Department of Mathematics
Birla Institute of Technology, Mesra, Ranchi - 835215 (India)

Institute Vision

To become a Globally Recognized Academic Institution in consonance with the social, economic and ecological environment, striving continuously for excellence in education, research and technological service to the National needs.

Institute Mission

- To educate students at Undergraduate, Post Graduate Doctoral and Post-Doctoral levels to perform challenging engineering and managerial jobs in industry.
- To provide excellent research and development facilities to take up Ph.D. programmes and research projects.
- To develop effective teaching and learning skills and state of art research potential of the faculty.
- To build national capabilities in technology, education and research in emerging areas.
- To provide excellent technological services to satisfy the requirements of the industry and overall academic needs of society.

Department Vision

- To become a globally recognized centre of excellence in teaching and research, producing excellent academicians, professionals and innovators who can positively contribute towards the society.

Department Mission

- Imparting strong fundamental concepts to students in the field of Mathematical Sciences and motivate them towards innovative and emerging areas of research.
- Creation of compatible environment and provide sufficient research facilities for undertaking quality research to achieve global recognition.

CBCS based Syllabus for IMSc in Mathematics and Computing
(1^{st} - 10^{th} Semester)

Important notes:

- The basic criteria of UGC have been followed in preparing the course structure of this programme.
- The Exit option with B.Sc. Honours in Mathematics and Computing can be offered to them who want to get it after successful completion of 6^{th} semester.
- Otherwise IMSc in Mathematics and Computing would be offered to them after the successful completion of 10^{th} semester.

Program Educational Objectives (PEO)

1. To impart conceptual knowledge of Mathematical Sciences for formulating and analyzing the real world problems with futuristic approach.
2. To equip the students sufficiently in both analytical and computational skills in Mathematical Sciences.
3. To develop a competitive attitude for building a strong academic - industrial collaboration, with focus on continuous learning skills.
4. To nurture and nourish strong communication and interpersonal skills for working in a team with high moral and ethical values.

Programme Outcomes(PO)

A graduate of this program are expected to:

1	gain sound knowledge on fundamental principles and concepts of Mathematics and computing with their applications related to Industrial, Engineering, Biological and Ecological problems.
2	exhibit in depth the analytical and critical thinking to identify, formulate and solve real world problems of science and engineering.
3	be proficient in arriving at innovative solution to a problem with due considerations to society and environment.
4	be capable of undertaking suitable experiments/research methods while solving the real life problem and would arrive at valid conclusions based on appropriate interpretations of data and experimental results.
5	exhibit understanding of societal and environmental issues (health, legal, safety, cultural etc) relevant to professional practice and demonstrate through actions, the need for sustainable development
6	be committed to professional ethics, responsibilities and economic, environmental, societal and political norms.
7	demonstrate appropriate inter-personal skills to function effectively as an individual, as a member or as a leader of a team and in a multi-disciplinary setting.
8	develop written and oral communications skills in order to effectively communicate design, analysis and research results.
9	be able to acquire competent positions in industry and academia as well.
10	be able to acquire lifelong learning and continuous professional development.
11	be conscious of financial aspects of all professional activities and shall be able to undertake projects with appropriate management control and control on cost and time.
12	recognize the need for continuous learning and will prepare himself/ herself appropriately for his/her all-round development throughout the professional career.

Details Syllabi for Choice Based Credit System of IMSC

in
Mathematics and Computing

COURSE INFORMATION SHEET

Course code: MA101

Course title: Calculus-I

Pre-requisite(s): Basics of differential Calculus and integral Calculus

Credits: L:3 T:1 P:0 C:4

Class schedule per week: 3 lectures, 1 tutorial

Class: IMSc.

Semester/level: I/1

Branch: Mathematics and Computing

Name of the Faculty:

Course Objectives : This course enables the students to understand the

1.	behaviour of functions studying different approach of derivatives for the function of single variable.
2	Nature of the function in cartesian and polar form and its behaviour at infinity.
3.	functions of two or more variables, their differentiation, properties and applications as most of entities in the real world are dependent of several independent entities
4.	definite Integral, Improper integrals and some special integrals as Beta functions, Gamma Functions and Error functions.
5	applications of the definite Integral to derive different important quantities as Arc Length, Area, Volume, Work and Moments.

Course Outcomes: After completion of the course, the learners will be able to:

CO 1	Find the nth derivatives of the function, evaluate its indeterminate forms and way to expand a function in series form using Taylor's and Maclaurain's theorems. Analytically and graphically understand the nature and forms of function
CO2	Study behavior of a function at infinity, knowledge on curvature with its properties in both cartesian and polar form.
CO3.	Understand the fundamental concepts of functions with several variables, its derivatives in partial forms with other important related concepts, their applications in maxima - minima problems.
CO4.	Apply the principles of integral to solve a variety of practical problems in sciences and engineering. Equip the students with standard concepts and tools at an intermediate to advanced level that will serve them well towards tackling more advanced level of mathematics
CO5.	Enhance and develop the ability of using the language of mathematics in analyzing the real world problems of sciences and engineering.

Syllabus

MA101 Calculus-I 3-1-0-4

Module I

Successive Differentiation and Mean Value **Theorem:** Leibnitz Theorem, Generalized Mean Value Theorem, Taylor's and Maclaurin's Expansion of Functions of Single Variable**.** Increasing and decreasing functions. Concavity, Convexity and Inflection point of a function. Extrema of functions. [6L]

Module II

Analysis of functions: Behavior of a function at infinity: Asymptotes. Orthogonal Intersection of Curves, Curvature and Radius of Curvature of a Curve in Cartesian, Parametric, Polar and Tangential Polar forms. [8L]

Module III

Functions of several variables: limit and continuity, partial derivatives. Euler's theorem, derivatives of composite and implicit functions, total derivatives, Errors and Approximations, Jacobian's. Taylor's and Maclaurin's expansion of functions of several variables, Maxima and minima of functions of several variables, Lagrange's method of undetermined multipliers. [9L]

Module IV

Definite Integral:

Reduction Formula, Differentiation under Integral Sign: Differentiation of Integrals with constant and variable limits, Leibnitz rule. [8L]

Improper integrals: convergence of improper integrals, test of convergence, Beta and Gamma Functions and its Properties, Error functions. [4L]

Module V

Application of Definite Integral:

Length of a Plane Curve, Area between Two Curves, Volume, Volume of Revolution, Area of Revolution, Work and Moments. [10L]

Text Books:

1. H Anton, I Brivens, S. Davis : Calculus, 10^{th} Edition, John Wiley and sons, Singapore Pte. Ltd.,2013.
2. M. J. Strauss, G. L. Bradley And K. J. Smith, Calculus, 3^{rd} Ed, Dorling.Kindersley (India)Pvt. Ltd. (P Ed), Delhi, 2007.
3. M. D. Weir, J. Hass and F. R. Giordano: Thomas' Calculus, 11^{th} edition, Pearson Educations,2008.

Reference Books:

1. Apostol: Calculus Vols 1 and 11.2^{nd} Edition(reprint), John Wiley and sons, 2015.
2. Robert Wrede & Murray R. Spiegel, Advanced Calculus, 3^{rd} Ed., Schaum's outline series, McGraw-Hill Companies, Inc.,2010.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course outcome (co) attainment assessment tools & evaluation procedure

Direct assessment

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

Mapping of course outcomes onto program outcomes

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA102
Course title: Real Analysis
Pre-requisite(s): Basics of real number system, basics of algebra.
Credits: L:3 T:1 P:0 C:4
Class schedule per week: 3 lectures, 1 tutorial
Class: IMSc.
Semester/level: I/1
Branch: Mathematics and Computing
Name of the Faculty:

Course Objectives: This course enables the students to understand

1.	real number system and their properties
2.	open and closed sets, sequences and series
3.	convergence and divergence criteria for sequence and series of functions
4.	Riemann integration of real valued functions.
5	fundamental theorem of calculus, mean value theorem of integral calculus

Course Outcomes: After the completion of this course, students will be able to

CO 1	understand the basic properties of real number system that will used later in development of real analysis theory.
CO 2	develop the logical thinking to proof the basic results of real analysis.
CO 3	solve the problems of convergence and divergence of sequences and series.
CO 4	develop an understanding of limits in abstract way and how they are used in sequences, series, differentiation and integration.
CO 5	appreciate how abstract ideas in real analysis can be applied to practical problems.

Syllabus

MA102 Real Analysis 3-1-0-4

Module I

Axiomatic description of R, Archimedean property, Bounds: Sup. And inf. Ofa subset of R, Notion of neighborhood, interior point and limit point of a subset of R, open set and closed set together with their usual properties.

[9L]

Module II

Monotonic sequence, limit of a sequence, convergent, divergent and oscillating sequences, lim sup and lim.inf. of sequences, Bolzano-Wierstrass theorem (Statement only), monotone convergence theorem, subsequence and Cauchy theorems on limit, Cauchy sequence, Nested interval theorem

[9L]

Module III

Convergence of series of real numbers of positive terms. P series test, comparison tests, Cauchy's root test, D' Alembert's ratio test, Raabe's test, Cauchy's Integral Test. Gauss's Ratio Test, Logarithmic and Higher Logarithmic Ratio Test, Absolute and conditional convergence, Leibnitz's Rule for Alternating series Test.

[9L]

Module IV

Sequence of functions, uniform boundedness, pointwise and uniform convergence of sequence of functions, Series of functions, pointwise and uniform convergence of series of functions, Weierstrass-M Test.

[8L]

Module V

Riemann integral, definition and existence of the integral, Upper and Lower Integrals, Darbous theorem, Properties of the integral, differentiation and integration, Fundamental theorem of integral calculus, Riemann integration of continuous and monotonic functions. Mean value theorems of integral calculus.

[10L]

Text Books:

1. N. P. Bali, Real Analysis, Firewall Media, Laxmi Publications Pvt. Ltd. 2009.
2. S.C. Malik, Principles of Real Analysis (Fourth Edition), New Age International publisher.

Reference book:

1. Donald R. Sherbert and Robert G. Bartle, Introduction to Real Analysis.
2. S. K. Mapa, Introduction to Real Analysis (Revised 6th edition), Sarat book distributers, 2011.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Semester Examination	25
End Semester Examination	50
Quiz (s)	10+10
Assignment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√				√
End Semester Examination	√	√	√		√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA109
Course title: Matrix Theory
Pre-requisite(s): Basics of Algebra
Credits: L:3 T:1 P:0 C:4
Class schedule per week: 3 lectures, 1 tutorial
Class: IMSC.
Semester/level: I/1
Branch: Mathematics and Computing
Name of the faculty:

Course objectives: This course enables the students to understand

1.	different types of matrices and their properties.
2.	the rank of a matrix and apply it to solving system of linear equations.
3.	analyzing eigen values and associated eigen vectors of a matrix and their geometric interpretation and their various properties
4.	when a matrix is diagonalizable and how to diagonalise it.
5.	analyzing a real quadratic form and conclusion regarding its positivity or negativity.

Course outcomes: After the completion of this course, students will be able to

CO1.	apply the matrix theory to study other branches of mathematics like algebra, vector analysis, cryptography, graph theory etc.
CO2.	apply the matrix theory to analyze the quantitative and qualitative properties of solutions of mathematical models in biological, ecological systems and in engineering problems.
CO3.	apply the matrix theory to study the properties of solutions of different algebraic systems.
CO4.	apply the matrix theory in different problems of computer graphics, electrical engineering, civil engineering, robotics and automation.
CO5.	apply the matrix theory in recording data arising in geology for seismic survey.

Syllabus

MA109 **MATRIX THEORY** **3-1-0-4**

Module-I
Matrices, matrix operations, algebra of matrices, orthogonal, idempotent, nilpotent, involutary, hermitian, skew- hermitian, unitary matrices and their properties, partition of matrices. [8L]

Module - II
Elementary operations, elementary matrices, inverse using elementary transformations, rank of a matrix, row-reduced echelon form, normal form, consistency of system of linear equations using rank (homogeneous and non - homogeneous). [9L]

Module - III

Solution to system of linear equations using gaussian elimination, gauss – jordan method, lu decomposition. Linear independence and dependence of vectors, introduction to linear transformations, matrix of linear transformation. [9L]

Module IV

Matric polynomials, characteristic equation, eigenvalues, eigenvectors, algebraic and geometric multiplicity of eigen values, diagonalization of matrices, orthogonal diagonalization, minimal polynomials. [10L]

Module V
Cayley-Hamilton theorem and its applications, real quadratic forms: definitions, examples of positive definite, positive semi definite, negative definite, negative semi definite and indefinite quadratic forms, rank, index and signature of quadratic forms. [9L]

Text books:
1. S. Lipschutz, M. L. Lipson: Schaum's Outline of Linear Algebra, Mcgraw-Hill.
2. David c. Lay, Linear Algebra and its Applications (3rd Edition), Pearson Ed. Asia, Indian Reprint, 2007.

Reference books:
1. Higher Algebra Abstract and Linear, S K Mapa, Levant Publications.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course outcome (co) attainment assessment tools & evaluation procedure

Direct assessment

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

Mapping of course outcomes onto program outcomes

Course outcome	Program outcomes											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: MT 123
Course title: Business Communication
Pre-requisite(s): NIL
Co- requisite(s): NIL
Credits: L: 2 T: 0 P: 2 C:3
Class schedule per week: 2 lectures, 2 sessional
Class: All
Semester/Level: 1/1
Name of Teacher:

Course Objectives

This course enables the students:

1.	To analyze and demonstrate writing and speaking processes through invention, organization, drafting, revision, editing, and presentation.
2.	To understand the importance of specifying audience and purpose and to select appropriate communication choices.
3.	To interpret and appropriately apply modes of expression, i.e., descriptive, expositive, Narrative, scientific, and self-expressive, in written, visual, and oral communication
4.	To participate effectively in groups with emphasis on listening, critical and reflective thinking, and responding.
5.	To develop the ability to research and write a documented paper and/or to give an oral presentation.

Course Outcomes

After the completion of this course, students will be able to:

CO1.	apply business communication strategies and principles to prepare effective communication for domestic and international business situations.
CO2.	utilize analytical and problem-solving skills appropriate to business communication.
CO3.	participate in team activities that lead to the development of collaborative work skills.
CO4.	select appropriate organizational formats and channels used in developing and presenting business messages
CO5.	communicate via electronic mail, Internet, and other technologies and deliver an effective oral business presentation.

Syllabus

MT123 **Business Communication** **2-0-2-3**

Module I

Introduction to Business Communication:
Importance and Objectives of Business communication, Process of communication, Barriers to effective communication, Techniques of effective communication. Forms of communication (Written, Oral, audio-visual communication). [8L]

Module II

Managing Business Communication:
Formal and Informal communication, Non- verbal communication (Body language, Gestures, Postures, Facial expressions). The cross cultural dimensions of business communication. Techniques to effective listening, methods and styles of reading. [8L]

Module III

Other aspects of communication:
Vocabulary:
Single word substitution, Idioms and phrases, Precis writing, Comprehension.
Group Discussions, Extempore, Principles of effective speech and presentations, Role playing.
[8L]

Module IV:

Introduction to managerial writing:

Business letters: Inquiries, Circulars, Quotations, Orders, Acknowledgement, Claims & adjustments, Collection letters, Sales letters, Drafting of different resumes, Covering letters Applying for a job, Social correspondence, Invitation to speak.
Official Correspondence: Memorandum, Notice, Agenda, Minutes, Circular letters. [8L]

Module V:

Report writing:
Business reports, Types, Characteristics, Importance, Elements of structure, Process of writing, Order of writing, the final draft, check lists for reports. [8L]

Text Books:
T1. Communication Skills, Sanjay Kumar &PushpLata, Oxford University Press
T2. Business Correspondence and Report Writing,R.C.Sharma, Krishna Mohan.Mcgraw Hill
T3. Communication for Business,Shirley Taylor, V.Chandra, Pearson
T4. Business Communication- HorySankar Mukherjee, Oxford University Press
T5. Basic Business Communication- .Lesikar I Flatley, McGraw Hill.
T6. Business Communication Today ,Bovee, Thill and Chaterjee, Pearson

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment:

Assessment Tool	% Contribution during CO Assessment
Quiz(I,II)	10+10
Mid Term Examination Marks	25
Attendance	5
End Term Examination Marks	50

AssessmentCompoents	CO1	CO2	CO3	CO4	CO5
Quiz(I,II)	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Mid Term Examination Marks			√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1,CD2,CD3
CD2	Tutorials/Assignments		CO2	CD1,CD2,CD3
CD3	Seminars		CO3	CD1,CD2,CD3
CD4	Mini projects/Projects		CO4	CD1,CD2,CD3,CO4 CD5
CD5	Laboratory experiments/teaching aids		CO5	CD1,CD2,CO5
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: CH 111
Course title: General Chemistry-I
Pre-requisite(s): Intermediate level chemistry
Co- requisite(s):
Credits: L: 3 T: 1 P: 0 C: 4
Class schedule per week: 3 Lectures, 1 Tutorial
Class: IMSc
Semester/ Level: I/1
Branch: All
Name of Teacher:

Course Objectives : This course enables the students:

1.	To understand the structure of atom at electronic level
2.	To develop knowledge on the physical and chemical properties of the atoms
3.	To create concept of interaction of atomic orbitals
4.	To understand the basics of organic chemistry including stereochemistry perspectives

Course Outcomes : After the completion of this course, students will be:

CO1	Able to explain the properties of the atoms quantum mechanically and calculate the atomic parameters
CO2	Able to predict the chemical reactivity
CO3	Able to explain the interaction between atoms
CO4	Able to explain the organic reaction mechanism

Syllabus

CH 111 **General Chemistry-I** **3-1-0-4**

Module I: Atomic Structure
Bohr's theory, Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule, Aufbau's principle, Variation of orbital energy with atomic number. [9L]

Module II: Periodicity of Elements
s, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of properties of the elements with reference to *s* and *p*-block. Shielding effect, Slater rules, variation of properties in periodic table. Atomic & Ionic radii (van der Waals), Ionization enthalpy, electron gain enthalpy, Electronegativity, hybridization, group electronegativity. Sanderson's electron density ratio. [9L]

Module III: Basics of Organic Chemistry
Organic Compounds: Classification, Nomenclature, Hybridization, Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation, Dipole moment. Organic acids and bases. Homolytic and Heterolytic fission, arrow rules, Electrophiles and Nucleophiles; Carbocations, Carbanions, Free radicals and Carbenes. Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions. [9L]

Module IV: Chemical Bonding
Ionic bond: Radius ratio rule, Packing of ions in crystals. Born-Landé equation, Madelung constant, Born-Haber cycle. *Metallic Bond:* valence bond and band theories, defects in solids. *Weak Chemical Forces:* Van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Hydrogen bonding. *Covalent bond:* Lewis structure, Valence Bond theory, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules, Valence shell electron pair repulsion theory (VSEPR), multiple bonding. Fajan's rules and consequences of polarization. [9L]

Module V: Stereochemistry
Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: *cis–trans* and, syn-anti isomerism E/Z notations with C.I.P rules.
Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations. [9L]

Text books:
1. Lee, J. D. Concise Inorganic Chemistry ELBS, 1991.
2. Douglas, B. E. and McDaniel, D. H. Concepts & Models of Inorganic Chemistry Oxford, 1970
3. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
4. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

Reference books:
1. Atkins, P. W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014.
2. Day, M. C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
3. Rodger, G. E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.
4. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Teacher's Assessment	5
Mid Sem	25
Two Quizzes	10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem	√	√		
Assignment	√	√	√	
Quiz –I	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	M	H	L	L
CO2	H	H	M	L
CO3	H	H	H	M
CO4	H	M	H	L

Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

COURSE INFORMATION SHEET

Course code: CH 112
Course title: General Chemistry- I Lab
Pre-requisite(s): Intermediate level chemistry
Co- requisite(s):
Credits: L: 0 T: 0 P: 3 C:1.5
Class schedule per week: 3 Sessional
Class: IMSc
Semester/Level: I/1
Branch: All
Name of Teacher:

Syllabus

(A) Titrimetric Analysis

(i) Calibration and use of apparatus

(ii) Preparation of solutions of different Molarity/Normality of titrants

(B) Acid-Base Titrations

(i) Estimation of carbonate and hydroxide present together in mixture.

(ii) Estimation of carbonate and bicarbonate present together in a mixture.

(iii) Estimation of free alkali present in different soaps/detergents

(C) Purification of organic compounds by crystallization using the following solvents:

a. Water

b. Alcohol

c. Alcohol-Water

(D) Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)

Reference book:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

COURSE INFORMATION SHEET

Course code: MA105
Course title: Calculus-II
Pre-requisite(s): Calculus-I
Credits: L:3 T:1 P:0 C:4
Class schedule per week: 3 lectures, 1 tutorial
Class: IMSc.
Semester/level:II/1
Branch: Mathematics and Computing
Name of the Faculty:

Course Objectives : This course is intended as a basic course enables the students to get the detailed idea about:

1.	coordinate axes and coordinate plane and surfaces in 3-dimensional space
2.	The mathematical tools needed in evaluating multiple integrals and their usage.
3.	vector differential calculus
4.	vector integral calculus
5.	vector valued functions in orthogonal curvilinear coordinate system

Course Outcomes: After completion of the course, the learners will be able to:

CO1.	explain coordinate axes and coordinate plane and surfaces in 3-dimensional space.
CO2.	visualize and deal with problems consisting of surface area, volume of solids and derive different important quantities as Centre of Mass and Moments.
CO3.	explain the characteristics of scalar and vector valued functions and provide a physical interpretation of the gradient, divergence, curl and related concepts and also give an account of important vector field models of Nature.
CO4.	transform line integral to surface integral, surface to volume integral and vice versa using Green's theorem, Stoke's theorem and Gauss's divergence theorem and understand the concept of vector valued functions in orthogonal curvilinear coordinate system
CO5.	enhance and develop the ability of using the language of mathematics in analyzing the real-world problems of sciences and engineering.

