code of conduct, Corporate Social Responsibility						05
	Total						24
Text	1. Mike W Martin and Roland Schinzinger, Ethics in Engineering, Tata McGraw Hill, 2003. 2. Govindarajan M, Natarajan S, Senthil Kumar V S, Engineering Ethics, Prentice Hall of India, 2004.						

Indian Institute of Information Technology Bhagalpur

B.Tech in Mathematics and Computing (MAC) – List of Electives

Specialization	Course Name	Dept.	Type	Semester
Applied Mathematics	**Fluid Dynamics**	**MAC**	Elective-I	VI
	Mathematical Methods	**MAC**		
	FEM	MEA		
Data Science and Computing	Image processing			
	Data Compression and Protection	CSE		
	Computational Intelligence	ECE		
	Combinatorial Optimization	**MAC**		
Pure Mathematics	**General Topology**	**MAC**		
	Measure Theory	**MAC**		
Applied Mathematics	**Computational Fluid Dynamics**	**MAC**	Elective-II / Elective-III	VII
	Dynamical Systems	**MAC**		
	Mathematical Modelling	**MAC**		
Data Science and Computing	Computational Geometry	CSE	Elective-II / Elective-III /Open Elective	
	Information Retrieval	CSE		
	Foundations of Cloud Computing	CSE		
	Introduction to Deep Learning	CSE		
	Computer Vision and Image Processing	ECE		
	Parallel Algorithm	CSE		
	Block Chain Technology	CSE		
	Introduction to Data Science	CSE		
	Information Theory & Coding	ECE		
	Fuzzy Logic Control	ECE		
Pure Mathematics	**Differential Geometry**	**MAC**	Elective-II / Elective-III	
	Representation Theory	**MAC**		
Applied Mathematics	**Mathematical Biology**	**MAC**	Open Elective	
Data Science and Computing	**Graph Algorithms**	**MAC**		
	Matrix Computation	**MAC**		

* Electives offered by Departments other than MAC are already approved in previous BoA meetings.

Course Code	Course name	L	T	P	C	Year	Semester
MA351	Fluid Dynamics	3	1	0	4	3rd	6th
Topic	Contents						No. of Lectures
Module-I	Review of gradient, divergence and curl. Elementary idea of tensors. Velocity of fluid, Streamlines and path lines, Steady and unsteady flows, Velocity potential, Vorticity vector.						09
Module-II	Conservation of mass, Equation of continuity. Equations of motion of a fluid, Pressure at a point in fluid at rest, Pressure at a point in a moving fluid.						07
Module-III	Euler's equation of motion, Bernoulli's equation. Singularities of flow, Source, Sink, Doublets, Rectilinear vortices.						07
Module-IV	Complex variable method for two-dimensional problems, Complex potentials for various singularities, Circle theorem, Blasius theorem, Theory of images and its applications to various singularities. Three dimensional flow, Irrotational motion, Weiss's theorem and its applications.						09
Module-V	Viscous flow, Vorticity dynamics, Vorticity equation, Reynolds number, Stress and strain analysis, Navier-Stokes equation, Boundary layer Equations.						09
						Total	42
Text	M D Raisinghania, Fluid Dynamics, S. Chand Publications						
Reference	G. K. Batchelor, An Introduction to Fluid Dynamics, Cambridge University Press, 1993. A. R. Patterson, A First Course in Fluid Dynamics, Cambridge University Press, 1992.						

Course Code	Course name	L	T	P	C	Year	Semester
MA352	Mathematical Methods	3	1	0	4	3rd	6th
Topic	Contents						No. of Lectures
Module-I	Power series solutions, recurrence relations, Bessel functions, Modified Bessel functions, Legendre polynomial, Laguerre polynomial, Chebyshev polynomial, Hermite polynomials.						09
Module-II	Concept and calculation of Green's function, Properties, Green's function method for ordinary and partial differential equations.						07
Module-III	Fourier Series, Fourier Cosine series, Fourier Sine series, Fourier integrals. Fourier transform, Laplace transform, Hankel transform, finite Hankel transform, Mellin transform.						08
Module-IV	Solution of differential equations by integral transform methods. Construction of the kernels of integral transforms on a finite interval through Sturm-Liouville problem. Occurrence of integral equations.						09
Module-V	Regular and singular integral equations: Volterra integral equations, Fredholm integral equations, Volterra and Fredholm equations with different types of kernels.						09
						Total	43
Text and Reference	A. D. Poularikas, The Transforms and Applications Handbook, CRC Press, 1996. L. Debnath and D.D. Bhatta, Integral Transforms and Their Applications, Chapman and Hall/CRC, 2011. G. F. Roach, Green's Functions, Cambridge University Press, 1995. Larry C. Andrews, Special Functions of Mathematics for Engineers, Oxford University Press, 1997.						

Course Code	Course name	L	T	P	C	Year	Semester
MA353	Combinatorial Optimization	3	1	0	4	3rd	6th
Topic	Contents						No. of Lectures
Module-I	Matching and weighted matching in bipartite and general graphs, non-bipartite matching.						09
Module-II	Solving maximum flows, minimum-cost flows, network labelling and digraph search.						09
Module-III	Matroids: intersection, weighted matroid intersection, matroid parity.						07
Module-IV	Review of Linear programming: Analysis of simplex algorithm, Ellipsoid method. Integer programming: total unimodularity, upper bounds.						09
Module-V	Approximation algorithms for various problems: TSP, Set-cover, graph coloring, minimum multi-cut, edge coloring, bin packing.						08
						Total	43
Text	Papadimitriou & Steiglitz, Combinatorial Optimization: Algorithms and Complexity, PHI. Schrijver, Combinatorial Optimization, Springer.						
Reference	V. Vazirani, Approximation Algorithms, Springer 2005.						

Course Code	Course name	L	T	P	C	Year	Semester
MA354	General Topology	3	1	0	4	3rd	6th
Topic	Contents						No. of Lectures
Module-I	Cardinal numbers, Cardinal arithmetic, Order types, Well-ordered sets and ordinal numbers, Axiom of choice, Well ordering Theorem and Zorn's Lemma –their equivalence. The Metric Topology: Interior Points, Limit Points, Boundary Points, Closure of a Set, Hausdorff Topological Spaces, Continuous Functions						09
Module-II	Product Space, The Box Topology, Quotient Spaces, Torus.						07
Module-III	Connected Spaces, Connected Subsets of the Real Line, Connected Components.						07
Module-IV	Compact Spaces, Local Compactness, One Point Compactification of a Topological Space, Tychonoff Theorem for Product Spaces.						09
Module-V	First and Second Countable Topological Spaces, Regular and Normal Topological Spaces, Urysohn Lemma, Baire Category Theorem, Urysohn Metrization Theorem,						09
						Total	42
Text	K.D. Joshi, Introduction to General Topology, Wiley G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill						
Reference	James R. Munkres, Topology, Second Edition, Prentice Hall, 1999. Stephan Willard, General Topology, Dover, 2004.						

Course Code	Course name	L	T	P	C	Year	Semester
MA355	Measure Theory	3	1	0	4	3rd	6th
Topic	Contents						No. of Lectures
Module-I	Extended Real Numbers, Algebra and Sigma Algebras, Monotone Class, Set Functions, The Length Function, Countably Additive Set Functions on Intervals, Uniqueness Problem for Measure.						09
Module-II	Extension of Measure, Outer Measure and its Properties, Measurable Sets, Lebesgue Measure, Characterization of Lebesgue Measurable Sets, Measurable Functions, Measure Spaces.						09
Module-III	Nonnegative Simple Measurable Functions and its integrals. Monotone Convergence Theorem and Fatou's Lemma. Properties of Integrable Functions and Dominated Convergence Theorem.						09
Module-IV	Lebesgue Integral and its Properties, Product Measures and its constructions, an Introduction, Computation of Product Measure – I and Product Measure – II.						07
Module-V	Integration on Product Spaces, Fubini's Theorems, Lebesgue Measure and Integral on R^2.						07
						Total	42
Text	I. K. Rana, An Introduction to Measure and Integration, Narosa, 1997. G. de Barra, Measure Theory and Integration, New Age International						
Reference	P.R.Halmos, Measure theory, Prentice Hall P.K.Jain & V.P.Gupta, Lebesgue Measure and Integration, Wiley Eastern Ltd.						

Course Code	Course name	L	T	P	C	Year	Semester
MA451	Computational Fluid Dynamics	3	0	2	4	4th	7th
Topic	Contents						No. of Lectures
Module-I	Introduction to Computational Fluid Dynamics and Principles of Conservation of Mass and Momentum: Continuity and Navier Stokes Equation, Energy Equation and General Structure of Conservation Equations Classification of Partial Differential Equations and Physical Behaviour. Approximate Solutions of Differential Equations: Error Minimization Principles.						09
Module-II	Weighted Residual Approach, Discretization: Finite Element Method, Difference and Finite Volume Method. Finite Volume Method: 1-D Steady State Diffusion Problems, Boundary Condition Implementation and Discretization of Unsteady State Problems, Hyperbolic Equations, Stability Analysis -Second Order Hyperbolic Equations Finite Volume Method: Discretization of 2-D Unsteady State Diffusion Type						09
Module-III	Elimination Methods: Error Analysis, Iterative Methods for Numerical Solution of Systems of Linear Algebraic Equations, Gradient Search Methods						09
Module-IV	Discretization of Convection-Diffusion Equations: A Finite Volume Approach, Discretization of Navier Stokes Equations.						07
Module-V	Fundamentals of Unstructured Grid Formulation, Introduction to Turbulence Modeling.						07
						Total	42
Text	P.Niyogi, S.K.Chakrabortty and M.K.Laha- Introduction to Computational Fluid Dynamics, Pearson education, Delhi 2005 Atul Sharma, Introduction to Computational Fluid Dynamics: Development, Application and Analysis, Wiley.						