Syllabus

MA105 Calculus-II 3-1-0-4

Module I

Three-dimensional space: rectangular coordinates in 3D space, parametric equations of lines, planes, sphere and cylinder. [9L]

Module II

Double and triple integrals, Iterated integrals and their connections, change of order of integration, Evaluation of area using double integrals, Change of variables in double and triple integrals, Evaluation of volumes using double and triple integrals, Center of Mass and Moment of Inertia. [9L]

Module III

Vector valued functions, unit tangent, normal and binormal vectors, curvature, torsion and TNB frame.
Motion along the curves: Tangential and normal components of velocity and acceleration.
Calculus of scalar and vector point functions, Gradient, Directional derivative, Divergence and curl, properties, second order derivatives, identities. [9L]

Module IV

Line integrals, vector field, work, circulation, path independence, potential function and conservative field.
Surface integral, flux, volume integral, Gauss, Green's and Stoke's theorems, application of vector calculus in engineering problems. [9L]

Module V

Transformation of coordinates, orthogonal curvilinear coordinates, Gradient, divergence and curl in curvilinear co-ordinate systems, Special orthogonal curvilinear coordinate system: cylindrical, spherical, etc. [9L]

Books:

1. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
2. M. D. Weir, J. Hass and F. R. Giordano: Thomas' Calculus, 11th edition, Pearson Educations, 2008.
3. H Anton, I Brivens, S. Davis : Calculus, 10th Edition, John Wiley and sons, Singapore Pte. Ltd., 2013

Reference Books:

1. M. J. Strauss, G. L. Bradley And K. J. Smith, Calculus (3rd Edition), Dorling Kindersley(India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
2. Murray R Spiegel: Vector Analysis, Metric Editions, Schaum's Outline series.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

<u>Course outcome (co) attainment assessment tools & evaluation procedure</u>

<u>Direct assessment</u>

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

<u>Mapping of course outcomes onto program outcomes</u>

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: MA 106
Course title: Ordinary Differential Equations
Pre-requisite(s): Differentiation, Integration.
Credits: L: 3 T: 1 P:0 C:4
Class schedule per week: 3 lectures, 1 tutorial
Class: IMSc
Semester / Level: II/1
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives : This course enables the students to understand

1.	first order linear and nonlinear differential equations and their solutions,trajectories and its types, Lagrange's equation,Clairaut's equation of ,envelopes
2.	existence and uniqueness theorem, Wronskian and its properties,higher-order linear differential equations with constant coefficients,method of variation of parameter
3.	simultaneous linear differential equations with constant coefficients, second order linear differential equations with variable coefficients, series solution. Bessel's and Legendre's equations
4.	Initial value problems, stability, Adjoint differential equations, Sturm-Liouville problem,Fourier series.

Course Outcomes: After the completion of this course, students will be able to

CO1.	identify, analyse and subsequently solve physical situations whose behaviour can be described by ordinary differential equations
CO2.	competence in solving applied problems which are linear and nonlinear form
CO3.	solve the problems choosing the most suitable method.
CO4.	determine the solution of differential equations with initial and boundary value problems
CO5.	enhance and develop the ability of using the language of mathematics in analyzing the real-world problems of sciences and engineering.

Syllabus

MA106 Ordinary Differential Equations 3-1-0-4

Module I

First order linear and nonlinear differential equations and their solutions, Trajectories (Orthogonal, oblique, polar and Cartesian coordinate). Equations of first order but not of first degree and singular solutions: equation solvable for x and y , Legrange's equation, Clairaut's equation, singular solutions (Envelopes). [10L]

Module II

Wronskian and linear dependence of functions, Abel's formula. Higher-order linear differential equations with constant coefficients, C.F and P.I. Euler-Cauchy equations. Method specific to second ODE: Methods of undetermined coefficients, reduction of order and Method of variation of parameters. [10L]

Module III

Simultaneous linear differential equations with constant coefficients, total differential equation and condition of integrability. [7L]

Module IV

Series solution around an ordinary point and a regular singular point, the method of Frobenius. Bessel and Legendre equations. [9L]

Module V

Initial value problems: Picards iteration method, Lipchitz condition, existence and uniqueness of solution of initial value problems for first order ODEs. Adjoint and Self-Adjoint differential equations, Sturm-Liouville problem, Eigen values and Eigen functions. [9L]

Text Book:

1. G.F. Simmons: Differential Equations with Applications and Historical Notes, McGraw-Hill
2. R. C. DiPrima and W. E. Boyce: Ordinary Differential Equations and Boundary Value Problems, Willey
3. Dennis G. Zill, Warren S. Wright: Advanced Engineering Mathematics, Jones and Bartlett Pubs.
4. Edwards & Penney: Differential Equations and Boundary value problems, Pearson Education
5. S. L. Ross: Differential Equations, Wiley

Reference books:

1. S.J. Farlow: An Introduction to Ordinary Differential Equations, PHI
2. M.D. Raisinghania: Ordinary and Partial Differential Equations, S. Chand & Co.
3. V. Sundarapandian: Ordinary and Partial Differential Equations, McGraw-Hill

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course outcome (co) attainment assessment tools & evaluation procedure

Direct assessment

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

Mapping of course outcomes onto program outcomes

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: MA 110
Course title: Complex Analysis
Pre-requisite(s): Complex Numbers, Basic Calculus
Co- requisite(s): ---
Credits: L: 3 T: 1 P: 0 C: 4
Class schedule per week: 3 lectures, 1 tutorial.
Class: IMSc
Semester / Level: II/I
Branch: Mathematics and Computing

Name of Teacher:

Course Objectives: This course enables the students to understand

1.	the strength of being analytic for a complex variable function and different properties associated with analytic functions
2.	the integration of complex variable functions and different techniques to evaluate complex integrals
3.	the series of complex variable functions, criteria for their convergence and divergence
4.	the singularities of complex variable functions and methods to compute residues
5.	mapping of complex variable functions and its different types

Course Outcomes: After the completion of this course, students will be able to

CO1.	demonstrate the remarkable properties of complex variable functions, which are not the features of their real analogues
CO2.	develop an understanding to prove the analytical results related to theory of complex variable functions
CO3.	conceptualise the differentiation and integration of complex variable functions
CO4.	acquire the skills to evaluate complicated real variable function properties in the light of complex variable theory
CO5.	apply the knowledge of complex variable theory in diverse fields related to mathematics

Syllabus

MA110 **<u>Complex Analysis</u>** **3-1-0-4**

Module I

Complex Differentiation: Regions in the complex plane, function of a complex variable, Limit, continuity, differentiability and analyticity of complex variable functions, analytic functions, Cauchy – Riemann equations in cartesian and polar forms, harmonic function, harmonic conjugate, Milne Thomson method [9 L]

Module II

Complex Integration: Integration of complex variable function along contour**,** line integral, properties of line integrals, Cauchy's theorem, Cauchy's Integral Formula, Cauchy's Integral formula for derivatives of analytic function, Cauchy's Inequality. [9 L]

Module III

Infinite Series and Singularities: Power Series, convergence of power series, Taylor's series, Laurent Series.

Zeros and singularities of analytic function, types of singularities, properties of singular points

[9L]

Module IV

Calculus of Residues: Residues, computation of residues at pole, Cauchy – Residue theorem. Application of residue calculus in evaluation of improper real integrals of types $\int_0^{2\pi} f(\cos\theta, \sin\theta)\, d\theta$ and $\int_{-\infty}^{\infty} f(x)\, dx$

[9L]

Module V

Conformal Mapping: Mapping (or Transformation) of complex variable function, Conformal Mapping, Types of elementary transformations – translation, rotation, magnification, inversion, Bilinear transformation, properties of bilinear transformation.

[9L]

Text Books:

1. J.W. Brown and R.V. Churchill, Complex Variable and its Applications, Tata McGraw Hill, Pub., 7th Edition, 2014.
2. D.G. Zill and P.D. Shanahan, A First Course in Complex Analysis with Applications, Jones and Bartlett Publishers, 2003
3. H.S. Kasana, Complex Variables: Theory and Applications, PHI, Second Edition, 2005.

Reference Books:

1. E. M. Stein and R. Shakarchi, Complex Analysis, Princeton University Press, 2003.
2. S. Ponnusamy and H. Silverman, Complex Variables with Applications, Birkhauser, 2006.
3. M. R. Spiegel, S. Lipschutz, J.J. Schiller and D. Spellman, Complex Variables, Schuam Outlines, Tata McGraw Publications, 2nd Edition, 2009.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Semester Examination	25
End Semester Examination	50
Quiz (s)	10+10
Assignment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√	√	
End Semester Examination	√	√	√	√	
Quiz (s)		√	√		
Assignment	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: CE101
Course title: Environmental Science
Pre-requisite(s): NA
Co- requisite(s): NA
Credits: L:2 T:0 P:0 C:2
Class schedule per week: 02 Lectures
Class: IMSc
Semester / Level: II/1
Branch: All
Name of Teacher:

Course Objectives :
This course enables the students:

1	To develop basic knowledge of ecological principles and their applications in environment.
2	To identify the structure and composition of the spheres of the earth, the only planet sustaining life.
3	To analyse, how the environment is getting contaminated and probable control mechanisms for them.
4	To generate awareness and become a sensitive citizen towards the changing environment.

Course Outcomes
After the completion of this course, students will be:

CO1	Able to explain the structure and function of ecosystems and their importance in the holistic environment.
CO2	Able to identify the sources, causes, impacts and control of air pollution.
CO3	Able to distinguish the various types of water pollution happening in the environment and understand about their effects and potential control mechanisms.
CO4	Able to judge the importance of soil, causes of contamination and need of solid waste management.
CO5	Able to predict the sources of radiation hazards and pros and cons of noise pollution.

Syllabus

CE101 **Environmental Science** **2-0-0-2**

Module 1. Ecosystem and Environment (6 lectures)
Concepts of Ecology and Environmental science, ecosystem: structure, function and services, Biogeochemical cycles, energy and nutrient flow, ecosystem management, fate of environmental pollutants, environmental status and reports on climate change. [6L]

Module 2: Air Pollution (6 lectures)
Structure and composition of unpolluted atmosphere, classification of air pollution sources, types of air pollutants, effects of air pollution, monitoring of air pollution, control methods and equipment for air pollution control, vehicular emissions and control, indoor air pollution, air pollution episodes and case studies. **[6L]**

Module 3: Water Pollution (6 lectures)
Water Resource; Water Pollution: types and Sources of Pollutants; effects of water pollution; Water quality monitoring, various water quality indices, water and waste water treatment: primary, secondary and tertiary treatment, advanced treatments (nitrate and phosphate removal); Sludge treatment and disposal. [6L]

Module 4: Soil Pollution and Solid Waste Management (5 lectures)
Lithosphere – composition, soil properties, soil pollution, ecological & health effects, Municipal solid waste management – classification of solid wastes, MSW characteristics, collection, storage, transport and disposal methods, sanitary landfills, technologies for processing of MSW: incineration, composing, pyrolysis. [5L]

Module 5: Noise pollution & Radioactive pollution (5 lectures)
Noise pollution: introduction, sources: Point, line and area sources; outdoor and indoor noise propagation, Effects of noise on health, criteria noise standards and limit values, Noise measurement techniques and analysis, prevention of noise pollution; Radioactive pollution: introduction, sources, classification, health and safety aspects, Hazards associated with nuclear reactors and disposal of spent fuel rods-safe guards from exposure to radiations, international regulation, Management of radioactive wastes. [5L]

Text books:

1. A, K. De. (3rd Ed). 2008. Environmental Chemistry. New Age Publications India Ltd.
2. R. Rajagopalan. 2016. Environmental Studies: From Crisis to Future by, 3rd edition, Oxford University Press.
3. Eugene P. Odum. 1971. Fundamentals of Ecology (3rd ed.) -. WB Sunders Company, Philadelphia.
4. C. N. Sawyer, P. L. McCarty and G. F. Parkin. 2002. Chemistry for Environmental Engineering and Science. John Henry Press.
5. S.C. Santra. 2011. Environmental Science. New Central Book Agency.

Reference books:

1. D.W. Conell. Basic Concepts of Environmental Chemistry, CRC Press.
2. Peavy, H.S, Rowe, D.R, Tchobanoglous, G. Environmental Engineering, Mc-Graw - Hill International
3. G.M. Masters & Wendell Ela. 1991. Introduction to Environmental Engineering and Science, PHI Publishers.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors √
Tutorials/Assignments √
Seminars √
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	50
Quiz (s) (1 & 2)	10+10
Teacher's assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid sem exam	✓	✓	✓		
End Sem Examination Marks	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	1	3	3	2	2	2	2	3
CO2	2	3	2	3	2	3	3	2	2	2	2	3
CO3	2	3	2	3	2	3	3	2	2	2	2	3
CO4	2	3	2	3	2	3	3	2	2	2	2	3
CO5	2	3	2	3	2	3	3	2	2	2	2	3

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: PH109
Course title: Physics I
Pre-requisite(s):
Co- requisite(s): ---
Credits: L: 3 T: 1 P: 0 C: 4
Class schedule per week: 3 lectures, 1 tutorial.
Class: IMSc
Semester / Level: II/I
Branch: Mathematics and Computing

Name of Teacher:

Course Objectives: This course enables the students

1.	To know the basic theories of Electrostatics and Magnetostatics.
2.	To get the basic knowledge of Electromagnetic theory.
3.	To gather a general information of Nuclear Physics.
4.	To make acquainted with the theories of Physical Optics.
5.	To have some basic knowledge of the Special Theory of Relativity.

Course Outcomes

After the completion of this course, students will be:

CO1	Able to implement the theories of Electrostatics and Magnetostatics for different physical problem.
CO2	Able to understand the practical and theoretical approaches of Electromagnetic theory.
CO3	Understanding about the Nuclear Reactor, Source of Sun Energy etc.
CO4	Acquainted with the theories of Physical Optics and its relevant results observed in practice.
CO5	Acquainted with the Special Theory of Relativity and its applications.

Syllabus

PH 109 **Physics- I** 3-1-0-4

Module I:
Electromagnetic Theory I:
Gauss's law and its applications, electric potential, relation between **E** and V, capacitance, energy density of an electric field, dielectrics, dielectric constant, dielectric polarization, three electric vectors **E, D, P,** boundary conditions for **E** and **D** at interface between two dielectrics. [10L]

Module II:
Electromagnetic Theory II:
Ampere's law, Biot-Savart law, inductance, energy density of a magnetic field, Gauss's law in magnetism, three magnetic vectors H**, B, M,** boundary conditions for **B** and H, Faraday's Law, Displacement current, Maxwell's equations in free space, plane electromagnetic waves in free space, Poynting vector, pressure and momentum of EM waves. [10L]

Module III:
Nuclear physics
Nuclear forces, binding energy, liquid drop model, fission, nuclear reactors, fusion, energy processes in stars, controlled thermonuclear reactions. [6L]

Module IV:
Physical Optics:
Huygen's construction for propagation of a wavefront, superposition principle, conditions for interference of light, coherence, Young's double-slit experiment, Newton's rings, Diffraction, Fraunhofer diffraction by a single slit, diffraction grating (qualitative), Polarization, polarizers, Malus' Law, Brewster's Law, Double Refraction. [10L]

Module V:
Special Theory of Relativity:
Postulates, Galilean transformations, Lorentz transformation, length contraction, time dilation, velocity addition, mass change and Einstein's mass energy relation, Application os Relativity in GPS system. [9L]

Text Books:
Modules 1 and 2: E.M. theory
1. Halliday, Resnick, Walker , Fundamentals of Physics, 6th Edition, John Wiley & Sons, 2004
2. D. J. Griffith, Introduction to Electrodynamics, 3rd Edition.
3. Mathew N.O. Sadiku, Elements of Electromagnetics, 4th Edition, Oxford University Press, (2012).

Modules 4:
1. Halliday, Resnick, Walker , Fundamentals of Physics, 6th Edition, John Wiley & Sons, 2004
2. Ajoy Ghatak , Optics, 5th Edition, Tata McGraw Hill, 2012
3. Jenkins and White: Fundamentals of Optics

Module 3 and 5: Relativity
1. Arthur Beiser, Concept of Modern Physics, 6th Edition, Tata McGraw Hill, 2009

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Semester Examination	25
End Semester Examination	50
Quiz (s)	10+10
Assignment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√	√	
End Semester Examination	√	√	√	√	
Quiz (s)		√	√		
Assignment	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: PH110
Course title: Physics I Lab
Pre-requisite(s):
Co- requisite(s): ---
Credits: L: 0 T: 0 P: 3 C: 1.5
Class schedule per week: 3 Sessional.
Class: IMSc
Semester / Level: II/I
Branch: Mathematics and Computing

Name of Teacher:

COURSE INFORMATION SHEET

Course code: **CS101**
Course title: **Programming for Problem Solving**
Pre-requisite(s): Mathematics-I
Co- requisite(s): Programming for Problem Solving Lab
Credits: L: 3 T: 1 P: 0 C:4
Class schedule per week: 3 Lectures, 1 tutorial
Class: B. Tech/ IMSc
Semester / Level: II / I
Branch: All

Course Objectives
This course enables the students:

1.	To learn computer language.
2.	To Learn coding for problems.
3.	To learn the problem-solving process through computer.
4.	To know the limitations of system during program execution.

Course Outcomes : After the completion of this course, students will be able :

CO1	To formulate simple algorithms for arithmetic and logical problems.
CO2	To translate the computer algorithms to computer programs.
CO3	To test and execute the programs and correct syntax and logical errors.
CO4	To apply programming to solve simple numerical method problems, differentiation of function and simple integration.
CO5	To decompose a problem into functions and synthesize a complete program using divide and conquer approach.

Syllabus

CS101 **Programming for Problem Solving** **3-1-0-4**

Module I
Introduction to Programming:
Introduction to Programming: Introduction to components of a computer system (disks, memory, processor, where a program is stored and executed, operating system, compilers etc.) Problem Solving: Steps to solve logical and numerical problems. Representation of Algorithm: Flowchart/Pseudo code with examples. From algorithms to programs; source code, variables (with data types) variables and memory locations, Syntax and Logical Errors in compilation, object and executable code. **[9L]**

Module II
Arithmetic expressions and precedence, Conditional Branching and Loops, Writing and evaluation of conditionals, Iterations, Loops. **[9L]**

Module III
Array, Character array, strings. Case studies to discuss the various Problems related to Basic science (Matrix addition, Matrix-matrix multiplication, Roots of an equation etc.), Sorting, Searching. **[9L]**

Module IV
Functions (including using built in libraries), Parameter passing in functions, call by value, call by reference. Passing arrays to functions, Recursion (Finding Factorial, Fibonacci series, Ackerman function etc.). **[9L]**

Module V
Structures, Defining structures and Array of Structures Pointers: Defining pointers, Use of Pointers in self-referential structures, File Handling **[9L]**

Text Books:

1. Hanly Jery R, Problem solving and Program design in C, 7th Edition Pearson Education.
2. Gottfried Byron, Schaum's Outline of Programming with C, McGraw-Hill.
3. Balaguruswamy E., Programming in ANSI C, Tata McGraw-Hill.
4. Dromey R.G., How to Solve it by Computer, Pearson Education.

Reference Book:

1. Kernighan Brian W. and Ritchie Dennis M., The C Programming Language, Prentice.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Semester Examination	25
End Semester Examination	50
Quiz (s)	10+10
Assignment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
End Semester Examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	1	3	1	1	1	2
CO2	3	3	3	3	3	1	1	2	1	1	1	2
CO3	3	3	3	3	3	1	1	1	1	2	2	2
CO4	3	3	3	3	2	1	1	2	1	3	2	2
CO5	3	3	2	2	3	1	1	2	1	2	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: **CS102**
Course title: **Programming for Problem Solving Lab**
Pre-requisite(s): Mathematics-I
Co- requisite(s):
Credits: L: 0 T: 0 P: 3 C:1.5
Class schedule per week: 3 Sessional
Class: B. Tech/ IMSc
Semester / Level: II / I
Branch: All

Course Objectives : This course enables the students:

1.	To learn computer language.
2.	To Learn coding for problems.
3.	To learn the problem-solving process through computer.
4.	To know the limitations of system during program execution.

Course Outcomes : After the completion of this course, students will be able :

CO1	To formulate simple algorithms for arithmetic and logical problems.
CO2	To translate the computer algorithms to computer programs.
CO3	To test and execute the programs and correct syntax and logical errors.
CO4	To apply programming to solve simple numerical method problems, differentiation of function and simple integration.
CO5	To decompose a problem into functions and synthesize a complete program using divide and conquer approach.

Sample Program List

COURSE INFORMATION SHEET

Course code: MA 201
Course title: Partial Differential Equation
Pre-requisite(s): Differentiation, Integration.
Co- requisite(s): ---
Credits: L: 3 T: 1 P:0 C:4
Class schedule per week: 3 lectures, 1 tutorial.
Class: IMSc
Semester / Level:III/2
Branch:Mathematics and Computing
Name of Teacher:

Course Objectives: This course enables the students to understand

1.	Origin of partial differential equations and their types, Lagrange’s method, Cauchy's problem,
2.	Charpit's and Jacobi's methods, Cauchy’s method of characteristics, Higher order linear partial differential equations with constant coefficients.
3.	Classification and canonical transformation of second order linear partial differential equations. Method of separation of variables for solving hyperbolic, parabolic.
4.	Dirichlet, Neumann, Cauchy boundary conditions. Dirichlet and Neumann problems for a rectangle, theory of Green’s function for Laplace equation.

Course Outcomes : After the completion of this course, students will be able to

CO1.	Identify, analyse and subsequently solve physical situations whose behaviour can be described by ordinary differential equations.
CO2.	competence in solving applied problems which are linear and nonlinear form.
CO3.	solve the problems choosing the most suitable method
CO4.	determine the solutions of differential equations with initial conditions
CO5.	determine the solutions of differential equations with initial and boundary conditions .

Syllabus

MA201 Partial Differential Equation 3-1-0-4

Module I

Formation of partial differential equations, definition and examples of linear and non-linear partial differential equations, order and degree of partial differential equations, linear partial differential equation of first order, equation solvable by direct integration, Lagrange's method, integral surfaces passing through a given curve, surfaces orthogonal to a given system of surfaces, and Cauchy's problem for first order partial differential equations. [10L]

Module II

Non-linear partial differential equations, compatible system of first order equations, Charpit's and Jacobi's methods, Cauchy's method of characteristics, Higher order linear homogenous and non-homogenous partial differential equations with constant coefficients. Classification and canonical transformation of second order linear partial differential equations. [10L]

Module III

Method of separation of variables for linear partial differential equations, Hyperbolic Equations: D'Alembert's solution, vibrations of an infinite string and a semi-infinite string. Vibrations of string of finite length (separation method). [9L]

Module IV

Parabolic Equations: Solution of heat equation (separation method), heat conduction problem for an infinite rod, a finite rod, Duhamel's principle for parabolic equations. [8L]

Module V

Elliptic Equations: Boundary value problems: Dirichlet, Neumann, Cauchy boundary conditions. Maximum and minimum principles, Dirichlet and Neumann problems for a rectangle (separation method), and theory of Green's function for Laplace equation. [8L]

Text Book:

1. I. N. Sneddon: Elements of Partial Differential Equations, McGraw-Hill
2. T. Amaranath: An Elementry Course in Partial differential equations, Narosa Publishing House
3. S. L. Ross: Differential Equations, Wiley
4. K. Sankara Rao: Introduction to Partial Differential Equations, PHI Learning

Reference books:

1. M.D. Raisinghania: Advanced Differential Equations, S. Chand & Co.
2. Walter A. Strauss: An Introduction to Partial Differential Equation, Wiley

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

<u>Course outcome (co) attainment assessment tools & evaluation procedure</u>

<u>Direct assessment</u>

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

<u>Mapping of course outcomes onto program outcomes</u>

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: MA 202
Course title: Modern Algebra
Pre-requisite(s):
Co- requisite(s): ---
Credits: L: 3 T: 1 P:0 C:4
Class schedule per week: 3 lectures, I tutorial.
Class: IMSc.
Semester / Level:III/2
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives: This course enables the students to understand

1.	Basics of set, relation, mapping, equivalence relation and partition, residue class of integers, Chinese remainder theorem, partition of integer, primitive roots.
2.	binary operation, group, permutation groups, subgroups, cyclic groups, cosets, normal, quotient group, homomorphism, Cayley's theorem, direct product of groups.
3.	conjugacy classes, Cauchy's theorem, p-groups, Sylow's theorem, solvable group, finitely generated abelian group, rings, subring, integral domains, ideals
4.	ring homeomorphisms, polynomial rings, factorization of polynomial, checking divisibility in integral domains, introduction to fields.

Course Outcomes: After the completion of this course, students will be able to

CO1.	understand relation, partition of groups, permutation and direct product of groups, conjugacy classes, solvable group, finitely generated abelian group, rings, subring, integral domains etc.
CO2.	Effectively write abstract mathematical proofs in a clear and logical manner and apply the theory of abstract algebra to specific research problems in mathematics or other fields.
CO3.	Demonstrate ability to think critically by recognizing patterns (like in Mathematical Crystallography) and principles of algebra and relating them to the number system and analyze them from abstract point of view.
CO4.	Gain an understanding to solve problems with the use of abstract algebra to diverse situations in mathematical contexts.
CO5.	Locate and use theorems to solve problems in number theory, use of ring theory to cryptography

Syllabus

MA202 **Modern Algebra** **3-1-0-4**

Module I

Primes, infinitude of primes, fundamental theorem of arithmetic, congruence $ax \equiv b \pmod{n}$, Chinese remainder theorem, partition of integers, Euler ϕ-function, τ-function, Möbius inversion formula. [9L]

Module II

Binary operations, introduction to groups (Symmetric group, Quaternion group, Dihedral group), permutation groups, subgroups, cyclic groups, cosets and Lagrange's theorem, normal subgroup, quotient groups, simple group. homomorphism's and isomorphism's of groups, Cayley's theorem, correspondence theorem and its corollary, direct products of groups. [9L]

Module III

Conjugacy classes, Cauchy's theorem and p-groups, Sylow's theorems and application. Finitely generated Abelian groups, fundamental theorem of finitely generated abelian group, invariant factors, elementary divisors. [9L]

Module IV

Introduction to rings, integral domain and field. Sub rings and ideals intersection, union and sums of ideals, generating set of an ideal. Nilpotent ideal, Ring Homomorphism and fundamental theorem. Factor rings, prime ideal and maximum ideals. Basic theorems of isomorphism, embedding of field of quotients of an integral domain. [9L]

Module V

Polynomial Rings, division Algorithm of R[x], where R is commutative ring with unity. Divisibility in Integral Domains, prime and irreducible elements. Concept and results about PID, ED and UFD. Reducibility tests, irreducibility test, UFD in Z[x]). [9L]

Text Books:

1. J.B. Fralieigh: A first Course in Abstract Algebra, Addison-Wesley
2. Joseph A.Gallian: Contemporary Abstract Algebra, Narosa Publishing House
3. I. N. Herstein: Topics in Algebra, Wiley
4. M. Artin: Algebra, Prentice Hall of India

Reference Books:

1. S.K. Mapa: Higher Algebra (Linear and Modern), Levant Publisher
2. V. K. Khanna & S.K. Bhambri: A Course in Abstract Algebra, Vikas Publishing House
3. A.K. Vasishtha & A.R. Vasishtha: Modern Algebra, Krishna Prakashan Media
4. Surjeet Singh & Qazi Zameeruddin: Modern Algebra, Vikas Publishing House

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

<u>Course outcome (co) attainment assessment tools & evaluation procedure</u>

<u>Direct assessment</u>

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

<u>Mapping of course outcomes onto program outcomes</u>

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: MA 208
Course title: Integral Transform and Applications
Pre-requisite(s): Some background in Ordinary and partial differential
Co- requisite(s): ---
Credits: L: 3 T: 1 P:0 C:4
Class schedule per week: 03 Lectures, 1 Tutorial
Class: IMSc.
Semester / Level: III/ 2
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives: This course enables the students to understand

1.	the key concept of popular and useful transformations techniques like; Laplace and inverse Laplace transform, Fourier transform, Hankel transform and Z-transform. with its properties and applications.
2.	the basic knowledge to solve ordinary and partial differential equations with different forms of initial and boundary conditions.

Course Outcomes: After the completion of this course, students will be able to

CO1.	Think logically and mathematically and apply the knowledge of integral transform to solve complex problems. They will gain and idea that by applying the theory of Integral transform the problem from its original domain can be mapped into a new domain where solving problems becomes easier.
CO2.	The inverse of the integral transform will be useful to map back the solution from the new domain to original domain.
CO3.	The students will gain an understanding to formulate and solve complex problems of ordinary and partial differential equations with techniques of Integral transform.
CO4.	Students can apply these techniques to solve research problems of signal processing, data analysis and processing, image processing, in scientific simulation algorithms etc.
CO5.	enhance and develop the ability of using the language of mathematics in analyzing the real-world problems of sciences and engineering.

Syllabus

MA208 **Integral Transform and Applications** **3-1-0-4**

Module I

Periodic Functions, Euler's formula, Dirichlet's conditions, Fourier series of functions with arbitrary period, expansion of even and odd functions, Half- range series, Perseval's formula, complex form of Fourier series. [9L]

Module II

Laplace Transform**:** Definition, linearity property, sufficient conditions for existence of Laplace transform, shifting properties, Laplace transform of derivatives, integrals, unit step functions, Dirac delta-function, impulse and periodic function.

Inverse Laplace transforms convolution theorem and inversion formula. Application of Laplace transform for solving ODEs, PDEs (Hyperbolic and parabolic types) and integral equations. [10L]

Module III

Fourier Transform: Fourier Integral formula, Fourier Transform, Fourier sine and cosine transforms. Linearity, Scaling, frequency shifting and time shifting properties. Self reciprocity of Fourier transform, convolution theorem. Application for solving PDEs (Hyperbolic and parabolic types). [10L]

Module IV

Henkel Transform: Definition and elementary properties: inversion theorem, Henkel transforms of derivatives, Parseval's theorem. Application for solving boundary value problems, and partial differential equations. [8L]

Module V

Z-Transform:Linear difference equations, Fibonacci relation, basic theory of Z-Transforms, Existence of Z-Transforms, Linearity property, translation and shifting theorems, scaling properties, convolution theorem, inverse of z -Transform, solution of difference equations using z -Transform. [8L]

Text Books:

1. I.N Sneddon: The use of integral Transforms, McGraw-Hill
2. K. Sankara Rao: Introduction to Partial Differential Equations, PHI Learning
3. B. V. Ramana: Higher Engineering Mathematics, McGraw Hill
4. R.K Jain, S.R.K Iyengar: Advanced Engineering Mathematics, Narosa Publication
5. R.S. Pathak: The wavelet transform, Atlantis Press

References:

1. M.D. Raisinghania: Advanced Differential Equations, S. Chand & Co
2. Vasishtha & Gupta: Integral Transforms, Krishna Prakashan, Meerut

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course outcome (co) attainment assessment tools & evaluation procedure

Direct assessment

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

Mapping of course outcomes onto program outcomes

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: **CS201**
Course title: **Data Structure**
Pre-requisite(s): Programming for Problem Solving
Co- requisite(s): Data Structure Lab
Credits: L: 3 T: 1 P: 0 C:4
Class schedule per week: **3 lectures, 1 tutorial.**
Class: B. Tech/ IMSc
Semester / Level: III/ 2
Branch: CSE/IT/IMSc

Course Objectives: This course enables the students:

1	To be familiar with basic techniques of algorithm analysis.
2.	To understand basic concepts about arrays, stacks, queues, linked lists, trees and graphs.
3.	To understand concepts of searching and sorting techniques.
4.	To implement various linear & non-linear data structures; and searching & sorting algorithms.
5.	To assess how the choice of data structures impacts the performance of a program**.**

Course Outcomes : After the completion of this course, students will be able to:

CO1	Define various linear and non-linear data structures like stack, queue, linked list, tree and graph.
CO2	Explain operations like insertion, deletion, traversal, searching, sorting etc. on various data structures.
CO3	Design various data structures and their operations.
CO4	Analyze the performance of data structure based operations including searching and sorting.
CO5	Justify the choice of appropriate data structure as applied to specified problem definition.

Syllabus

CS 201 **Data Structure** **3-1-0-4**

Module I
Basic Concepts
Definition and basics of: Data Structure, ADT, Algorithms, Time and Space Complexity, Asymptotic Notations (O, θ, Ω), Time complexity computation of non-recursive algorithms (like Matrix addition, Selection sort – using step count), Array – basic operations, concept of multi-dimensional array, Polynomial operations using Array, Sparse Matrix. **[9L]**

Module II
Stack and Queue
Stack ADT: basic operations, Queue ADT: basic operations, Circular Queue, Evaluation of Expressions, Another application or Mazing Problem. **[9L]**

Module III
Linked List
Singly Linked List: concept, representation and operations, Circular Linked List, Polynomial and Sparse Matrix operations using LL, Doubly Linked List: basic concept. **[9L]**

Module IV
Tree and Graph
Basic concepts and terminologies, Binary Search Tree and Heap, Disjoint Set, Graph: concept and terminologies, Concept of BFS, DFS, Spanning Tree, Connected Components. **[9L]**

Module V
Searching and Sorting
Sequential Search and Binary Search, Insertion Sort, Heap Sort, Radix Sort,External Sorting: k-way merging approach. **[9L]**

Text book:

1. Sahni Horwitz,, Freed Anderson, Fundamentals of Data Structures in C, 2nd Edition (or latest) , University Press.

Reference books:

1. Thareja Reema, Data Structures Using C, 2nd Edition, Oxford University Press.
2. Tanenbaum, Langsam, Augenstein, Data Structures using C, Pearson.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course outcome (co) attainment assessment tools & evaluation procedure

Direct assessment

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

Mapping of course outcomes onto program outcomes

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	1	1	1	1	1	1	1
CO2	2	3	2	1	1	1	1	1	1	1	1	1
CO3	3	2	2	3	1	1	1	1	1	1	1	2
CO4	2	3	1	1	1	1	1	1	1	1	1	1
CO5	1	2	1	1	3	1	1	1	1	1	1	1

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: **CS202**
Course title: **Data Structure Lab**
Pre-requisite(s): Programming for Problem Solving
Co- requisite(s): Data Structure Lab
Credits: L: 0 T: 0 P: 3 C: 1.5
Class schedule per week: **3 Sessional**
Class: B. Tech/ IMSc
Semester / Level: III/ 2
Branch: CSE/IT/IMSc

COURSE INFORMATION SHEET

Course code: PH 111
Course title: Physics II
Pre-requisite(s):
Co- requisite(s): ---
Credits: L: 3 T: 1 P: 0 C: 4
Class schedule per week: 3 lectures, 1 tutorial.
Class: IMSc
Semester / Level: III/I
Branch: Mathematics and Computing

Name of Teacher:

Course Objectives: This course enables the students

1.	To get the basic knowledge of Thermodynamics and Statistical Physics
2.	To know the basic theories of Quantum mechanics
3.	To gather a general information of Laser Physics.
4.	To have some basic knowledge of dielectric materials.
5.	To have some basic knowledge of magnetic materials.

Course Outcomes: After the completion of this course, students will be:

CO1.	Able to understand the practical and theoretical approaches of Thermodynamics and Statistical Physics.
CO2.	Able to implement the theories of Quantum mechanics for microscopic particles and the concerned nanoscience.
CO3.	Understanding about the Laser source, Optical fibres, holography etc.
CO4.	Acquainted with the properties and applications of dielectric materials.
CO5.	Acquainted with the properties and applications of magnetic materials.

Syllabus

PH 111 **Physics-II** **3-1-0-4**

Module I:

Thermodynamics and Statistical Physics

Zeroth law, first law, second law, entropy, heat transfer, steady state one-dimensional heat conduction. Elementary ideas, comparison of Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics. [10L]

Module II:

Quantum mechanics

Planck's theory of black-body radiation, Compton effect, wave particle duality, De Broglie waves, Davisson and Germer's experiment, uncertainty principle, physical interpretation of wave function and its normalization, expectation value. Schrodinger equation in one dimension, solutions of time-independent Schrodinger equation for free particle, particle in an infinite square well, potential barrier and tunneling. [10L]

Module III:

Lasers and applications

Emission of light by atoms, spontaneous and stimulated emission, Einstein's A and B coefficients, laser: population-inversion, properties of laser radiation, Ruby & He-Ne lasers, applications of lasers, elementary ideas of holography and fiber optics. [9L]

Module IV:

Dielectrics properties

Dielectric constant and polarization of dielectric materials. Types of polarization. Equation for internal field in liquids and solids (one dimensional). Ferro and Piezo electricity. Frequency dependence of dielectric constant. Important applications of dielectric materials. [8L]

Module V:

Magnetic properties

Classification of dia, para and ferro-magnetic materials. Hysterisis in ferromagnetic materials. Soft and hard magnetic materials, Applications. [8L]

Text Books:

1. Perspective of Modern Physics, A. Beiser (AB), Mc Graw Hill Int. Ed. 2002
2. Physics for Engineers, M. R. Srinivasan, New Age International, 1996.
3. Fundamentals of Thermodynamics, 6th Ed., Sonntag, Borgnakke & Van Wylen, John Wiley & Sons.

COURSE INFORMATION SHEET

Course code: PH 112
Course title: Physics II Lab
Pre-requisite(s):
Co- requisite(s): ---
Credits: L: 0 T: 0 P: 3 C: 1.5
Class schedule per week: 3 Sessionals.
Class: IMSc
Semester / Level: III/I
Branch: Mathematics and Computing
Name of Teacher:

COURSE INFORMATION SHEET

Course code: MA 205
Course title: Discrete Mathematics
Pre-requisite(s):
Co- requisite(s):
Credits: L:3 T:1 P:0 C:4
Class schedule per week: 3 Lectures, 1 tutorial
Class: I.M.Sc.
Semester / Level: IV/2
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives: This course enables the students to

1.	exposed to a wide variety of mathematical concepts that are used in the Computer Science discipline, which may include concepts drawn from the areas of Number Theory, Graph Theory and Combinatorics.
2.	come across a number of theorems and proofs. Theorems will be stated and proved formally using various techniques.
3.	gain the various graphs algorithms along with its analysis
4.	apply graph theory based tools in solving practical problems.