Reference	Joel H. Ferziger, Computational methods for fluid dynamics, Springer

Course Code	Course name	L	T	P	C	Year	Semester
MA452	Dynamical Systems	3	1	0	4	4th	7th
Topic	Contents						No. of Lectures
Module-I	Linearization of Non-linear Systems, Limitations, Hartman–Grobman Theorem, Local Stability, Global Stability, Lyapunov Function, Lyapunov Theorem on Stability, LaSalle Invariance Principle,						08
Module-II	Oscillations: Limit Set, Attractors, Periodic Orbits, Limit Cycle, Poincare-Bendixson Theorem, Bendixson-Dulac Criterion.						09
Module-III	Discrete Dynamical Systems: Maps and Flows, Composition of Maps, Orbits, Phase Portrait, Fixed Points, Stable and Unstable Fixed Points, Basin of Attraction and Basin Boundary, Linear Stability Analysis, Cobweb Diagram, Periodic Points, Periodic Cycles, Stability of Periodic Point and Periodic Cycle, Hyperbolic Points, Non-Hyperbolic Points, Schwarzian Derivative.						09
Module-IV	Bifurcations in One-Dimensional Systems: Saddle-Node Bifurcation, Pitchfork Bifurcation, Transcritical Bifurcation. Bifurcations in Two-Dimensional Systems: Saddle-Node Bifurcation, Pitchfork Bifurcation, Transcritical Bifurcation, Hopf-Bifurcation, Homoclinic and Heteroclinic Bifurcations. Period Doubling Bifurcation, Neimark-Sacker Bifurcation.						08
Module-V	Sensitive Dependence on Initial Conditions (SDIC), Sarkovskii's Theorem, Period-Three Implies Chaos for 1-D Maps. Some Chaotic Maps, Universal Sequence, Feigenbaum Number, Poincaré Section, Lyapunov Exponents, Routes of Chaos, Some Examples of Chaos.						08
	Total						42
Text	G C Layek - An Introduction to Dynamical Systems, Springer S. H. Strogatz, Nonlinear dynamics and chaos with applications to Physics, Biology, Chemistry, and Engineering (Westview Press)						
Reference	Lawrence Perko, Differential Equations and Dynamical Systems, Springer J Hale and H Koack - Dynamics and Bifurcations, Springer.						

Course Code	Course name	L	T	P	C	Year	Semester
MA453	Mathematical Modelling	3	1	0	4	4th	7th
Topic	Contents						No. of Lectures
Module-I	Basic concepts of continuous-time dynamical systems. Local and global bifurcations with special emphasis on Hopf-bifurcation. Centre manifold theorem. Direction of Hopf-bifurcation. Chaos. Different route to chaos. Lyapunov exponent.Introduction to continuous time Mathematical Modeling. Non-dimensionalisation techniques.						08
Module-II	Stability criteria of a system. Routh-Hurwitz criteria, Descartes' rule of signs. Boundedness of a system. Positiveness of a solution. Persistence of a system. Kolmogorov Analysis. Single species differential equation models- Malthus model, Logistic model, Model with harvesting, Model with Allee effect. Insect outbreak model. Modeling predator functional response- Holling type-I, type-II, type-III, type-IV, ratio-dependent, Beddington- DeAngelis.						09
Module-III	Two and three species differential equation models- Predator-prey model. Food chain model. Model with one prey-two predators. Model with one predator-two preys. Model with generalist predator. Model with two preys-two predators. Modeling two and three species continuous time models by incorporating different phenomena like imposition of a population floor, addition of refugia, omnivory, intraspecific density dependence, toxic inhibition, spatial effect, disease in prey, dispersal, predator switching, Allee effect , additional predator, additional food ,						09

	harvesting of predator, disease in predator, mutualism, commensalism, parasitism, fear factor, seasonal variation, cooperation, group defense, cross predation, anti predator, etc.	
Module-IV	Modeling of excitable systems. Chemostat Model. Tumour-growth model. Cancer model. HIV-model. Model of divorce prediction and marriage repair. Metapopulation and patch Model. Epidemic Models (SI,SIR, SIS, SIRS, SEIR etc).	08
Module-V	Models with time delay (single and double delay). Derivation of a critical delay for stability of a system. Periodic solutions.	08
	Total	42
Text	J.D. Murray, Mathematical Biology (Vol. I, II) (Springer-Verlag). J.N. Kapur, Mathematical models in biology and medicine, East-West Press Pvt. Ltd.,	
Reference	S. H. Strogatz, Nonlinear dynamics and chaos with applications to Physics, Biology, Chemistry, and Engineering (Westview Press). B.D. Hassard, N.D.Kazarinoff, Y.H. Wan, Theory and Applications of Hopf Bifurcation (London Mathematical Society. Maia Martcheva, An Introduction to Mathematical Epidemiology, Springer.	

Course Code	Course name	L	T	P	C	Year	Semester
MA454	Differential Geometry	3	0	2	4	4th	7th
Topic	Contents						No. of Lectures
Module-I	Local theory of plane and space curves, Curvature and torsion formulas, Serret-Frenet formulas, Fundamental Theorem of space curves.						09
Module-II	Regular surfaces, Change of parameters, Differentiable functions, Tangent plane, Differential of a map.						09
Module-III	First and second fundamental form. Orientation, Gauss map and its properties, Euler's Theorem on principal curvatures. Isometries, and Gauss' Theorema Egregium.						09
Module-IV	Parallel transport, Geodesics, Gauss-Bonnet theorem and its applications to surfaces of constant curvature.						07
Module-V	Hopf-Rinow's theorem, Bonnet's theorem, Jacobi fields, Theorems of Hadamard. Riemann's Habilitationsvortrag.						07
	Total						42
Text	Barret O'Neill, Elementary Differential Geometry, Academic Press. T.J. Willmore, An introduction to Differential and Riemannian Geometry, Oxford University Press						
Reference	J.A.Thorpe, Introduction to Differential Geometry, Springer-Verlag.						

Course Code	Course name	L	T	P	C	Year	Semester
MA454	Representation Theory	3	1	0	4	4th	7th
Topic	Contents						No. of Lectures
Module-I	Fundamental concepts of representation theory. Representations and actions, one-dimensional representations. Finite Fourier analysis.						09
Module-II	Irreducible representations of S3, tensor product representation, dual representation.						07
Module-III	Hom(V, W) representation. Symmetric and alternating powers. Complete reducibility theorem and Schur's lemma.						07

Module-IV	Character Theory. Representations of S4 and A4. Character tables, orthogonality relations. Frobenius divisibility. Introduction to representations of Sn. Alternating powers of standard representation of Sn.	09
Module-V	Bilinear forms and quaternionic representations. Finite subgroups of SO(3) and SU(2). Finite sub- groups of SO(3) and SU(2). Hamiltonian quaternions and SU(2). Schur indicator. Induced representations, definition and characterizations. Examples	09
	Total	42
Text	J.P. Serre , Introduction to representation theory, Springer GTM	
Reference	Fulton and Harris, Representation Theory, Springer GTM Barry Simon, Representation of Finite and Compact Groups, AMS, 1996.	

Course Code	Course name	L	T	P	C	Year	Semester
MA471	Mathematical Biology	3	1	0	4	4^{th}	7^{th}
Topic	Contents						No. of Lectures
Module-I	Mathematical models: Deterministic and Stochastic. Single species population models. P-V Logistic equation. Population growth model– An age structured model. Interactions between two species: Host-Parasite type of interactions, Competitive type of interactions. Trajectories of interactions of H-P and competitive types between two species. Effect of migration on H-P interactions. Some consequences of Lotka-Volterra equations. Generalized L-V equations. Constant of motion in the dynamical system.						08
Module-II	Stochastic processes and need of stochastic models. Pure birth process, Pure death process, Birth and death process. Linear birth-death-immigration-emigration processes. Effects of both immigration and emigration on the dynamics of population.						09
Module-III	Biological mechanisms responsible for "time-delay". Discrete and continuous time-delay. The single species logistic model with the effect of time-delay. Stability of equilibrium position for the logistic model with general delay function. Stability of logistic model for discrete time lag. Time-delayed H-P model together with their stability analysis.						09
Module-IV	Introduction; Some basic definitions. Simple epidemic model, General epidemic model. Kermack-McKendrik threshold theorem. Recurring epidemic model. A comparative study of these models. Control of an epidemic. Simple extensions of SIR model: Different case studies --- (i) Loss of immunity, (ii) Inclusion of immigration and emigration, (iii) Immunization. SIR endemic disease model.						08
Module-V	Fick's laws of diffusion, One-dimensional diffusion model and its solution, Some solutions of two-dimensional diffusion equation, Various modifications of diffusion equation to diffusion-reaction models arising in Pharmaco-kinetics and ecology. Solutions of basic equation for a circular-duct dialyser by (i) separation of variables method and (ii) Galerkin's method. Solution for parallel-plate dialyser.						08
	Total						42
Text	J D Murray, Mathematical Biology, Springer-Verlag, J. N. Kapur, Mathematical Models in Biology and Medicine, East West Press Pvt Ltd						
Reference	R. Rosen, Foundation of Mathematical Biology (vol. I& II), Academic Press M. Kot, Elements of Mathematical Ecology,Cambridge University Press.						