Course Outcomes: After the completion of this course, students will be able to

CO1.	to model and analyze computational processes using analytic and combinatorial methods
CO2.	solve the problems of graph theory using graph algorithms
CO3.	apply computer programs (e.g. SAGE) to study graphs.
CO4.	apply counting techniques to solve combinatorial problems and identify, formulate, and solve computational problems in various fields.
CO5.	apply graph theory in the areas of computer science, operation research, biology, chemistry, physics, sociology, and engineering

Syllabus

MA 205 **Discrete Mathematics** **3-1-0-4**

Module I

Mathematical logic and Mathematical Reasoning, Compound Statements, Propositional Equivalences, Predicates and Quantifiers, Methods of Proof, Mathematical Induction, Well-ordering principal, Recursive Definition and Algorithms. [9L]

Module II

Recurrence Relations, Classification of Recurrence Relations and their solutions by Characteristic Root method, Generating function and their various aspects, Utility of Generating function in solving Recurrence Relations. [9L]

Module III

Set, Operations on Set, Computer representation of Set, Relations, Properties/Classification of Relations, Closure operations on Relations, Matrix representation of Relations, Digraphs. Functions and their Representation, Classification of Functions, Warshall's algorithm, Discrete Numeric Functions, Growth of Functions, Big O, Big Q, Hash Function, Growth Functions. [9L]

Module IV

Binary Operations, Groups, Product and Quotients of Groups, Semi group, Products and Quotients of Semi groups, Permutation Group, Composition of Permutation, Inverse Permutation, Cyclic Permutation, Transposition, Even and Odd Permutation, Coding of Binary Information and Error Correction, Decoding and Error Correction. [9L]

Module V

Introduction to Graph, Graph Terminologies and their Representation, Connected & Disconnected graphs, Isomorphic Graph, Euler & Hamilton graphs. Introduction to Trees, Versatility of Trees, Tree traversal. Spanning Trees, Minimum Spanning Tree. [9L]

Text Books:

1. **Mott, Joe L., Abraham Kandel, and Theodore P. Baker** Discrete Mathematics for Computer Scientists & Mathematicians, PHI, 2nd edition 2002.
2. **Swapan Kumar Chakraborty and Bikash Kanti Sarkar**: Discrete Mathematics, Oxford Univ. Publication, 2010.
3. **Kolman, Bernard, Robert C. Busby, and Sharon Ross.** Discrete mathematical structures, Prentice-Hall, Inc., 2003**.**

Reference Books:

1. **Bikash Kanti Sarkar and Swapan Kumar Chakraborty,** *Combinatorics and Graph Theory*, PHI, 2016.
2. **Seymour Lipschuz and Mark Lipson**, *Discrete Mathematics*, Shaum's outlines, 2003.
3. **Liu, Chung Laung,** *Elements of Discrete mathematis*, Mcgraw Hill, 2nd edition, 2001.
4. Bondy and Murty, Grapg Theory with Applications, American Elsevier,1979.
5. Robin J. Wilson, Introduction to Graph Theory, Pearson, 2010.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course outcome (co) attainment assessment tools & evaluation procedure

Direct assessment

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

Mapping of course outcomes onto program outcomes

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 206
Course title: Linear Algebra
Pre-requisite(s):
Co- requisite(s): ---
Credits: L: 3 T: 1 P: 0 C:4
Class schedule per week: 3 lectures, 1 tutorial
Class: IMSc.
Semester / Level: IV/2
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives: This course enables the students to understand

1.	the basic ideas of vector algebra, linear dependent and independent set, basis
2.	the fundamental properties of eigenvalue, eigenvectors of a linear transformation
3.	Various types of real quadratic forms and their applications
4.	be familiar with the notion of inner product space and orthogonal vectors

Course Outcomes: After the completion of this course, students will be able to

CO1.	apply the theory of linear algebra to specific research problems in mathematics and engineering
CO2.	find the eigenvalues and eigenvectors of a square matrix and to know diagonalizable matrix
CO3.	handle a non-diagonalizable matrix with the help of upper triangular form or Jordan canonical form
CO4.	understand the concept of positive and negative definite of matrices arising problems in optimization and engineering
CO5.	apply linear algebra to solve initial and boundary value problems for ordinary and partial differential equations

Syllabus

MA206 Linear Algebra 3-1-0-4

Module I

Fields, Vector spaces, subspaces, linear combination, linear span, spanning sets, linearly dependence and independence , Basis and dimension of a vector space, sums, Direct sums, Complementary subspaces, Quotient space and coordinates. [9L]

Module II

Linear transformation (L.T.), kernel and image, rank-nullity theorem and its applications, singular and non-singular L.T, matrix representation of a linear transformation, change-of-basis (Transition) matrix, Isomorphism, Inverse of linear transformation, Space of linear transformations, Linear functional, Dual and double dual of a vector space, Self-adjoint, Unitary and normal operators, Orthogonal projections. [9L]

Module III

Eigenvalues and eigenvectors, characteristic and minimal polynomials, Cayley-Hamilton theorem and applications. Eigenvalues of symmetric, skew symmetric, orthogonal and unitary matrices, Diagonalization and triangular form of matrices. Introduction to Jordan blocks and matrices in Jordon canonical form(examples only). An algorithm to find Jordan form of a square matrix (No proof). [9L]

Module IV

Real quadratic forms: Definitions, examples, Congruence of matrices, congruent reduction of a symmetric matrix. positive definite, positive semi definite, negative definite, negative semi definite and indefinite quadratic forms, associated matrix of quadratic forms, rank and signature of real quadratic forms. [9L]

Module V

Inner product spaces over R (real numbers) and C (complex numbers), Norm of a vector, Schwarz's Inequality, Triangle inequality, Orthogonality of vectors, orthogonal sets and basis, Parallelogram law, Bessel's inequality, Gram-Schmidt orthogonalization process, Orthogonal projection. Introduction of normal operator in inner product space. [9L]

Text Books:

1. K.M. Hoffmann and R. Kunze: Linear Algebra, Pearson Education
2. Stephen H. Friedberg, Lawrence E. Spence, Arnold J. Insel: Linear Algebra, Pearson
3. Sheldon Axler: Linear Algebra Done Right, Springer
4. S. Lipschutz, M. L. Lipson: Schaum's Outline of Linear Algebra, McGraw-Hill

Reference Books

1. Gilbert Strang: Introduction to Linear Algebra, Wellesley-Cambridge press
2. Shanti Narayan and P.K Mittal: A text book of Matrices, S. Chand.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

<u>Course outcome (co) attainment assessment tools & evaluation procedure</u>

<u>Direct assessment</u>

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

<u>Mapping of course outcomes onto program outcomes</u>

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: MA 209

Course title: Integral Equations and Green's Function

Pre-requisite(s): Laplace Transform, Ordinary Differential Equation and Partial Differential Equation, Basic Linear Algebra.

Co- requisite(s): ---

Credits: L: 3 T: 1 P:0 C: 4

Class schedule per week: 3 Lectures, 1 tutorial

Class: IMSc.

Semester / Level: IV/ 2

Branch: Mathematics and Computing

Name of Teacher:

Course Objectives: This course enables the students to get the detailed idea about:

1.	the integral equation, its classification, different types of kernals.
2.	the relationship between the integral equations and ordinary differential equations and how to solve the linear and non linear integral equations by different methods with some problems which give rise to integral equations.
3.	how to solve Fredholm integral equation with separeble kernel and how to reduce homogeneous Fredholm integral equation to Sturm-Liouville problem and solve it as eigen value and eigen vector problem.
4.	different types of solution methods like successive approximation, resolvent kernel, iteration method, integral transform method and which method is applicable for which type of integral equation.
5.	The Green function and its construction and its application in solving boundary value problem by converting it to a integral equation.

Course Outcomes : After the completion of this course, students will be able to

CO1.	acquire sound knowledge of different types of Integral equations: Fredholm and Volterra integral equations.
CO2.	obtain integral equation from ODE and PDE arising in applied mathematics and different engineering branches and solve accordingly using various method of solving integral equation.
CO3.	demonstrate a depth of understanding in advanced mathematical topics in relation to geometry of curves and surfaces
CO4.	apply the knowledge of integral transformation like Laplace transformation, Fourier transformation to solve different types of integral equation.
CO5.	construct Green function in solving boundary value problem by converting it to a integral equation

Syllabus

MA209 **Integral Equations and Green's Function** **3-1-0-4**

Module I

Definition, classification of integral equation, types of kernels, solution of integral equation. Leibnitz's rule of differentiation under integral sign, identity for converting multiple integral into single integral. Conversion of IVPs into Volterra integral equation, BVPs into Fredholm integral equation. [9L]

Module II

Solution of Fredholm integral equations with separable (degenerate) kernels, Fredholm theorem. Eigenvalues and eigenfunctions of homogeneous Fredholm integral equation of second kind with separable or degenerate kernels. [9L]

Module III

Method of successive approximation: Iterated kernels, Resolvent kernel, solution of Fredholm and Volterra equation of second kind by successive substitutions (method of iteration). Solution of Volterra integral equation by reducing into differential equation. Solution of Volterra integral equation of first kind. [9L]

Module IV

Symmetric kernel, orthonormal system of function, fundamental properties of eigenvalues and eigenfunctions for symmetric kernels, expansion of symmetric kernel in eigen function. Hibert-Schmidt theorem, solution of symmetric integral equation by Hilbert- Schmidt theorem. [9L]

Module V

Construction of Green's function, existence and uniqueness theorem, conversion of BVPs into Fredholm integral equation and IVPs into Volterra integral equation by Green's function. Solution of Volterra integral equation with convolution type kernel, integro-differential equation, Able's integral equation by Laplace and Fourier transform methods . [9L]

Text Books:

1. David Porter, David S.G. Stirling: Integral Equation, Cambridge Texts in Applied Mathematics.
2. M.D. Raisinghania:Integral Equations and Boundary Value Problems, 2016.

Reference Book:

1. Dr. C. S. Manjarekar, Integral Equation, 2^{nd} Edition, 2015.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course outcome (co) attainment assessment tools & evaluation procedure

Direct assessment

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –
1. Student feedback on course outcome

Mapping of course outcomes onto program outcomes

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: CS204
Course title: **Object Oriented Programming and Design Patterns**
Pre-requisite(s): Data Structure
Co- requisite(s):
Credits: L:3 T:0 P:0 C:3
Class schedule per week: 3 Lectures
Class: B. Tech/ IMSc
Semester / Level: IV/2
Branch: CSE/IT/IMSc

Course Objectives : This course enables the students:

1.	The course shall allow students to understand the basic tenets of OOP.
2.	The course will exemplify the basic syntax and constructs of JAVA.
3.	The course will help students understand the application OOP principles in various use cases.
4.	The course will explain basic JAVA GUI components and their working.
5.	The course aims to expose students to newer JAVA constructs like NIO, Lambdas etc.

Course Outcomes : After the completion of this course, students will be able to:

CO1	Identify the difference between procedural and OO programming.
CO2	Construct programs using various OOP principles.
CO3	Design UI using JAVA GUI components.
CO4	Operate on files and strings in real life scenarios.
CO5	Analyze thread performance and inter thread communication issues

Syllabus

CS204 Object Oriented Programming and Design Patterns 3-0-0-3

Module I

Introduction to Classes, Objects and Java

Introduction to Object Technology, Java, Understanding the Java development environment, Programming in Java, Memory concepts, Doing basic Arithmetic, Comparing entities, Classes, Objects, Methods, Strings, Primitive vs reference types. [6L]

Module II

Control Statements, Methods and Arrays

Basic selection statements, Iterative constructs, Relative and Logical operators, break, continue, Methods, static methods, parameter passing, argument promotion and casting, scopes, method overloading. Arrays and ArrayList in Java, Enhanced for statement, Passing arrays to methods, Multidimensional arrays, Using command line arguments. [6L]

Module III

Object Oriented Concepts: Polymorphism & Inheritance

Controlling access to class members, the use of this keyword, getters and setters, Composition, enum, the use of static and final, Garbage collection. Superclass and subclass, protected members, constructors in subclass, the Object class, Introduction to polymorphism, Abstract classes and methods, Assignment between subclass and superclass variables, Creating and using interfaces. **[12L]**

Module IV

Exception Handling & GUI Design

When to use exception handling, Java exception hierarchy, finally block, Stack unwinding, Chained exceptions, Declaring new exception types, Assertions, try with resources. Simple I/O with GUI, Basic GUI Components, GUI Event handling, Adapter classes, Layout managers, Using panels. **[8L]**

Module V

Strings, characters & Files

Working with the String and StringBuilder class, Character class, Tokenizing strings, Regular Expressions, Files and Streams, Using NIO classes, Sequential file handling, Object serialization, JFileChooser, Introduction to threading, Introduction to Generics and lambda expressions. **[8L]**

Text book:

1. Deitel P., Deitel H., Java How to Program, 10th Edition, Pearson Publications, 2016.

Reference book:

1. Wu C. T., Object Oriented Programming in Java, 5th Edition, McGrawHill Publications, 2010.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course outcome (co) attainment assessment tools & evaluation procedure

Direct assessment

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

Mapping of course outcomes onto program outcomes

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	2	3	1	1	1	3	2	1	1
CO2	2	3	1	1	1	1	1	1	1	1	1	1
CO3	3	2	1	1	2	2	1	1	2	1	2	2
CO4	1	1	3	2	1	1	1	1	2	1	1	2
CO5	2	1	1	1	1	1	1	1	1	2	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: CS205
Course title: **Object Oriented Programming and Design Patterns Lab**
Pre-requisite(s): Data Structure
Co- requisite(s):
Credits: L:0 T:0 P:3 C:1.5
Class schedule per week: 3 Sessional
Class: B. Tech/ IMSc
Semester / Level: IV/2
Branch: CSE/IT/IMSc

COURSE INFORMATION SHEET

Course code: CH 213
Course title: General Chemistry-II
Pre-requisite(s): Intermediate level chemistry
Co- requisite(s):
Credits: L: 3 T: 1 P: 0 C:4
Class schedule per week: 3 Lectures , 1 tutorial
Class: IMSc
Level: IV/2
Branch: All
Name of Teacher:

Course Objectives :

This course enables the students:

A.	To differentiate the states of matter based on molecular level interactions
B.	To understand the concept of ideal and real gases from the molecular level energetics
C.	To grow knowledge on the hybridization, bonding and structural properties of the molecules
D.	To create concept of molecular orbital, arrow in mechanism, with 3D structural understanding.
E.	To know the process of reaction driven by nucleophiles and electrophiles

Course Outcomes:

After the completion of this course, students will be:

CO1.	Able to derive the Van der Waals equation of state and explain the deviation of real gases from ideal gases
CO2.	Able to analyse surface tension and viscocity coefficient of liquids
CO3.	Able to calculate pH/pKa, degree of ionization, dissociation constant, solubility product of electrolytes
CO4.	Able to explain the interaction between reaction intermediates
CO5.	Able to predict and analyses the configuration and conformation of molecules

Syllabus

CH 213 **General Chemistry-II** **3-1-0-4**

Module-I: States of Matter

Gaseous state: Kinetic theory of gas, Maxwell distribution equation, *Ideal & real gases,* compressibility factor, *Z.* Van der Waals equation of state, Boyle temperature. Continuity of states, critical state, law of corresponding states. Liquid state: Physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity. Solid state: Miller indices, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law. Analysis of powder diffraction patterns [9L]

Module-II: Ionic Equilibria

Strong, moderate and weak electrolytes, degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di-and triprotic acids Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications. Solubility and solubility product of sparingly soluble salt. Qualitative treatment of acid – base titration curves. Theory of acid–bases; Arrhenius, Bronsted Lowry, Lewis concept, SHAB, solvent systems; selection of indicators and their limitations. Hydrolysis and hydrolysis constants. [9L]

Module-III: Chemistry of Aromatic Hydrocarbons

Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: Isotopic effect, halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism & energy diagram,. Directing effects of the groups. [9L]

Module-IV: Oxidation-Reduction

Galvanic cells and electrolytic cells, Daniel cell, different kind of half-cells, electromotive forces of a cell and its measurement, Nernst equation, Redox equilibrium, Standard Electrode Potential and its application to inorganic reactions, different types of galvanic cells, Thermodynamics of electrochemical cells and applications, Potentiometric titrations to determine various equilibrium constants. [8L]

Module-V: Chemistry of Aliphatic Hydrocarbons

Carbon-Carbon sigma bonds: Chemistry of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation. Carbon-Carbon pi bonds: elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, *e.g.* propene, 1-butene, toluene, ethyl benzene. Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes. Alkanes & Cycloalkanes: Types, Conformational Analysis, relative stability & Energy diagrams. [10L]

Text books:

1. Kapoor, K. L. A Textbook of Physical Chemistry, Volume 1, Mcmillan Publishers India Ltd, 2004
2. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 10th Ed., Oxford University Press (2014).
3. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
4. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

Reference books:

1. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
2. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
3. Engel, T. & Reid, P. Physical Chemistry 3rd Ed. Pearson (2013).
4. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Teacher's Assessment	5
Mid Sem	25
Two Quizzes	10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem	√	√		
Assignment	√	√	√	
Quiz -1	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

Indirect Assessment –

1. **Student Feedback on Faculty**
2. **Student Feedback on Course Outcome**

Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1	**H**	**H**	**L**	**L**
CO2	**H**	**H**	**M**	**L**
CO3	**H**	**H**	**H**	**M**
CO4	**H**	**H**	**L**	**L**
CO5	**H**	**H**	**L**	**L**

Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

COURSE INFORMATION SHEET

Course code: CH 214
Course title: General Chemistry- II Lab
Pre-requisite(s): Intermediate level chemistry
Co- requisite(s):
Credits: 1.5 L: 0 T: 0 P: 3
Class schedule per week: 3 Sessional
Class: IMSC
Level: IV/2
Branch: All
Name of Teacher:

Syllabus

1. Surface tension measurements.
a. Determine the surface tension by (i) drop number (ii) drop weight method.
b. Study the variation of surface tension of detergent solutions with concentration.
2. Viscosity measurement using Ostwald's viscometer.
3. Indexing of a given powder diffraction pattern of a cubic crystalline system.
4. pH metry
a. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
b. Preparation of buffer solutions of different pH
c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
d. Determination of dissociation constant of a weak acid.
5. Oxidation-Reduction Titrimetry
6. Chromatography
a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography
b. Separation of a mixture of two sugars by ascending paper chromatography
c. Separation of a mixture of *o*-and *p*-nitrophenol or *o*-and *p*-aminophenol by thin layer chromatography (TLC)

Reference Books

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed*.; McGraw-Hill: New York (2003).
3. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
4. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).

Assessment Tool	% Contribution
Progressive Evaluation	**60 (Day to day performance: 30, Quiz: 10, Viva: 20)**
End Sem Examination	**40 (Experiment Performance: 30, Quiz: 10)**

COURSE INFORMATION SHEET

Course code: MA 301
Course title: Probability and Statistics
Pre-requisite(s): NIL
Co- requisite(s): ---
Credits: L: 3 T: 1 P: 0 C:4
Class schedule per week: 3 Lectures, I tutorial.
Class: IMSc.
Semester / Level: V/ 3
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives : This course enables the students to understand

1.	the concepts in probability theory
2.	the properties of probability distributions
3.	estimation of mean, variance and proportion
4.	the concepts of statistical hypothesis

Course Outcomes: After the completion of this course, students will be able to

CO 1	learn basic probability axioms, rules and the moments of discrete and continuous random variables as well as be familiar with common named discrete and continuous random variables.
CO 2	derive the distribution of function of random variables,
CO 3	how to derive the marginal and conditional distributions of random variables.
CO 4	find the point and interval estimates, derive confidence intervals and understand the methods of estimation
CO 5	analyse data statistically and interpretation of the results

Syllabus

MA301 **Probability and Statistics** **3-1-0-4**

Module I

Axioms of probability, Probability space, Conditional probability, Independent events, Bayes' theorem, discrete and continuous random variables, cumulative distribution function, probability mass and density functions, mathematical expectation, variance, moment generating function. [9L]

Module II

Discrete and continuous probability distributions such as Bernoulli, Binomial, Negative Binomial, Poisson, Uniform, Exponential, Beta, Gamma and Normal distribution, distribution of function of random variable. Covariance, Correlation and regression Analysis. [9L]

Module III

Joint distribution for two dimensional random variables, marginal distributions, conditional distributions, conditional expectation, conditional variance, independence of random variables, distribution of sum of two independent random variables. The Central Limit Theorem, t-distribution, Chi-Square Distribution, F- Distribution. [9L]

Module IV

Point Estimation and Interval Estimation, Interval Estimation of three Common Parameters: mean, variance and proportion. The method of moments and the method of maximum likelihood estimation, confidence intervals for the mean(s) and variance(s) of normal populations. [9L]

Module V

Testing of Statistical hypothesis: Null and alternative hypotheses, the critical and acceptance regions, two types of error, tests involving a population mean, tests involving a population proportion, tests involving a population variance, tests for two population means, tests for two population proportions, tests for two population variance. [9L]

Text Books

1. Johnson R.A, Miller I. and Freund J.: Probability and Statistics for Engineers, PHI
2. Hogg, R.V. and Tanis E.A.: Probability and Statistical Inference, Pearson
3. Pal N. and Sarkar S.: Statistics: Concepts and Applications, PHI
4. Gupta S.C and Kapoor V.K.: Fundamental of Mathematical Statistics, Sultan Chand and Sons
5. Walpole, R.E., Myers, R.E., Myers R.H., Myers S.L. and Ye K.: Probability for Statistics and Engineers, Pearson

Reference Books

1. Feller W.: Introduction to Probability theory and applications, John Wiley
2. Freund J.E.: Mathematical Statistics, Pearson
3. Meyer P.L.: Introductory Probability and Statistical Applications, Oxford & IBH,
4. Hines W., Montgomery D., Goldsman, D. and Borror, C.: Probability & Statistics in Engineering, John Wiley

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Semester Examination	25
End Semester Examination	50
Quiz (s)	10+10
Assignment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√				√
End Semester Examination	√	√	√		√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	CO1	3	3	2	1	1	1	1	3	2	3	2
CO2	CO2	3	3	3	2	1	1	1	1	3	3	2
CO3	CO3	3	3	3	2	1	1	1	1	3	3	2
CO4	CO4	2	2	3	3	1	1	1	1	3	3	2
CO5	CO5	2	2	3	3	1	1	1	1	3	3	1

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 302
Course title: Probability and Statistics Lab
Pre-requisite(s):
Co- requisite(s): ---
Credits: L: 0 T: 0 P: 3 C:1.5
Class schedule per week: 03
Class: IMSc.
Semester / Level: V/3
Branch: Mathematics and Computing
Name of Teacher:

List of Practicals
(Using MS-EXCEL / SPSS / R)

1. Determination of Mean, Variance and Coefficient of Variation for a given set of observations.
2. Fitting of Binomial and Poisson distributions.
3. Fitting of a straight line to given data using Principle of Least Squares.
4. Calculation of correlation coefficients for bivariate data and interpretation of results.
5. Determination of two lines of regression for bivariate data.
6. Normality Test of data
7. Spearman's rank Correlation coefficient and Pearson's Correlation coefficient.
8. Testing of goodness of fit by applying Chi-Square Distribution.
9. Testing of independence of attributes by applying Chi-Square Distribution.
10. Interval estimation for Mean and Variance of a Normal Distribution.
11. Interval estimation for a Population Proportion.
12. Testing of single Mean and two Means.
13. Testing of single Variance and two Variances.
14. Testing of Population Proportion(s).

COURSE INFORMATION SHEET

Course code: MA303
Course title: FUZZY LOGIC
Pre-requisite(s): A basic knowledge of set theory would be helpful in understanding operations and properties of fuzzy sets
Co- requisite(s): ---
Credits: L: 3 T: 1 P: 0 C:4
Class schedule per week: 3 Lectures, 1 Tutorial
Class: IMSc
Semester / Level: V/3
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives: The course objective is to

1.	familiarize the students with the fundamentals of fuzzy sets, operations on these sets and concept of membership function.
2.	familiar with fuzzy relations and the properties of these relations
3.	know the concept of a fuzzy number and how it is defined. Become aware of the use of fuzzy inference systems in the design of intelligent systems.
4.	apply fuzzy linear programming in real life problems in various area of research.

Course Outcomes: After the completion of the course, the students will be able to:

CO1	be able to distinguish between the crisp set and fuzzy set concepts through the learned differences between the crisp set characteristic function and the fuzzy set membership function.
CO2	become familiar with fuzzy relations and the properties of these relations.
CO3	know the concept of a fuzzy number and apply in real world problems.
CO4	*become capable of drawing a distinction between binary logic and fuzzy logic at the conceptual level. *become capable of representing a simple classical proposition using crisp set characteristic function and likewise representing a fuzzy proposition using fuzzy set membership function. *become knowledgeable of conditional fuzzy propositions and fuzzy inference systems. *become aware of the use of fuzzy inference systems in the design of intelligent systems.
CO5	apply fuzzy linear programming in real life problems like inventory control etc.

Syllabus

MA305 Fuzzy Logic 3-1-0-4

Module I

Classical sets: operations on classical (crisp) sets, Properties of classical sets, Mapping of classical sets to functions. Fuzzy Sets: Basic Fuzzy set operations, Properties of Fuzzy sets. Representation of Fuzzy Sets, Types of Membership Function, Development of Membership Functions. Properties of membership functions, Fuzzification and Deffuzification. [9L]

Module II

Crisp Relations: cartesian product, other crisp relations, operations on Relations. The Extension Principle for fuzzy sets. Fuzzy Relations: Fuzzy Cartesian product, operations of Fuzzy relations. Compositions of Fuzzy Relations, Properties of the Min-Max Composition. [9L]

Module III

Fuzzy Arithmetic: Fuzzy Numbers, Linguistic Variables, Arithmetic operations on interval, arithmetic operations on fuzzy numbers, Algebraic Operations with Fuzzy Numbers, Lattice of Fuzzy Numbers. [9L]

Module IV

Crisp logic: Law of Propositional logic, Inference in Propositional Logic. Predicate Logic: Interpretation of Predicate Logic Formula, Inference in Predicate Logic. Fuzzy Logic: Fuzzy Quantifiers, Fuzzy Inference. Fuzzy Rule based system. Defuzzification Methods. [9L]

Module V

Decision Making in Fuzzy Environment: Fuzzy Decisions, Fuzzy Linear Programming, Symmetric Fuzzy LP, Fuzzy LP with crisp objective Function. Applications: Fuzzy Approach to Transportation Problem, Fuzzy sets model in inventory control. [9L]

Text Books:

1. Timothy J. Ross, Fuzzy Logic with Engineering Applications, Wiley, India.
2. George J. Klir /Bo Yuan, Fuzzy Sets and Fuzzy Logic, Theory and Applications, PHI learning private Limited.

Reference Books:

1. H.-J. Zimmermann, Fuzzy Set Theory and its Application, Kluwer Academic Publishers.
2. John Yen and Reza Langari, Fuzzy Logic: Intelligence, Control and information, Pearson Education.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Semester Examination	25
End Semester Examination	50
Quiz (s)	10+10
Assignment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√				√
End Semester Examination	√	√	√		√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	1	1	1	1	3	2	3	2
CO2	3	3	3	3	2	1	1	1	1	3	3	2
CO3	3	3	3	3	2	1	1	1	1	3	3	2
CO4	3	2	2	3	3	1	1	1	1	3	3	2
CO5	3	2	2	3	3	1	1	1	1	3	3	1

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: CS203
Course title: **Computer System Architecture**
Pre-requisite(s): Digital Logic
Co- requisite(s):
Credits: L: 3 T: 1 P: 0 C:4
Class schedule per week: 3 Lectures, 1 tutorial
Class: B. Tech/IMSc
Semester / Level: V/2
Branch: CSE/IT/IMSc

Course Objectives: This course enables the students:

1.	To understand the basic architecture and organization of systems along with their performances.
2.	To Familiar with Digital Logic circuits, Data representation and Instruction Set Architecture.
3.	To build a complete data path for various instructions.
4.	To understand the pipeline concepts and Hazards.
5.	To familiar with Memory and I/O Organization.

Course Outcomes: After the completion of this course, students will be to:

CO1.	Explain the merits and pitfalls in computer performance measurements and analyze the impact of instruction set architecture on cost-performance of computer design
CO2.	Explain Digital Logic Circuits ,Data Representation, Register and Processor level Design and Instruction Set architecture
CO3.	Solve problems related to computer arithmetic and Determine which hardware blocks and control lines are used for specific instructions
CO4.	Design a pipeline for consistent execution of instructions with minimum hazards
CO5.	Explain memory organization, I/O organization and its impact on computer cost /performance.

Syllabus

CS203 **Computer System Architecture** **3-1-0-4**

Module I

Basic Structures of Computers

Introduction to Digital Logic, Basic Structure of Computers: Computer Types, Functional Units, Input Unit, Memory Unit, Arithmetic and Logic Unit, Output Unit, Control Unit, Basic Operational Concepts: Fixed and floating point Representation and Arithmetic Operations, Performance, Historical Perspective

[8L]

Module II

Instruction Set Architecture

Memory Locations and Addresses: Byte Addressability, Big-Endian and Little-Endian Assignments, Word Alignment, Instructions and Instruction Sequencing, Addressing Modes, Assembly Language, Subroutines, Additional Instructions, Dealing with 32-Bit Immediate Values.

[8L]

Module III

Basic Processing Unit & Pipelining

Basic Processing Unit: Some Fundamental Concepts, Instruction Execution, Hardware Components, Instruction Fetch and Execution Steps, Control Signals, Hardwired Control, CISC-Style Processors.

Pipelining: Basic Concept, Pipeline Organization, Pipelining Issues, Data Dependencies, Memory Delays, Branch Delays, Pipeline Performance Evaluation **[9L]**

Module IV

Memory Organization

Basic Concepts, Semiconductor RAM Memories, Read-only Memories, Direct Memory Access, Memory Hierarchy, Cache Memories, Performance Considerations, Virtual Memory, Memory Management Requirements, Secondary Storage [10L]

Module V

Input Output & Parallel Processing

Basic Input Output

Accessing I/O Devices, Interrupts

Input Output Organization

Bus Structure, Bus Operation, Arbitration, Interface, Interconnection Standards.

Parallel Processing

Hardware Multithreading, Vector (SIMD) Processing, Shared-Memory Multiprocessors, Cache Coherence, Message-Passing Multicomputers, Parallel Programming for Multiprocessors, Performance Modeling. [10L]

Text Book:

1. Patterson David A., Hennessy John L., Computer Organization and Design: The Hardware / Software Interface, 5th Edition, Elsevier.

Reference Books:

1. Hamachar Carl et. al , Computer Organization and Embedded Systems, 6th Edition, McGraw Hill.
2. Mano M. Morris, Computer System Architecture, Revised 3rd Edition, Pearson.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Semester Examination	25
End Semester Examination	50
Quiz (s)	10+10
Assignment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√				√
End Semester Examination	√	√	√		√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	1	1	1	1	1	1	2
CO2	2	2	1	1	1	1	3	3	1	2	1	2
CO3	2	3	3	3	2	1	1	1	1	2	1	2
CO4	2	2	3	3	2	1	1	2	2	1	1	2
CO5	2	2	3	3	3	1	1	1	1	3	1	1

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: CS206
Course title: **Design and Analysis of Algorithm**
Pre-requisite(s): Data Structure
Co- requisite(s): Algorithms Lab
Credits: L: 3 T: 0 P: 0 C:3
Class schedule per week: 3 Lectures
Class: B. Tech/ IMSc
Semester / Level: V/II
Branch: CSE/IT/IMSc

Course Objectives : This course enables the students :

1.	To analyze the performance of recursive and nor-recursive algorithms.
2.	To understand various algorithm design techniques.
3.	To use of different paradigms of problem solving.
4.	To find efficient ways to solve a given problem.
5.	To compare various algorithms of a given problem.

Course Outcomes : After the completion of this course, students will be able to:

CO1	Define the concepts and mathematical foundation for analysis of algorithms.
CO2	Explain different standard algorithm design techniques, namely, divide & conquer, greedy, dynamic programming, backtracking and branch & bound.
CO3	Demonstrate standard algorithms for fundamental problems in Computer Science.
CO4	Design algorithms for a given problem using standard algorithm design techniques.
CO5	Analyze and compare the efficiency of various algorithms of a given problem.

Syllabus

CS206 **Design and Analysis of Algorithm** **3-0-0-3**

Module I
Algorithms and Complexity
Introduction, Algorithm Complexity and various cases using Insertion Sort, Asymptotic Notations, Time complexity of Recursive Algorithm, Solving Recurrences using Iterative, Recursion Tree and Master Theorem. [8L]

Module II
Divide and Conquer
Discussion of basic approach using Binary Search, Merge Sort , Quick Sort , Selection in Expected linear time, Maximum Subarray , Matrix Multiplication , Introduction of Transform and Conquer and AVL Tree. [8L]

Module III
Dynamic Programming
Introduction and Approach, Rod Cutting, LCS, Optimal BST, Transitive closure and All-pair Shortest Path, Travelling Salesperson Problem. [8L]

Module IV
Greedy and other Design Approaches
Introduction to greedy using fractional knapsack, Huffman Code, Minimum Spanning Tree – Prim and Kruskal, Single Source Shortest Path Dijkstra's and Bellman-Ford, Introduction to Backtracking using N-Queens problem, Introduction to Branch and Bound using Assignment Problem or TSP. [8L]

Module V
NP Completeness and Other Advanced Topics
Non-deterministic algorithms – searching and sorting, Class P and NP, Decision and Optimization problem, Reduction and NPC and NPH, NP Completeness proof for: SAT, Max-Clique, Vertex Cover, Introduction to Randomized Algorithms, Introduction to Approximation Algorithms. [8L]

Text Book:

1. Cormen Thomas H. et al., Introduction to Algorithms. 3rd Edition, PHI Learning, latest edition.

Reference Books:

1. Horowitz E., Sahani, Fundamentals of Computer Algorithms, Galgotia Publication Pvt. Ltd.
2. Dave and Dave, Design and Analysis of Algorithms, 2nd Edition, Pearson.
3. Goodrich, Tamassia. Algorithm Design. Wiley.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Semester Examination	25
End Semester Examination	50
Quiz (s)	10+10
Assignment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√				√
End Semester Examination	√	√	√		√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	2	1	3	1	1	2	1	2	1	1	1
CO2	**3**	2	3	1	1	1	1	1	1	3	2	1
CO3	**1**	3	2	2	2	1	1	2	1	1	1	1
CO4	**1**	2	3	1	1	2	3	2	1	2	1	1
CO5	**2**	3	1	1	2	1	1	1	1	1	1	1

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: CS207
Course title: **Design and Analysis of Algorithm Lab**
Pre-requisite(s): Data Structure
Co- requisite(s): Algorithms Lab
Credits: L: 0 T: 0 P: 3 C:1.5
Class schedule per week: 3 Sessional
Class: B. Tech/ IMSc
Semester / Level: V/II
Branch: CSE/IT/IMSc

COURSE INFORMATION SHEET

Course code: MA 309
Course title: Optimization Techniques
Pre-requisite(s):
Co- requisite(s): ---
Credits: L: 3 T: 1 P: 0 C:4
Class schedule per week: 3 Lectures, 1 Tutorial
Class: IMSc.
Semester / Level: VI / 3
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives: This course enables the students to get an idea about the

1	Mathematical Formulation of LPP, Solution of LPP: Graphical Method with special cases, Simplex Method, Big-M Method, Two Phase method. Special cases in simplex method, Duality theory, Dual Simplex algorithm, Post-optimal Analysis: cases of changes in objective function and right hand side parameter of the constraints.
2	Solution of Transportation problem: Initial Basic Feasible Solution by North-West Corner Method, least Cost, Vogel Approximation Method. Optimal solution by MODI Method. Assignment Model: Hungarian Method.
3	Revised Simplex Method, Parametric Linear Programming, Integer Linear Programming: Branch and Bound Method, Cutting Plane Method, Solution of Travelling salesman Problem by integer programming.
4	Network and basic components, Determination of critical path: Critical Path Method (CPM),Project Evaluation and Review Techniques(PERT).Time-cost optimization Algorithm.
5	Problem of Sequencing, Processing n Jobs through Two Machines, Processing n Jobs through 3 Machines and Processing n Jobs through k Machines.

Course Outcomes: After the completion of the course, the students will be able to:

CO1	Formulate a LPP and solve it by simplex and graphical method.Also do post optimal analysis of the forumalted problem or other application areas.
CO2	To be able to solve a Transportation and Assignment problem.
CO3	To be able to use advanced LPP in his or her application area.
CO4	Fundamentals of Network Analysis using cPM and PERT.
CO5	Solve a sequencing Problem for various jobs and machines.

Syllabus

MA309 **Optimization Techniques** **3-1-0-4**

Module I

Linear Programming Problem (LPP): Mathematical Formulation of LPP, Solution of LPP: Graphical Method with special cases, Simplex Method, Big-M Method, Two Phase method. Special cases in simplex method, Duality theory, Dual Simplex algorithm, Post-optimal Analysis: cases of changes in objective function and right hand side parameter of the constraints. [9L]

Module II

Transportation and Assignment Models: Solution of Transportation problem: Initial Basic Feasible Solution by North-West Corner Method, least Cost, Vogel Approximation Method. Optimal solution by MODI Method. Assignment Model: Hungarian Method. [9L]

Module III

Advanced Linear Programming: Revised Simplex Method, Parametric Linear Programming, Integer Linear Programming: Branch and Bound Method, Cutting Plane Method, Solution of Travelling salesman Problem by integer programming. [9L]

Module IV

Network Analysis (CPM and PERT): Network and basic components, Determination of critical path: Critical Path Method (CPM),Project Evaluation and Review Techniques(PERT).Time-cost optimization Algorithm. [9L]

Module V

Sequencing Problem: Problem of Sequencing, Processing n Jobs through Two Machines, Processing n Jobs through 3 Machines and Processing n Jobs through k Machines. [9L]

Text Books:

1. Hamdy A Taha : Operations Research, Pearson Education.
2. Kanti Swarup, P.K.Gupta and Manmohan: Operations Research, Sultan chand & Sons.

Reference Books:

1. Hiller and Lieberman: Operation Research, McGraw Hill.
2. J.K.Sharma: Operations Research: Theory and applications, Mac-Millan Publishers.
3. S. S. Rao: Engineering Optimization: Theory and Practice, Fourth Edition, John Wiley and Sons.
4. R. K.Gupta: Operations Research, Krishna Prakashan Media Pvt.Ltd.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Semester Examination	25
End Semester Examination	50
Quiz (s)	10+10
Assignment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√				√
End Semester Examination	√	√	√		√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	1	1	1	1	3	2	3	2
CO2	3	3	3	3	2	1	1	1	1	3	3	2
CO3	3	3	3	3	2	1	1	1	1	3	3	2
CO4	2	2	2	3	3	1	1	1	1	3	3	2
CO5	2	2	2	3	3	1	1	1	1	3	3	1

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 310

Course title: Optimization Techniques Lab

Pre-requisite(s):

Co- requisite(s): ---

Credits: L: 0 T: 0 P: 3 C:1.5

Class schedule per week: 3 Sessionals

Class: IMSc.

Semester / Level: VI / 3

Branch: Mathematics and Computing

Name of Teacher:

List of Assignments

1. Solving by graphical method (including special cases) the LPP using TORA.
2. Solve by simplex method the LPP by LINGO & TORA only.
3. Solve by BIG- method the LPP by LINGO & TORA only.
4. Solve by Two-Phase Method by LINGO& TORA only.
5. Solve a LPP by dual simplex method by TORA only.
6. Solve the integer Programming Problem (Branch and Bound Method) by TORA and LINGO.
7. Solve the Transportation problem by LINGO & TORA only.
8. Solve the minimal spanning tree problem using TORA.
9. Solve the shortest route problem using TORA only.
10. Solve the minimal flow problem using TORA only.
11. Solve the Critical Path (CPM) Problem using TORA only.
12. Solve the PERT problem using TORA only.

COURSE INFORMATION SHEET

Course code: MA 311
Course title: Numerical Techniques
Pre-requisite(s):
Co- requisite(s): ---
Credits: L: 3 T: 1 P: 0 C:4
Class schedule per week: 3 Lectures, 1 Tutorial
Class: IMSc.
Semester / Level: VI / 3
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives: This course enables the students to

1.	derive appropriate numerical methods to solve algebraic and transcendental equations
2.	derive appropriate numerical methods to solve linear system of equations
3.	approximate a function using various interpolation techniques
4.	to find the numerical solution of initial value problems and boundary value problems

Course Outcomes: After the completion of this course, students will be able to

CO 1	solve algebraic and transcendental equation using an appropriate numerical method arising in various engineering problems
CO 2	solve linear system of equations using an appropriate numerical method arising in computer programming, chemical engineering problems etc.
CO 3.	Approximate a function using an appropriate numerical method in various research problems
CO 4	evaluate derivative at a value using an appropriate numerical method in various research problems
CO 5	solve differential equation numerically

Syllabus

MA311 Numerical Techniques 3-1-0-4

Module I
Definition and sources of errors, propagation of errors, backward error analysis, sensitivity and conditioning, stability and accuracy, floating-point arithmetic and rounding errors. Solution of algebraic and transcendental equations: Bisection method, Secant method, Regula-Falsi method, Newton-Raphson method and its variants, General iterative method and their convergence analysis. [9L]

Module II
Gauss-Elimination, Gauss-Jordan, LU-Decomposition, Cholsky, Gauss-Jacobi and Gauss-Siedel methods to solve linear system of equation. Error and convergence analysis of above methods. Power method to find least and largest eigenvalues. [9L]

Module III
Lagrange's interpolation, Newton's divided differences interpolation formulas, inverse interpolation, interpolating polynomial using finite differences, Hermite interpolation, Piecewise interpolation, spline interpolation, B-splines, cubic splines and function approximations by least squares and uniform approximations. [9L]

Module IV
Differentiation using interpolation formulas, Integration using Newton-Cotes formulas (Trapezoidal rule, Simpson's 1/3, 3/8 rule, Weddle's rule) and their error analysis. [8L]

Module V
Euler's method, modified Euler's method, Runge Kutta Methods of second and fourth order, Predictor-Corrector methods (Milne & Adams-Bashforth) to solve initial value problems, Shooting and finite difference methods for boundary value problems. [10L]

Text Books
1. Jain M.K.: Numerical Methods for Scientific and Engineering Computation, New Age Publication.
2. Sastry S.S.: Introductory Methods of Numerical Analysis, PHI

Reference Books
1. Chapra S.C. and Canale R.P.: Numerical Methods for Engineers, McGraw Hill
2. Hamming R.W.: Numerical Methods for Scientists and Engineers, Dover Publications

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Semester Examination	25
End Semester Examination	50
Quiz (s)	10+10
Assignment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√				√
End Semester Examination	√	√	√		√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	1	1	1	1	3	2	3	2
CO2	3	3	3	3	2	1	1	1	1	3	3	2
CO3	3	3	3	3	2	1	1	1	1	3	3	2
CO4	2	2	2	3	3	1	1	1	1	3	3	2
CO5	2	2	2	3	3	1	1	1	1	3	3	1

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 312
Course title: Numerical Techniques Lab
Pre-requisite(s):
Co- requisite(s): ---
Credits: L: 0 T: 0 P: 3 C:1.5
Class schedule per week: 03 Sessional.
Class: IMSc.
Semester / Level: VI/ 3
Branch: Mathematics and Computing
Name of Teacher:

List of Assignment

1. Find a simple root of $f(x)=0$ using bisection method. Read the end points of the interval (a,b) in which the root lies, maximum number of iterations n and error tolerance eps.
2. Find a simple root of $f(x)=0$ using Regula-Falsi method. Read the end points of the interval (a,b) in which the root lies, maximum number of iterations n and error tolerance eps.
3. Find a simple root of $f(x)=0$ using Newton Raphson method. Read any initial approximation x_0, maximum number of iterations n and error tolerance eps.
4. Solution of a system of $n \times n$ linear equations using Gauss elimination method with partial pivoting. The program is for 10×10 system or higher order system.
5. Matrix inversion and solution of $n \times n$ system of equations using Gauss-Jordan method. If the system of equations is larger than 15×15 change the dimensions of the float statement.
6. Program to solve a system of equation using Gauss-Seidel iteration method. Order of the matrix is n, maximum number of iterations $niter$, error tolerance is eps and the initial approximation to the solution vector is x_0. If the system of equations is larger than 10×10 change the dimension in float.
7. Program to find the largest Eigen value in magnitude and the corresponding Eigen vector of a square matrix A of order n using power method.
8. Program for Lagrange interpolation.
9. Program for Newton divided difference interpolation.
10. Program for Newton's forward and backward interpolation.
11. Program for Gauss's central difference interpolation (both backward and forward).
12. Program to evaluate the integral of $f(x)$ between the limits a to b using Trapezoidal rule of integration based on n subintervals or $n+1$ nodal points. The values of a,b and n are to be read. The program is tested for $f(x)=1/(1+x)$.
13. Program to evaluate the integral of $f(x)$ between the limits a to b using Simpson's rule of integration based on $2n$ subintervals or $2n+1$ nodal points. The values of a,b and n are to be read and the integrand is written as a function subprogram. The program is tested for $f(x)=1/(1+x)$.
14. Program to solve an IVP, $dy/dx = f(x), y(x_0)=y_0$ using Euler method. The initial value x_0, y_0 the final value x_f and the step size h are to be read. The program is tested for $f(x,y)=-2xy^2$.
15. Program to solve an IVP, $dy/dx = f(x), y(x_0)=y_0$ using the classical Runge-Kutta fourth order method with step size h, $h/2$ and also computes the estimate of the truncation error. Input parameters are: initial point, initial value, number of intervals and the step length h. Solutions with h, $h/2$ and the estimate of the truncation error are available as output. The right hand side The program is tested for $f(x,y)=-2xy^2$.