Course Code	Course name	L	T	P	C	Year	Semester
MA472	Graph Algorithms	3	0	2	4	4th	7th
Topic	Contents						No. of Lectures
Module-I	Introduction to Graphs: Definition and basic concepts, Efficient representations of Graphs; Graph Searching: DFS and BFS; Application of Graph Searching: finding connected components, bi-connected components, testing for bipartite graphs, finding cycle in graph; Trees: Different MST algorithms, enumeration of all spanning trees of a graph.						09
Module-II	Paths and Distance in Graphs: Single source shortest path problem, All pairs shortest path problem, centre and median of a graph, activity digraph and critical path; Hamiltonian Graphs: sufficient conditions for Hamiltonian graphs, traveling Salesman problem; Eulerian Graphs: characterization of Eulerian graphs, construction of Eulerian tour, The Chinese Postman problem.						09
Module-III	Planar Graphs: properties of planar graphs, a planarity testing algorithms. Graph Coloring: vertex coloring, chromatic polynomials, edge coloring, planar graph coloring.						07
Module-IV	Matching: maximum matching in bipartite graphs, maximum matching in general graphs; Networks: The Max-flow min-cut theorem, max-flow algorithm.						07
Module-V	NP-Complete Graph Problems: proving NP-Completeness, Methods to tackle NP-Hard Graph Problems. Approximation Algorithms for NP-Hard Graph Problems: Vertex Cover, Metric TSP						09
						Total	42
Text	Cormen, Leiserson, Rivest, and Stein; Introductions to Algorithms, PHI. G. Chatrand and O.R. Oellermann, Applied and algorithmic Graph Theory, McGraw Hill.						
Reference	M C Golumbic, Algorithmic Graph Theory and Perfect Graphs, Volume 57 in the series-Annals of Discrete Mathematics. North Holland, second edition. D.B. West, Introduction to Graph Theory, 2nd Edition, PHI.						

Course Code	Course name	L	T	P	C	Year	Semester
MA473	Matrix Computation	3	0	2	4	4th	7th
Topic	Contents						No. of Lectures
Module-I	Review of linear algebra: Vector spaces, Linear transformations, eigen values and eigen vectors. Floating point computations, IEEE floating point arithmetic, analysis of roundoff errors; Sensitivity analysis and condition numbers; Linear systems, LU decompositions, Gaussian elimination with partial pivoting;						09
Module-II	Banded systems, positive definite systems, Cholesky decomposition - sensitivity analysis; Gram-Schmidt orthonormal process, Householder transformation, Givens rotations; QR factorization, stability of QR factorization.						09
Module-III	Solution of linear least squares problems, normal equations, singular value decomposition (SVD), polar decomposition, Moore-Penrose inverse; Rank deficient least-squares problems; Sensitivity analysis of least-squares problems.						09
Module-IV	Review of canonical forms of matrices; Sensitivity of eigenvalues and eigenvectors. Reduction to Hessenberg and tridiagonal forms; Power, inverse power and Rayleigh quotient iterations.						07
Module-V	Explicit and implicit QR algorithms for symmetric and nonsymmetric matrices; Reduction to bidiagonal form; Sensitivity analysis of singular values and singular vectors, conjugate gradient method, Golub- Kahan algorithm for computing SVD.						07
						Total	42
Text	D. S. Watkins, Fundamentals of Matrix Computations, 2nd Ed., John Wiley, 2002 L. N. Trefethen and D. Bau, Numerical Linear Algebra, SIAM, 1997.						
Reference	B.N. Datta, Numerical Linear Algebra and applications, PHI. G. H. Golub and C. F. Van Loan, Matrix Computations, John Hopkins University Press.						