COURSE INFORMATION SHEET

Course code: CS301
Course title: **Database Management System**
Pre-requisite(s): Data Structures.
Co- requisite(s):
Credits: L:3 T:0 P:0 C:3
Class schedule per week: 3 Lectures
Class: B. Tech/ IMSc
Semester / Level: VI/ 3
Branch: CSE/IT/IMSc

Course Objectives : This course enables the students to:

1.	Understand the fundamental concepts, historical perspectives, current trends, structures, operations and functions of different components of databases.
2.	Recognize the importance of database analysis and design in the implementation of any database application.
3.	Describe the role of transaction processing in a database system.
4.	Understand various concurrency control mechanisms for a database system.
5.	Describe the roles of recovery and security in a database system.

Course Outcomes : After the completion of this course, students will be able to:

CO1	Analyze data organization requirements and their inter relationships.
CO2	Illustrate the features of data models and their application for storing data.
CO3	Design queries to maintain and retrieve useful information from the databases created.
CO4	Analyze the physical database design with respect to their expected performance using normalization and query processing.
CO5	Examine the best practices according to concepts of indexing, transaction control and concurrency maintenance

Syllabus

CS301 **Database Management System** **3-0-0-3**

Module I
Database Design and Entity - Relational Model
Purpose of Database System; View of Data, Database Languages, Transaction Management, Database architecture, Database Users and Administrator, Types of database System, Overview of design process, E-R model, Constraints, E–R Diagram, E-R Diagram issues, Weak Entity Sets, Extended E – R Features, Reduction to E–R Schemas. [8L]

Module II
Relational Model
Structure of Relational Database, Codd's Rules, Fundamental Relational Algebra Operations, Additional Relational Algebra Operations, Extended Relational Algebra Operations, Data definition, Basic structure of SQL queries, Set Operations, Aggregate Functions, Null Values, Nested Sub Queries, complex queries, views, modification of database, Joined relations, SQL data types & schemas, Integrity constraints, authorization, Embedded SQL, Triggers. [8L]

Module III
Relational Database Design
Functional dependency, Decomposition, Normalization, First normal form, Second normal form, Third normal form, BCNF, Multivalued dependencies and Fourth normal form, Join dependencies and Fifth normal form, DKNF. [8L]

Module IV
Indexing & Hashing
Ordered Indices, B+ Tree index files, B-Tree index files, Multiple key access Static hashing, Dynamic Hashing, Comparison of ordered indexing and hashing, Index definition in SQL.
Query Processing
Measure of Query Cost, Selection Operation, Evaluation of Expressions. [8L]

Module V
Transaction & Concurrency Control
Transaction Concepts & ACID Properties, Transaction States, Implementation of Atomicity & Durability, Concurrent Executions, Serializability& Its Testing, Recoverability, Lock-Based protocols, Validation based protocol, Multiple Granularity, Multiversion Schemes, Deadlock Handling. [8L]

Text Book:
1. Silberschatz A. et.al, Database System Concepts, 6th Edition, Tata Mc-Graw Hill, New Delhi, 2011.
Reference Books:
1. Elmasri R., Fundamentals of Database Systems, 7th Edition, Pearson Education, New Delhi, 2016.
2. Ullman Jeffrey D et.al., A First course in Database Systems, 3rd Edition, Pearson Education, New Delhi- 2014.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

<u>Course outcome (co) attainment assessment tools & evaluation procedure</u>

<u>Direct assessment</u>

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

<u>Mapping of course outcomes onto program outcomes</u>

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	2	1	2	1	1	1	1
CO2	1	3	2	1	3	2	1	1	1	1	1	1
CO3	1	1	2	3	1	1	1	1	1	1	1	1
CO4	1	3	1	2	1	1	2	1	2	1	1	1
CO5	1	3	1	2	1	2	1	1	1	1	1	1

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: CS302
Course title: **Database Management System Lab**
Pre-requisite(s): Data Structures.
Co- requisite(s):
Credits: L:0 T:0 P:3 C:1.5
Class schedule per week: 3 Sessional
Class: B. Tech/ IMSc
Semester / Level: VI/ 3
Branch: CSE/IT/IMSc

COURSE INFORMATION SHEET

Course code: CS303
Course title: **Operating System**
Pre-requisite(s): Data Structure, Computer System Architecture, Basic Course on Computer Programming
Co- requisite(s): None
Credits: L:3 T:0 P:0 C:3
Class schedule per week: 3 Lectures
Class: BTech/IMSc
Semester / Level: VI/3
Branch: CSE/IT/IMSc

Course Objectives : This course enables the students to:

1.	Present the main components of OS and their working
2.	Introduce the concepts of process and thread and their scheduling policies
3.	Handling synchronization of concurrent processes and deadlocks
4.	Analyze the different techniques for managing memory, I/O, disk and files
5.	Design the components of operating system

Course Outcomes : After the completion of the course student will be able to:

CO1	Describe the main components of OS and their working
CO2	Explain the concepts of process and thread and their scheduling policies
CO3	Solve synchronization and deadlock issues
CO4	Compare the different techniques for managing memory, I/O, disk and files
CO5	Design components of operating system

Syllabus

CS303 **Operating System** **3-0-0-3**

Module I

Operating system Overview

Operating system Objective and Functions, Evolution of Operating System, Major Advances in OS Components, Characteristics of Modern Operating Systems

Process Description and Control

Process Concept, Process States, Process Description, Process Control, Threads, Types of Threads, Multicore and Multithreading **[8L]**

Module II

Scheduling

Type of scheduling, Uniprocessor Scheduling, Multiprocessor Scheduling **[8L]**

Module III

Concurrency

Mutual Exclusion and Synchronization

Principle of Concurrency, Mutual Exclusion, Hardware Support, Semaphores, Monitors, Message Passing, Readers/Writers Problem

Deadlock and Starvation

Principle of Deadlock, Deadlock Prevention, Deadlock Avoidance, Deadlock Detection, Dining Philosopher Problem **[8L]**

Module IV

Memory Management

Memory Management Requirements, Memory Partitioning, Paging, Segmentation

Virtual Memory

Hardware and Control Structures, Operating System Policies for Virtual Memory **[8L]**

Module V

I/O Management and Disk Scheduling

I/O device, Organization of the I/O Function, Operating System Design Issues, I/O Buffering, Disk Scheduling, RAID, Disk Cache

File Management

Overview, File Organization and Access, File Directories, File Sharing, Record Blocking, File Allocation and Free Space Management **[8L]**

Text Book:

1. Stallings W., Operating systems - Internals and Design Principles, , 8th Edition, Pearson, 2014.

Reference Books:

1. Silberchatz Abraham , Galvin Peter B., Gagne Greg, Operating System Principles, 9th Edition, Wiley Student Edition, 2013.
2. Tanenbaum Andrew S. , Modern Operating Systems, 4th Edition, Pearson, 2014.
3. Dhamdhere D. M. , Operating Systems A concept - based Approach, 3rd Edition, McGrawHill Education, 2017.
4. Stuart B. L., Principles of Operating Systems, 1st Edition, 2008, Cengage learning, India Edition.
5. Godbole A. S., Operating Systems, 3rd Edition, McGrawHill Education, 2017.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

<u>Course outcome (co) attainment assessment tools & evaluation procedure</u>

<u>Direct assessment</u>

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

<u>Mapping of course outcomes onto program outcomes</u>

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	2	1	1	1	1	3	1	1
CO2	3	2	2	1	2	1	1	1	1	2	1	1
CO3	3	3	3	2	3	1	1	1	1	3	1	1
CO4	3	3	3	2	3	1	1	1	1	3	1	1
CO5	3	3	3	2	3	1	1	2	2	3	1	1

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: MA 401
Course title: Real Analysis and Measure Theory
Pre-requisite(s): Basics of real analysis, Riemann Integration.
Co- requisite(s): ---
Credits: L: 3 T: 1 P: 0 C:4
Class schedule per week: 3 Lectures, 1 Tutorial.
Class: IMSc/ MSc
Semester / Level: VII / 4
Branch: Mathematics and Computing/Mathematics
Name of Teacher:

Course Objectives: This course enables the students to understand

1.	Continuous functions and their bounded variation property
2.	Riemann Stieltjes Integration and their applications.
3.	Difference between Riemann Integration and Riemann Stieltjes Integration of functions.
4.	The concept of Lebesgue integration and their applications, different theorems and their applications.
5	Application of Fatou's lemma, Lebesgue dominated convergence theorem, Comparison of Lebesgue integral and Riemann integral.

Course Outcomes: After the completion of this course, students will be able to

CO1.	apply Riemann Stieltjes Integration on different boundary value problems
CO2.	apply Lebesgue theory and integration in the applications of qualitative theory of differential equations and difference equations.
CO3.	demonstrate a depth of understanding in advanced mathematical topics in relation to Biomathematics and engineering.
CO4	apply measure theory on functional analysis.
CO5	apply analysis on Topology.

Syllabus

MA401 — Real Analysis and Measure Theory — 3-1-0-4

Module I

Properties of Monotone functions, Functions of bounded variation along with their properties, Total variation, Functions of bounded variation expressed as the difference of increasing functions, Continuous function of bounded variation. Jordan's rectifiable curve theorem. [9L]

Module II

Definition Riemann-Stieltjes integral, Linear properties, Change of variable in a Riemann-Stieltjes integral, Necessary and Sufficient conditions for existence of Riemann-Stieltjes integral, Mean value theorem for Riemann-Stieltjes integral. [9L]

Module III

Borel Sets, σ-ring, σ-algebra, Lebesgue outer measure, measurable sets and their properties, Lebesgue measure, measurable function. [9L]

Module IV

Simple function and measurable function, Lebesgue integral of a non-negative measurable function using simple functions, Lebesgue integral of functions of arbitrary sign and basic properties (linearity and monotonicity). [9L]

Module V

Monotone convergence theorem and its consequences, Fatou's lemma, Lebesgue dominated convergence theorem, Comparison of Lebesgue integral and Riemann integral. [9L]

Text Book:

1. H. L. Royden and P. M. Fitzpatrick – Real Analysis, Pearson, Fourth edition, 2017.

References:

1. R. R. Goldberg – Methods of Real Analysis, Oxford and IBH Publishing, 1970.
2. Tom M. Apostol – Mathematical Analysis, Second Edition, Addison Wesley, 1974.
3. Walter Rudin, Principles of Mathematical Analysis, McGraw Hill International Edition, 2014

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	√	√	√	√	√
End Semester Examination	√	√	√	√	√
Quiz (s)	√	√	√	√	√
Assignment	√	√	√	√	√

Indirect Assessment

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	1	1	2	2	3	3	3	1	1
CO2	3	3	1	1	1	2	2	3	3	3	1	1
CO3	3	3	1	1	3	2	2	3	3	3	1	2
CO4	3	3	2	1	1	2	2	3	3	3	2	2
CO5	3	3	2	1	1	2	2	3	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 402
Course title: Advanced Complex Analysis
Pre-requisite(s): Basics of Complex Variable Functions
Co- requisite(s): ---
Credits: L: 3 T: 1 P:0 C:4
Class schedule per week: 3 Lectures, 1 Tutorial.
Class: IMSc/MSc
Semester / Level: VII / 4
Branch: Mathematics and Computing/ Mathematics
Name of Teacher:

Course Objectives : This course enables the students to understand

1.	the complex differentiation and integration of analytic functions
2.	the convergence and divergence of series of complex variable functions, with special emphasis on Taylor and Laurent series
3.	the theory behind multivalued functions associated with complex variables
4.	the different properties associated with meromorphic functions
5.	convergence of infinite products of complex variable functions and their connection with zeros of entire functions

Course Outcomes : After the completion of this course, students will be able to

CO1	demonstrate the remarkable properties of complex variable functions, which are not the features of their real analogues
CO2	acquire knowledge about different types of functions viz. analytic, entire and meromorphic functions occur in complex analysis along with their properties
CO3	apply the knowledge of complex analysis in diverse fields related to mathematics
CO4	utilize the concepts of complex analysis to specific research problems in mathematics or other fields.
CO5	enhance and develop the ability of using the language of mathematics in analyzing the real-world problems of sciences and engineering.

Syllabus

MA402 **Advanced Complex Analysis** 3-1-0-4

Module I

Topology of the complex plane, functions on the complex plane, Stereographic projection
Holomorphic (analytic) functions, Cauchy - Riemann equations, Integration of complex variable functions along curves, parameterization of curves, smooth curve, contours, contour Integrals and their properties, Cauchy's Theorem, Goursat Theorem, Cauchy – Integral Formula, Cauchy Integral Formula for derivatives, Cauchy's Inequality, Morera's theorem, Liouville's theorem. [10L]

Module II

Conformal mapping, fractional transformation, Riemann mapping theorem, Schwartz – Christoffel transformation
Convergence of Sequences and Series, Power series, absolute and uniform convergence of power series of complex functions, Integration and Differentiation of power series, Radius of convergence, Taylor series, Laurent series, Analytic continuation. [9L]

Module III

Zeros of analytic function, singularities of analytic function and their different types, Residues, Residue theorem. Multivalued functions, branch point, branch cut, evaluation of integrals involving branch point using calculus of residues. [9L]

Module IV

Meromorphic function and its properties, zeros and poles of meromorphic function, Riemann sphere, winding number, Argument principle, Rouche's theorem and its applications, Identity theorem, Schwarz's lemma, Maximum Modulus theorem, Fundamental theorem of algebra. [9L]

Module V

Infinite products, convergence of infinite products, Entire functions, Weierstrass primary factors, Weierstrass infinite product, Hadamard's factorization theorem, genus and order of entire function, growth of entire functions, Jensen's formula, functions of finite order. [8L]

Text Books:

1. E. M. Stein and R. Shakarchi, Complex Analysis, Princeton University Press, 2003.
2. J.B. Conway, Function of One Complex Variable, Springer – Verlag Publishers, Second Edition, 1978.
3. S. Ponnusamy and H. Silverman, Complex Variables with Applications, Birkhauser, 2006.
4. Reinhold Remmert, Theory of Complex Functions, Springer International Edition, 1991.

Reference Books:

1. J.W. Brown and R.V. Churchill, Complex Variable and its Applications, Tata McGraw Hill Publications, 7^{th} Edition, 2014.
2. H.S. Kasana, Complex Variables: Theory and Applications, PHI, Second Edition, 2005.
3. D.G. Zill and P.D. Shanahan, A First Course in Complex Analysis with Applications, Jones and Bartlett Publishers, 2003.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: CA504
Course title: AUTOMATA THEORY
Pre-requisite(s):
Co- requisite(s):
Credits: L:3 T:1 P: 0 C:4
Class schedule per week: 3 Lectures 1 tutorial
Class: MCA/ **IMSc**
Semester / Level: III,VII/5
Branch: MCA/ **IMSc**

Course Objectives : This course enables the students to:

1	Define a system and recognize the behavior of a system.
2	Design finite state machines and the equivalent regular expressions.
3	Construct pushdown automata and the equivalent context free grammars
4	Design Turing machines and Post machines
5	Learn about the issues in finite representations for languages and machines, as well as gain a more formal understanding of algorithms and procedures.

Course Outcomes: After the completion of this course, students will be able to:

CO1	Relate formal languages and mathematical models of computation
CO2	Analyze different types of languages and the corresponding machines
CO3	Analyze the Pushdown machine and its role in compiler construction
CO4	Find the capability of real computers and learn examples of unsolvable problems.
CO5	Analyze classes of P, NP, NP-C and NP-Hard problems

Syllabus

CA504 — AUTOMATA THEORY — 3-1-0-4

Module: I

Basic Mathematical Objects and Mathematical Induction: Sets, logic, Functions, Relations, Alphabets, Strings, Languages, Principle of mathematical induction, Recursive definition. **[9L]**

MODULE: II

Regular Expressions and Finite Automata: Regular languages and Regular Expressions, Memory required to recognize a language, Finite Automata, capability & limitations of FSM, Deterministic Finite Automata , Non-Deterministic Finite Automata, NFA with e-moves, regular sets & regular expressions, Equivalence of DFA and NDFA, NFA from regular expressions, regular expressions from DFA, Moore versus Mealy m/c, two way finite automata equivalence with one way , Kleen's Theorem, applications of finite automata. **[9L]**

MODULE: III

Regular and Non-regular languages: Criterion for Regularity, Minimal Finite Automata, Pumping Lemma for Regular Languages, Decision problems, Regular Languages and Computers.

Context Free Grammars: Introduction, definition, Regular Grammar, Derivation trees, Ambiguity, Simplified forms and Normal Forms, Applications. **[9L]**

MODULE: IV

Pushdown Automata: Definition, Moves, Instantaneous Descriptions, Language recognised by PDA, Deterministic PDA, Acceptance by final state & empty stack, Equivalence of PDA , Pumping lemma for CFL, Interaction and Complements of CFL,Decision algorithms.

Turing Machines: Definition and examples, Computing Partial Functions with Turing Machine(TM), Combining TMs, Variations of TMs, Multi-tape TMs, Non-deterministic TM, Universal TM, Church Thesis. **[9L]**

MODULE: V

Recursively Enumerable Languages: Recursively Enumerable and Recursive, Enumerating Language, Context Sensitive and Chomosky Hierarchy.

Unsolvable Problems and Computable Functions: Nonrecursive Language and unsolvable Problems, Halting Problem, Rice Theorem, Post Correspondence Problem.

Computational Complexity: Discussion on P, NP, NPC and NP-Hard Problems. **[9L]**

Text Books:

1. Martin John "Introduction to Languages and the Theory of Computation", 3rd Edition, TMH.

Reference Books:

1. Mishra K.L.P & Chandrasekharan N., "Theory of Computer Science", PHI.
2. Hopcroft John E. And Ullman Jeffrey D., "Introduction to Automata Theory, Languages & Computation", 3rd Edition, Narosa, 2008.
3. Lewis H. R. and Papadimitrou C. H, "Elements of the theory of Computation", PHI.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3	1	1	2	3	3	*2*	2
CO2	3	3	3	2	2	1	1	2	2	2	*2*	2
CO3	3	3	2	2	3	1	1	2	3	3	*2*	2
CO4	2	3	3	2	2	1	1	2	2	2	*2*	2
CO5	3	3	3	2	2	1	1	2	2	2	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: CA505
Course title: SOFTWARE ENGINEERING
Pre-requisite(s):
Co- requisite(s):
Credits: L:3 T:1 P: 0 C:4
Class schedule per week: 3 Lectures , 1 tutorial
Class: MCA/IMSc
Semester / Level: III,VII/5
Branch: MCA/IMSc

Course Objectives : This course enables the students to:

1.	Students are effective team members, aware of cultural diversity, who conduct themselves ethically and professionally
2.	Students use effective communication skills and technical skills to assure production of quality software, on time and within budget.
3.	Students build upon and adapt knowledge of science, mathematics, and engineering to take on more expansive tasks.
4.	Able to increase level of self-reliance, technical expertise, and leadership.

Course Outcomes : After the completion of this course, students will be able to :

CO1	Explain the software engineering principles and techniques
CO2	Apply Software Project Management Practices
CO3	Apply the knowledge gained for their project work as well as to develop software following software engineering standards
CO4	Develop self-reliance, technical expertise, and leadership.
CO5	adapt knowledge of science, mathematics, and engineering to take on more expansive tasks.

Syllabus

CA505 **SOFTWARE ENGINEERING** **3-1-0-4**

MODULE: I

Introduction to Software Engineering: Evolving Role of Software, Changing Nature of Software, Legacy Software, Process Frame work, Process Patterns, Process Models, Waterfall Model, Incremental Process Models, Evolutionary Process Models, Specialized Process Models, Unified Process Model, Agile Process Model. **[9L]**

MODULE: II

Requirement Engineering: A bridge to design and construction, Requirement Engineering Task, Initiating the Requirement Engineering Process, Eliciting Requirements, Developing Use case, Building the Analysis Model, Negotiating Requirements, Validating Requirements. **[9L]**

MODULE: III

Design Engineering: Design Process and Design Quality, Design Concepts, Design Models, Pattern Based Software Design. **[9L]**

MODULE: IV

Testing Strategies and Testing Tactics: Strategic Approach to software Testing, Test Strategies for conventional and Object Oriented Software, Validation Testing System Testing, White Box Testing, Basic Path Testing Control Structure Testing, Black Box Testing, Object Oriented Testing Methods. [9L]

MODULE: V

Metric for process and Estimation Techniques: Process metrics, Software Measurement, Software Project Estimation, Decomposition Techniques, Empirical Estimation Models, Estimation for Object Oriented Projects Specialized Estimation Techniques.

Software Quality and Configuration Management: Quality Concepts, Software Quality Assurance, Software Reliability, Software Configuration Management, SCM Repository, SCM Process. [9L]

Text Book:

1. Pressman Roger S., “Software Engineering – A Practitioner’s Approach”, 6th Edition., Tata McGraw Hill.

Reference Books:

1. Vliet Haus Van, “Software Engineering – Principles and Practice”, Wiley John and Sons, 2nd Edition.
2. Sommerville Ian, “Software Engineering”, 7th Edition., Pearson Education.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

<u>Course Outcome (CO) Attainment Assessment tools & Evaluation procedure</u>

<u>Direct Assessment</u>

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

<u>Mapping of Course Outcomes onto Program Outcomes</u>

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3	1	1	2	3	3	*2*	2
CO2	3	3	3	2	2	1	1	2	2	2	*2*	2
CO3	3	3	2	2	3	1	1	2	3	3	*2*	2
CO4	2	3	3	2	2	1	1	2	2	2	*2*	2
CO5	3	3	3	2	2	1	1	2	2	2	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: CA506
Course title: SOFTWARE ENGINEERING LAB
Pre-requisite(s):
Co- requisite(s):
Credits: L:0 T:0 P: 3 C:1.5
Class schedule per week: 3 Sessionals
Class: MCA/IMSc
Semester / Level: III, VII/5
Branch: MCA/IMSc

SYLLABUS

List of Programs as Assignments:

1. **Lab Assignment No: 1**

Objective: To Understand and Implement Identification of Requirements from Problem Statements

Q1. To consider the problem statement for a project to be developed and list out the ambiguities, inconsistencies and incompleteness of the problem statement.

Q2. To identify different functionaries to be obtained from a system and characteristics that a system should have, but not possessed by the system itself

2. **Lab Assignment No: 2**

Objective: To Understand and Implement Estimation of Project Metrics

Q1. To estimate the minimum size of the team one would require to develop a project through application of intermediate COCOMO.

Q2. To use Halstead's metrics to estimate the effort required to recreate a program in JAVA from C.

3. **Lab Assignment No: 3**

Objective: To Understand and Implement Modeling UML Use Case Diagrams and Capturing Use Case Scenarios

Q1. To draw a use case diagram for the given case study.

Q2. To identify the primary and secondary actors for the system and generalization of use cases and «include» stereotypes to prevent redundancy in the coding phase.

4. **Lab Assignment No: 4**

Objective: To Understand and Implement E-R Modeling from the Problem Statements

Q1. To identify the possible entity sets, their attributes, and relationships for the given case study.

Q2. To draw an ER diagram for the given case study.

5. **Lab Assignment No: 5**

Objective: To Understand and Implement Identification of Domain Classes from the Problem Statements

Q1. To identify potential classes and their attributes for the given case study.

Q2. To utilize expert knowledge on the subject matter to identify other relevant classes.

6. **Lab Assignment No: 6**

Objective: To Understand and Implement Identification of Components from the Problem Statements

Q1. To identify potential components for the given case study.

Q2. To draw component diagram for the given case study

7. **Lab Assignment No: 7**

Objective: To Understand and Implement State Chart and Activity Modeling

Q1. To draw a state chart diagram to graphically represent the given case study.

Q2. To draw an activity diagram to graphically represent the workflow of the given case study.

8. **Lab Assignment No: 8**

Objective: To Understand and Implement Modeling UML Class Diagrams and Sequence diagrams

Q1. To draw class diagram for the given case study.

Q2. To draw sequence diagram for the given case study.

9. **Lab Assignment No: 9**

Objective: To Understand and Implement Modeling Data Flow Diagrams

Q1. To draw data flow diagram (Level 0, 1 and 2) for the given case study.

10. **Lab Assignment No: 10**

Objective: To Understand and Implement Estimation of Test Coverage Metrics and Structural Complexity

Q1. To identify the basic blocks for a given program

Q2. To draw a CFG using the basic blocks

Q3. To determine McCabe's complexity from a CFG.

11. **Lab Assignment No: 11**

Objective: To Understand and Implement Designing Test Suites

Q1. To design a test suite for the given case study.

Q2. To verify implementation of functional requirements by writing test cases.

Q3. To analyze results of testing to ascertain the current state of the project.

12. **Lab Assignment No: 12**

Objective: To Understand and Implement Forward and Reverse Engineering

Q1. To obtain programs from UML diagrams.

Q2. To obtain UML diagrams from programs.

Books recommended:

TEXT BOOKS

1. Software Engineering, Ian Sommerville, Pearson, 10th Edition, 2016. **(T1)**
2. Software Engineering: A Practioner's Approach, Roger S. Pressman, McGraw Hills, 7th Edition, 2009. **(T2)**

REFERENCE BOOKS

1. Fundamentals of Software Engineering, Rajib Mall, Prentice-Hall of India, 3rd Edition, 2009. **(R1)**

COURSE INFORMATION SHEET

Course code: MA 412
Course title: Topology
Pre-requisite(s): Basics of real Analysis and Functional Analysis
Co- requisite(s): ---
Credits: L: 3 T: 1 P: 0 C:4
Class schedule per week: 03 Lectures, 1 Tutorial
Class: IMSc/ MSc
Semester / Level: VIII/4
Branch: Mathematics and Computing/ Mathematics
Name of Teacher:

Course Objectives : This course enables the students to understand

1.	The concept of a Topological space which generalizes the spaces arising in Real and Functional Analysis
2.	The generalization of the concept of continuity on Topological spaces
3.	The connectedness and compactness of spaces through the concepts of topological properties.
4	Generalization of different structure of spaces to Topological spaces
5	Fundamental concepts of topology.

Course Outcomes : After the completion of this course, students will be able to

CO1.	Understand the concept of topology in real world problems.
CO2.	Applications of topological approach in the study of solutions of different boundary value problems using differential equations arising in Biological and Ecological systems and different engineering problems.
CO3.	Applications of topological approach to study the qualitative properties of solutions of mathematical models arising in real world phenomena.
CO4.	Applications of topological approach in the study of solutions of Difference Equations in different boundary value problems arising in Biological and Ecological systems and different engineering problems.
CO5.	Use of topological concepts in Architecture Engineering.

Syllabus

MA412 Topology 3-1-0-4

Module I

Topological spaces: Definition and examples, Basis for a Topology, Standard Topology, Sub-basis. Product Topology: Definition, Projections, Subspace Topology, Closed sets and Limit points: closure and interior of a set, Hausdorff space, Continuity of a function on Topological Space, Homeomorphisms, Rules for constructing continuous functions. [9L]

Module II

Metric Topology: Metrizable space, Euclidean metric, uniform topology, Subspaces, Uniform convergence of sequence of functions, Uniform limit theorem, Quotient Topology : Quotient map, Quotient space. example and glimpse of continuous maps on quotient spaces in specific situations.

Connected spaces : Separation and connected space, union of connected sets, continuous image of connected spaces, Cartesian product of connected spaces, Path connected spaces: Definition and examples, Components and path components, local connectedness. [9L]

Module - III

Countability and Separation Axioms: Countable basis, first and second countable axioms, dense sets, separable space, Separable axioms: Housdroff space, Regular space, Normal Space, Completely regular space, Urishon’s lemma, Tietze Extension theorem. [9L]

Module- IV

Compact Spaces: Cover, Open cover, Compactness: basic results and finite Intersection property, Compact subspaces of real line, Extreme value theorem, the Lebesgue number lemma, uniformly continuous, uniform continuity theorem, Limit points and Compactness, Sequentially compact, local compactness and one point compactification. [9L]

ModuleV

Compactness in Metric Spaces: ε-net, Lebesgue number, equivalence of compactness, sequential compactness and limit point compactness in a metric space, uniform continuity theorem. [9L]

Text Book:

1. J. R. Munkres – Topology :Pearson New International Edition, 2nd Edition, 2013.

References:

1. W. J. Thron – Topological Structures.
2. K. D. Joshi – Introduction to General Topology.
3. J. L. Kelly – General Topology.
4. G. F. Simmons – Introduction to Topology & Modern Analysis.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

<u>Course Outcome (CO) Attainment Assessment tools & Evaluation procedure</u>

<u>Direct Assessment</u>

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

<u>Mapping of Course Outcomes onto Program Outcomes</u>

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	2	1	2	2	2	2	3	3
CO2	3	3	2	2	2	1	2	2	2	2	3	3
CO3	3	2	1	1	1	1	2	1	2	2	3	2
CO4	3	2	1	2	1	1	2	1	2	2	3	2
CO5	3	2	2	2	1	1	2	1	2	2	2	3

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 413
Course title: Stochastic Process and Simulation
Pre-requisite(s):Basics of statistics and probability
Co- requisite(s): ---NIL
Credits: L: 4 T: 1 P: 0 C:5
Class schedule per week: 4 lectures and 1 Tutorial.
Class: IMSc
Semester / Level: VIII / 4
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives: This course enables the students to get the detailed idea about:

1.	Generating functions, Laplace Transforms and their applications
2.	Stochastic process and their classifications
3.	Markov chain and its applications
4.	Poisson process, its postulates and applications; also renewal and diffusion process, Brownian motion
5.	Simulate various probability distributions both discrete and continuous

Course Outcomes: After completion of the course, the learners will be able to:

CO1.	Apply the concept of concept of generating functions and Laplace transforms in real life problems
CO2.	Classify a stochastic process given a real life situation
CO3.	Apply Markov chain in real life problems
CO4.	Apply Poisson other appropriate stochastic process in real life problems
CO5.	Generate variates from discrete and continuous probability distributions and use them in simulation studies

Syllabus

MA413 **Stochastic Process and Simulation** 4-1-0-5

Module I

Generating Function and probability generating function with applications, Laplace transforms (LT), properties and applications of Laplace transforms, Laplace transforms for a random variable. **[10L]**

Module II

Definition of a stochastic process, classification of a stochastic process, applications in queues, birth and death processes, concept of stationarity, Gaussian process. **[10L]**

Module III

Markov chains, order of a Markov chain, classifications of chains and states, applications of Markov chains, Random walk, martingales, gambler's ruin problem. **[10L]**

Module IV

Poisson Process and its postulates, properties and applications, Renewal process, Diffusion process and Brownian motion. **[10L]**

Module V

Simulation: definition, Monte Carlo Simulation, techniques for simulating well known discrete and continuous probability distributions (Binomial, Poisson, discrete uniform, Geometric, Hypergeometric, Negative Binomial, continuous uniform, Normal, exponential, Chi-Square, Cauchy, t, F, Beta 1, Beta 2).

[10L]

Text Books:

1. J. Medhi, Stochastic Processes, New Age International Publishers
2. S. M. Ross, Simulation, Academic Press

Reference Books:

1. S. Karlin and H. M. Taylor, A First Course in Stochastic Processes Academic Press, N.Y.
2. U.N. Bhat and G. K. Miller, Elements of Applied Stochastic Processes, Wiley

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

<u>Course Outcome (CO) Attainment Assessment tools & Evaluation procedure</u>

<u>Direct Assessment</u>

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

<u>Mapping of Course Outcomes onto Program Outcomes</u>

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 414
Course title: Advanced Operations Research
Pre-requisite(s): Optimization Techniques , Introductory statistics, linear algebra and calculus.
Co-requisite(s): -
Credits: L:3 T:1 P:0 C:4
Class schedule per week: 3 Lectures 1 tutorial
Class: IMSc /MSc
Semester: VIII / 4
Branch: Mathematics and Computing/Mathematics
Name of the Faculty:

Course Objectives: This course enables the students to understand

1.	dynamic programming concepts
2.	deterministic as well as stochastic inventory problems
3.	decision making problems under various decision making environments
4.	performance measures of queuing systems
5	non-linear programming concepts

Course Outcomes: After the completion of this course, students will be able to

CO 1	Conceptualize various dynamic programming models and their applications in solving multi-stage decision problems.
CO 2	Determine economic order quantity (EOQ) for minimizing total inventory cost, and handle inventory problems with probabilistic demand to determine EOQ.
CO 3	Make decision under various decision making environments like certainty, risk and uncertainty; and determine strategies to win a game.
CO 4	Analyze various performance measures of queuing systems, and derive those performance measures for single server and multiple server queuing models.
CO 5	Solve constrained optimization problems with equality as well as inequality constraints.

Syllabus

MA414 Advanced Operation Research 3-1-0-4

Module I

Dynamic Programming:

Introduction of Dynamic Programming, Deterministic Dynamic Programming: Forward and Backward Recursion, Selected DP Applications: Cargo load problem, Equipment Replacement Problem, Reliability problem. Solution of linear programming problem by dynamic programming. [9L]

Module II

Inventory Models:

Deterministic Inventory Models: General Inventory Models, Static EOQ models: classical EOQ model (EOQ without shortage), EOQ with shortage, EOQ with price breaks, multi-item EOQ with storage limitations. Dynamic EOQ models: No set-up model; set-up model.

Stochastic Inventory Models: Probabilistic EOQ models; Single period models, Multi period models. [9L]

Module III

Decision Analysis and Games:

Decision making under certainty, Decision making under risk, Decision Tree Analysis, Utility theory, Decision making under uncertainty.

Game Theory: Optimal Solution of Two – person Zero-Sum games, Solution of mixed strategy games. [9L]

Module IV

Queuing Systems:

Queue, Elements of queuing model, Pure Birth and Death Models, Poisson Queuing systems: single server models- $\{(M/M/1):(\infty/FCFS)\}$, $\{(M/M/1):(N/FCFS)\}$, multiple server models-$\{(M/M/S):(\infty/FCFS)\}$, $\{(M/M/S):(N/FCFS)\}$,Non Poisson queuing system (Erlangian service time distribution). [9L]

Module V

Non-linear Programming:

Unconstrained Algorithm: Direct search Method and Gradient Method,Constraint Optimization with equality constraints (Lagrange's Multiplier Method), Constraint Optimization with inequality constraints(Kuhn Tucker Conditions),Quadratic Programming (Wolfe's Method), Separable Programming, Goal Programming. [9L]

Text Books:

1. Hamdy A Taha: Operations Research, Pearson Education.
2. Kanti Swarup,P.K.Gupta and Manmohan: Operations Research, Sultan chand & Sons.

Reference Books:

1. Hiller and Lieberman: Operation Research, McGraw Hill.
2. J.K.Sharma: Operations Research: Theory and applications, Mac-Millan Publishers.
3. S. S. Rao: Engineering Optimization: Theory and Practice, Fourth Edition,John Wiley and Sons.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 415
Course title: Advanced Operations Research Lab
Pre-requisite(s): Knowledge of software like TORA, LINGO, Excel, Matlab
Co-requisite(s): -
Credits: L:0 T:0 P:3 C:1.5
Class schedule per week: 3 Sessionals
Class: IMSc.
Semester/Level: VIII / 4
Branch: Mathematics and Computing
Course Co-ordinator:

List of Assignments:

The following types of problems have to be solved by TORA, LINGO, Excel, or Matlab as applicable:

1. Solution of shortest-route problems.
2. Solution of LPP using dynamic programming.
3. Computation of economic order quantity (EOQ) for deterministic inventory models.
4. Solution of decision making problem under certainty – Analytical Hierarchy Process (AHP)
5. Solution of mixed strategy games by graphical method.
6. Solution of single server (M/M/1) and multiple sever (M/M/S) queuing problems (Poisson queuing systems).
7. Solution of constraint optimization problems with equality constraints.
8. Solution of constraint optimization problems with inequality constraints.
9. Solution of goal programming problems.
10. Solution of quadratic programming problems.

COURSE INFORMATION SHEET

Course code: MA 417

Course title: Numerical Solutions of Boundary Value Problems

Pre-requisite(s): Some background in numerical analysis, Ordinary and partial differential equations

Co- requisite(s): ---

Credits: L: 3 T: 0 P:0 C:3

Class schedule per week: 03 Lectures

Class: IMSc/ MSc

Semester / Level: VIII/4

Branch: Mathematics and Computing / Mathematics

Name of Teacher:

Course Objectives: This course enables the students to understand

1.	various forms of difference operators and approaches of finite difference schemes that can be used to approximate the partial differential equation by a suitable grid function defined by a finite number of grid/ mesh points that lie in the underlying domain and its boundary.
2.	recognize three basic types of partial differential equations viz., Hyperbolic, parabolic and elliptic and understand the best suited techniques to be applied to find the solutions to those equations.
3.	analyses numerical issues such as the stability, condition of convergence and the compatibility of the methods that have been introduced to find the numerical solutions of partial differential equation (s) of specific type.
4.	Visualize connection between mathematical expressions and physical meaning of the problem.

Course Outcomes: After the completion of this course, students will be able to

CO1	classify the partial differential equations and approximate the problems using appropriate finite difference scheme
CO2	obtain simple numerical approximations to the solutions to certain boundary value problems
CO3	analyse the consistency, stability and convergence properties of such numerical methods.
CO4	solve eigenvalues problem and physical problems in engineering
CO5	demonstrate the strength of mathematics in modelling and simulating real world problems of science and engineering

Syllabus

MA417 **Numerical Solutions of Boundary Value Problems** **3-0-0-3**

Module I

Finite Differences: Review of finite difference operators and finite difference methods.

[8L]

Module II

Hyperbolic PDE: Solution of one and two-dimensional wave equation (hyperbolic equations) using finite difference method, and their limitations and error analysis. [8L]

Module III

Parabolic PDE: Concept of compatibility, convergence and stability, stability analysis by matrix method and Von Neumann method, Lax's equivalence theorem, explicit, full implicit, Crank-Nicholson, du-Fort and Frankel scheme, finite difference methods to solve two-dimensional equations with error analysis.

[8L]

Module IV

Elliptic PDE: Five-point formulae for Laplacian, replacement for Dirichlet and Neumann's boundary conditions, curved boundaries, solution on a rectangular domain, block tri-diagonal form and its solution using method of Hockney, condition of convergence. [8L]

Module V

Weighted Residual Methods: Collocation, least squares, Galerkins, Rayleigh-Ritz methods and their compatibility. [8L]

Text Books:

1. L. Lapidus and G.F. Pinder: Numerical Solution of Partial Differential Equations in Science and Engineering, John Wiley, 1982.
2. G.D. Smith: Numerical Solutions to Partial Differential Equations, Oxford University Press, 1986.
3. M.K. Jain, S.R.K. Iyenger and R.K. Jain: Computational Methods for Partial Differential equations, Wiley Eastern, 1994.

Reference Books:

1. C. Johnson: Numerical Solution of Partial Differential Equations by the Finite Element Method, Dover Publications, 2009.
2. H.P. Langtangen: Computational Partial Differential Equations, Springer Verlag, 1999.
3. C.F. Gerald, and P.O. Wheatly: Applied Numerical Analysis, Addison-Wesley Publishing, 2002

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 501
Course title: Functional Analysis
Pre-requisite(s): Basics of Real Analysis and Linear Algebra
Co- requisite(s): ---
Credits: L: 3 T: 1 P: 0 C:4
Class schedule per week: 3 Lectures, 1 Tutorials
Class: IMSc/MSc
Semester / Level: IX/5
Branch: Mathematics and Computing/Mathematics
Name of Teacher:

Course Objectives: This course enables the students to understand

1.	Extension of concepts of Real analysis and Linear Algebra
2.	Different Linear Spaces and their applications
3.	Extension of Eigen values and Eigen functions in Banach Spaces and Hilbert spaces.
4.	Concepts of Bounded Linear operators on Hilbert spaces
5	Concepts on Hilbert Space

Course Outcomes: After the completion of this course, students will be able to

CO1.	Apply the theory of functional analysis in the qualitative study of different mathematical models in Biological and Ecological systems and different engineering problems.
CO2.	This will help the students to study the stability theory of Differential equations and difference equations
CO3	Understand the concept of topology in real world problems.
CO4.	Applications of topological approach in the study of solutions of Difference Equations in different boundary value problems arising in Biological and Ecological systems and different engineering problems.
CO5	Use of topological concepts in Architecture Engineering.

Syllabus

MA501 **Functional Analysis** **3-1-0-4**

Module I

Preliminaries: Relation on a set, function, equivalence relation, partial order relation, partial order set, maximal, totally ordered set, Zorn's lemma, Axiom of choice.

Introduction to linear spaces, linear maps, convex, span of a set, linearly dependent and independent set, finite and infinite dimensional linear spaces, quotient spaces, linear map, zero space, null space, zero map, linear functional, hyperspace, hyperplane.

Metric space and continuous functions: Definition and examples, Holder inequality, Minkowski inequality, open sets, separable metric spaces, Cauchy sequence, complete metric space, Baire theorem, Compactness, Heine-Borel theorem, Continuity of functions, Uryshon's lemma, Tietze's Extension theorem, Ascolli's theorem. [10L]

Module II

Normed Linear Space: Normed linear spaces over R and C, Definitions and examples including N/M where M is a closed subspace of N and ||x+M||=inf{||x+M: x ϵM}. With normed linear spaces N and N' over same scalars: N→N' continuous bounded linear maps and equivalent formulations of continuous linear maps. Norm in B(N,N') and equivalent descriptions. N* (dual of N) and functionals on N, equivalence of norms, special features of finite dimensional normed linear spaces, convexity, Riesz lemma, Hahn-Banach extension theorem and its applications, Natural embedding of N and N*, to find l_p^*, C_0^* and C*[0,1]. [10L]

Module III

Banach Space: Definition and examples together with N/M and B(N,N'), Open mapping theorem, Projection on Banach space, closed Graph theorem, Uniform bounded theorem, conjugate of an operator on a normed linear space, Properties of T→T* maps. [7L]

Module IV

Hilbert spaces: Inner product spaces, Polarization identity, Jordan Von-Neumann theorem, Parallelogram law, Schwarz's inequality. Hilbert space, orthonormal set, Pythagoras theorem, The Gram-Schmidt orthogonalization theorem, Bessel inequality, Orthonormal basis, Fourier expansion and Parseval's formulae.

Projection theorem, Riesz Representation theorem, unique Hanh- Banach extension theorem. [8L]

Module V

Operators on a Hilbert space : Adjoint of an operator on a Hilbert space (existence and uniqueness), properties of Adjoint, Self Adjoint operator and its characteristics and positive operator, real and imaginary parts of an operator: Normal operator and Unitary operator together with their characterization, Projection operator, Invariance and Reducibility, Orthogonal projections and sum of projections on closed subspaces of H, Matrix of an operator on a finite dimensional H, Spectral theorem for finite dimensional H. [10L]

Text Books:

1. B. V. Limaye, Functional Analysis, Revised Third Edition, New Age International Ltd., New Delhi.

Reference Books:

1. Erwin Kreyszig, Introductory functional analysis with applications, John Wiley and Sons, New York, 1978.
2. M.T. Nair, Functional Analysis: A first course,PHI learning pvt. Ltd. 2010.
3. J. B. Conway, A course in Functional Analysis, Springer Verlag, New York, 1985.
4. P. R. Halmos, A Hilbert space problem book, Van Nostrand, Princeton, New Jersey, 1967.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	2	1	2	2	2	2	3	3
CO2	3	3	2	2	2	1	2	2	2	2	3	3
CO3	3	2	1	1	1	1	2	1	2	2	3	2
CO4	3	2	1	2	1	1	2	1	2	2	3	2
CO5	3	2	2	2	1	1	2	1	2	2	2	3

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 502
Course title: Number Theory
Pre-requisite(s): Modern Algebra, Linear Algebra
Co- requisite(s): ---NIL
Credits: L: 3 T: 1 P: 0 C:4
Class schedule per week: 3 Lectures, 1 Tutorials
Class: IMSc.
Semester / Level: IX / 5
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives : This course enables the students to

1.	identify and apply various properties of integers including factorization, the division algorithm, and greatest common divisors. This course also enables students to identify certain number theoretic functions and their properties.
2.	understand the concept of a congruence, Chinese Remainder Theorem, Euler's Theorem, Fermat's Theorem. It also enables students to solve certain types of Diophantine equations, Pelle's equation and its relation to continued fraction
3.	Understand the concept of primitive roots for primes, Legendre Symbol, Jacobi Symbol
4.	identify how number theory is related to cryptography

Course Outcomes : After the completion of this course, students will be able to

CO 1	apply the number theory to specific research problems in mathematics or in other fields.
CO 2	Use Fermat's, Euler's and Chinese remainder theorems to solve congruence equations arise in various research problems
CO 3	solve Pell's equation with the use of continued fraction, and learn how to find primitive roots
CO 4	use Primality test and factorization algorithm to factor large composite numbers.
CO 5	learn how to apply number theory in various research problems arising in cryptography.

Syllabus

MA502 **Number Theory** **3-1-0-4**

Module I

Divisibility: basic definition, properties, prime numbers, some results on distribution of primes, Division algorithm, greatest common divisor, Euclid's Lemma, Euclidean Algorithm, fundamental theorem of arithmetic, the greatest common divisor of more than two numbers. Arithmetic functions and properties: Mobius function $\mu(n)$, Euler's totient function $\phi(n), \sigma(n), \tau(n), d(n)$ Mobius inversion formula. [9L]

Module II

Congruences: definitions and basic properties, residue classes, Reduced residue classes, complete and Reduced residue systems, Fermat's little Theorem, Euler's Theorem, Wilson's Theorem, Algebraic congruences and roots. Linear congruences, Chinese Remainder theorem and its applications. Polynomial congruences: Meaning of "divisor" modulo n, root and divisor. Theorem of Lagrange on polynomial congruence modulo p. Application of Taylor's series for polynomial congruence modulo prime power. Primitive roots: A property of reduced residue system belonging to an exponent modulo m, primitive roots, existence and number of primitive roots of a prime. [10L]

Module III

Quadratic Number fields: Integers, Units, Primes and irreducible elements, Failure of unique factorization, simple continued fractions: finite and infinite, linear Diophantine equations, Pell's equation via simple continued fraction. [9L]

Module IV

Primality Testing and factorization algorithms, Pseudo-primes, Fermat's pseudo-primes, Pollard's rho method for factorization. Euler's criterion, quadratic residue, Legendre and Jacobi Symbol and their properties, Evaluation of (-1/p) and (2/p), Gauss's Lemma, Quadratic reciprocity law. [9L]

Module V

Public Key cryptography, Diffie-Hellmann key exchange, Discrete logarithm-based cryptosystems, RSA crypto-system, Rabin crypto-system, Knapsack crypto-system, Paillier crypto-system, Introduction to elliptic curves: Group structure, Rational points on elliptic curves, Elliptic Curve Cryptography: applications in cryptography and factorization. [8L]

Text Books

1. Apostal T.M.: Introduction to Analytic Number Theory, Springer-Verlag
2. Burton D.M.: Elementary Number Theory, Tata McGraw-Hill Publishing Company
3. Douglas R. Stinson: Cryptography Theory and Practice, Chapman and Hall/CRC

Reference Books

1. Niven, Zuckerman H.S. and Montgomery H.L.: An Introduction to the Theory of Numbers, Wiley,
2. Hardy G.H and Wright E.M.: An Introduction to the Theory of Numbers, Fifth Ed., Oxford University Press.
3. George E. Andrews: Number Theory, HPC.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
End Semester Examination	√	√	√	√	√
Quiz (s)	√	√	√	√	√
Assignment	√	√	√	√	√
Seminar	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	3	3	3	2	2
CO2	3	3	3	3	1	1	1	3	3	3	2	2
CO3	3	3	3	3	1	1	1	3	3	3	2	2
CO4	3	3	3	3	1	1	1	3	3	3	2	2
CO5	3	3	3	3	1	1	1	3	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 513
Course title: Computing Lab (MAT Lab)
Pre-requisite(s):
Co- requisite(s): ---
Credits: L: 0 T: 0 P:3 C:1.5
Class schedule per week: 3 Sessionals
Class: IMSc
Semester / Level: IX / 5
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives: This course enables the students to understand:

1.	The main features of the MATLAB integrated design environment and its user interfaces.
2.	About MATLAB commands, with an emphasis on creating variables, accessing and manipulating data in variables, and creating basic visualizations. Collect MATLAB commands into scripts for ease of reproduction and experimentation.
3.	How to use MATLAB to compute the numerical solution of the nonlinear equations, system of ODEs, solving linear system and curve fitting.

Course Outcomes : After the completion of this course, students will be able to:

CO1	perform mathematical calculations with vectors. Use MATLAB syntax to perform calculations on whole data sets with a single command.
CO2	organize scripts into logical sections for development, maintenance, and publishing.
CO3	use matrices as mathematical objects or as collections of (vector) data.
CO4	understand the appropriate use of MATLAB syntax to distinguish between these applications.
CO5	Solve the numerical analysis problems.

Syllabus

MA513 **MATLAB** **0-0-3-3**

List of Assignments

1. **Handling Variables and Creating Scripts.**
2. **Basic Maths in MATLAB**: addition, multiplication, subtraction and powers-operation precedence-Computing GCD, LCM, Permutations and Prime numbers-Trignometric functions-Set operations (Union, intersection, complement and others)-Vectors and Matrices-Handling random numbers-cross product and dot product-Basic logical Opertaions.
3. **Operations on Matrices:** Determining unique elements, Determining membership of elements to a matrix, Shifting Matrix Elements, Determinant, inverse and diagnal elements, Data selection with the colon operator, Relational operations, Commonly used Matrices, Sorting matrix values, Size and length functions, Concatenating Matrices, Finding non-zero elements, Frequency of values within a vector.
4. **Advance Math Functions with Symbolic Data Type:** Symbolic variables-Differentiation and Integration using symbolic variables-Solving Equations -Symbolic Functions
5. **Interacting with MATLAB and Graphics:** Input output commands-More input output commands -Plotting data-Plotting 3-D data-More on plotting options: axis, grid, gtext, legend, text, xlabel, ylabel, title.
6. **Importing Data into MATLAB:** Importing data from excel into MATLAB**-**Importing data in different formats.
7. **MATLAB Programming:** While Loop**,** For Loop, while loop, If-Else – Elseif, `try/catch` statements, Switch Case Otherwise Statement. Creating a Simple MATLAB Function, Using MATLAB Functions in Scripts, Using Functions in the Command Window, Adding Functions in a Script, Anonymous Functions
8. **Making your own functions: Creating Custom built Functions-**Functions with inputs-Functions with multiple inputs and outputs-Returning from a function
9. **Application :**Root finding methods to solve nonlinear equations: Bisection, Secant, Newton-Raphshon, modified newton method.
10. Solving Ordinary Differential Equations with MATLAB: ode45, ode23, ode113, ode15s.
11. Use matrix methods to solve systems of linear equations and perform eigenvalue decomposition.
12. **Interpolation and Approximation Methods:** Lagrange Interpolation, Piecewise Linear Interpolation, Raised Cosine Interpolation, Least Squares Approximation.

Text Book:

1. Jaan Kiusalaas, Numerical Methods in Engineering with MATLAB, Second Edition,2009
2. Steven Chapra, Applied Numerical Methods With MATLAB for Engineers & Scientists, 3rd Edition, McGraw-Hill Science Engineering Math, 2011

COURSE INFORMATION SHEET

Course Code : CA 601
Course title: Computer Graphics
Pre-requisite(s): Data Structures and Programming skills
Co- requisite(s):
Credits: L:3 T:0 P:0 C:3
Class schedule per week: 3 Lectures
Class: MCA/IMSc
Semester / Level:V, IX/6
Branch: MCA/IMSc

Course Objectives : This course enables the students :

1.	To understand different hardware used for graphical requirement
2.	To perform visual computations for geometrical drawings.
3.	To display 3D objects in a 2D display devices using projection techniques
4.	To model 3D
5.	To create realistic images using color and shading techniques

Course Outcomes : After the completion of this course, students will be:

CO1	Able to understand different hardware used for graphical requirement.
CO2	Able to perform visual computations for geometrical drawings.
CO3	Able to display 3D objects in a 2D display devices using projection techniques
CO4	Able to model 3D objects
CO5	Able to create realistic images using color and shading techniques

Syllabus

CA 601 Computer Graphics 3-0-0-3

MODULE -I

Introduction: Image Processing as Picture Analysis, The Advantages of Interactive Graphics, Representative Uses of Computer Graphics, Classification of Applications, Development of Hardware and Software for Computer Graphics, Conceptual Framework for Interactive Graphics.

Basic Raster Graphics Algorithms for Drawing 2D Primitives: Overview, Scan Converting Lines, Scan Converting Circles, Scan Converting Ellipses, Filling Rectangles, Filling Polygons, Filling Ellipse Arcs, Pattern Filling, Thick Primitives, Line Style and Pen Style, Clipping in a Raster World, Clipping Lines, Clipping Circles and Ellipses, Clipping Polygons, Generating Characters, SRGP_copyPixel, Antialising. [9L]

Module- II

Graphics Hardware: Hardcopy Technologies, Display Technologies, Raster-Scan Display Systems, The Video Controller, Random-Scan Display Processor, Input Devices for Operator Interaction, Image Scanners.

Geometrical Transformations: 2D Transformations, Homogeneous Coordinates and Matrix Representation of 2D Transformations, Composition of 2D Transformations, The Window-to-View port Transformation, Efficiency, Matrix Representation of 3D Transformations, Composition of 3D Transformations, Transformations as a Change in Coordinate System. [9L]

Module- III

Viewing in 3D: Projections, Specifying an Arbitrary 3D View, Examples of 3D Viewing, The Mathematics of Planar geometric Projections, Implementing Planar Geometric Projections, Coordinate Systems. [9L]

Module -IV

Input Devices, Interaction Techniques, and Interaction Tasks: Interaction Hardware, Basic Interaction Tasks, Composite Interaction Tasks.

Representation Curves and Surfaces : Polygon Meshes, Parametric Cubic Curves, Parametric Bicubic Surfaces, Quadric Surfaces.

Achromatic and Colored Light: Achromatic Light, Chromatic Color, Color Models for Raster Graphics, Reproducing Color, Using Color in Computer Graphics. [9L]

Module-V

The Quest for Visual Realism: Why Realism?, Fundamental Difficulties, Rendering Techniques for Line Drawings, Rendering Techniques for Shaded Images, Improved Object Models, Dynamics, Stereosis, Improved Displays, Interacting with Our Other Senses, Aliasing and Antialiasing.

Visible-Surface Determination: Functions of Two Variables, Techniques for Efficient Visible-Surface Algorithms, Algorithms for Visible-Line Determination, The z-Buffer Algorithms, List-Priority Algorithms, Area-Subdivision Algorithms, Algorithms for Octress, Algorithms for Curved Surfaces, Visible-Surface Ray Tracing.

Illumination and Shading: Illumination Models, Shading Models for Polygons, Surface Detail, Shadows, Transparency, Inter object Reflections, Physically Based Illumination Models, Extended Light Sources, Spectral Sampling. [9L]

Text Book:

1. Foley, Dam Van, Feiner, Hughes "Computer Graphics Principles & Practice", 11th Edition., Pearson Education, New Delhi, 2004.

Reference Book:

1. Hearn D. & Baker M.P. "Computer Graphics", PHI, New Delhi, 2006.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
End Semester Examination	√	√	√	√	√
Quiz (s)	√	√	√	√	√
Assignment	√	√	√	√	√
Seminar	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	1	1	2	1	1	1	1	2
CO2	1	1	2	3	3	1	1	1	1	2	2	2
CO3	3	1	2	1	2	3	2	1	1	1	1	2
CO4	2	3	3	3	2	1	1	2	2	1	1	2
CO5	3	1	2	2	1	1	1	1	1	2	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course Code : CA 602
Course title: Computer Graphics Lab
Pre-requisite(s): Data Structures and Programming skills
Co- requisite(s):
Credits: L:3 T:0 P:0 C:3
Class schedule per week: 3 Lectures
Class: MCA/IMSc
Semester / Level:V, IX/6
Branch: MCA/IMSc

SYLLABUS

List of Programs as Assignments:

1. **Lab Assignment No: 1**

Objective: To write a C program for drawing a line and to display the pixel positions using digital differential Analyser (DDA) algorithm.

Q1. Write a program To Draw a line using DDA Algorithm

2. **Lab Assignment No: 2**

Objective: To write a C program for drawing a line and to display the pixel positions using Bresenham line drawing algorithm

Q1. WAP to draw a line using Bresenham line drawing algorithm

3. **Lab Assignment No: 3**

Objective: To write a C program for drawing a circle using midpoint circle algorithm.

Q1. To draw a circle using midpoint circle algorithm.

4. **Lab Assignment No: 4**

Objective: To write a C program for drawing an ellipse.

Q1. WAP to draw an ellipse using midpoint ellipse algorithm.

5. **Lab Assignment No: 5**

Objective: To write a C program to set attributes.

Q1. WAP to set attributes to line, circle and ellipse

6. **Lab Assignment No: 6**

Objective: To write a C-Program to perform various 2D-Transformations.

Q1. write a C-Program to perform Translations, Scaling, Rotations, Reflection, Shear

7. **Lab Assignment No: 7**

Objective: To write a C-Program to perform various 2D composite transformations

Q1. WAP to show 2D transformations.

8. **Lab Assignment No: 8**

Objective: To write a C-program to perform line clipping

Q1. write a C-program to perform line clipping using Cohen Sutherland line clippingalgorithm

9. **Lab Assignment No: 9**

Objective: To write a C-program to perform polygon clipping

Q1. write a C-program to perform polygon clipping using Sutherland Hodgeman polygon clipping algorithm

10. **Lab Assignment No: 10**

Objective: Use OpenGL which is a software interface that allows you to access the graphics hardware without taking care of the hardware details or which graphics adapter is in the system.

Q1. To identify the basic blocks for a given program.

Q2. To execute basic operations in OPENGL.

11. **Lab Assignment No: 11**

Objective: IMPLEMENTATIONOF 3D OBJECTS USING OPENGL

Q1. To write a program using OPENGL for displaying a three-dimensional objects.

12. **Lab Assignment No: 12**

Objective: Implementation of 3d Scenes Using OPENGL

Q1. To write a program using OPENGL concept for displaying a three-dimensional scene.

13. **Lab Assignment No: 12**

Objective: Implementation of 3d Transformation using OPENGL

Q1. To write a c program for performing3D transformation using OPENGL

Text Book:

2. Foley, Dam Van, Feiner, Hughes "Computer Graphics Principles & Practice", 11th Edition., Pearson Education, New Delhi, 2004.

Reference Book:

2. Hearn D. & Baker M.P. "Computer Graphics", PHI, New Delhi, 2006.

Detail Course Structures
of
PROGRAM SPECIFIC ELLECTIVES (PE)

COURSE INFORMATION SHEET

Course code: MA 304
Course title: Tensor Analysis
Pre-requisite(s): Vector Analysis
Co- requisite(s): ---
Credits: L: 3 T: 1 P: 0 C:4
Class schedule per week: 3 Lectures 1 Tutorial
Class: IMSc.
Semester / Level: V / 3
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives

This course enables the students to understand

1.	tensors, difference between contravariant and covariant tensors and their algebraic properties
2.	importance of Riemannian metric in n – dimensional space, calculus of tensors in Riemannian space
3.	derivatives of covariant and contravariant tensors, along with concept of gradient, divergence and curl in Riemannian space
4.	special types of tensors like curvature, Ricci tensor etc. and different properties associated with them
5.	realm of geodesics and applications of tensors analysis in diverse fields

Course Outcomes

After the completion of this course, students will be able to

CO1.	understand tensors and its difference with scalars and vectors
CO2.	demonstrate the properties associated with covariant and contravariant tensors
CO3.	develop the understanding of Riemannian space and its properties of tensors in it
CO4.	gain an understanding to solve problems with the use of tensors to diverse situations in mathematical contexts
CO5.	work efficiently in multi - disciplinary research areas of sciences and engineering

Syllabus

MA 304 **Tensor Analysis** **3-1-0-4**

Module I

Tensor Algebra: Preliminaries: systems of different orders, indicial and summation convention, Kronecker symbols. Introduction to tensors, n – dimensional space, transformation of coordinates, invariants, covariant vectors, contravariant vectors, second order contravariant, covariant and mixed tensors, Higher order tensors, Zero tensor, Tensor field. Addition and Subtraction of tensors, Equality of tensors, Symmetric and Skew Symmetric tensors, Contraction, Multiplication of tensors – Outer Product, Inner Product, Quotient Law, Conjugate (Reciprocal) tensors of second order. [10L]

Module II

Tensor Calculus: Line Element, Riemannian metric, fundamental metric tensor and its properties, Riemannian space, Conjugate (or reciprocal) of fundamental metric tensor, Associated Tensors, Length of a curve, Magnitude of a vector, Angle between vectors, Orthogonality. Christoffel symbols of first and second kind, Properties of Christoffel Symbols, Law of transformation of Christoffel symbols of first and second kind. [10L]

Module III

Covariant Differentiation: Covariant Differentiation of Covariant and Contravariant vectors, Covariant differentiation of second and higher order tensors, Properties of covariant differentiation, Ricci's theorem, gradient, divergence and curl in tensorial forms, intrinsic derivative. [9L]

Module IV

Curvature Tensors: Riemann Christoffel tensor, Curvature tensor, properties of Riemann – Christoffel Curvature tensor, Bianchi identities, Ricci tensor, Riemannian curvature, Flat space, space of constant curvature, Einstein space, Einstein tensor. [8L]

Module V

Geodesics: Introduction to calculus of variations, Euler conditions, geodesics, differential equations of geodesics, Riemannian and geodesic coordinates, Parallelism, applications of tensor analysis. [8L]

Text Books:

1. Barry Spain, Tensor Calculus: A Concise Course, Dover Publications, New York, 2003.
2. David Kay, Schuam's Outline of Tensor Calculus, Tata Mcgraw Hill Publishers, 2011.

Reference Books:

1. L.P. Eisenhart, Riemannian Geometry, Princeton University Press, 1949.
2. J.G. Simmonds, A Brief on Tensor Analysis, Springer - Verlag Publishers, 1982.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Semester Examination	25
End Semester Examination	50
Quiz (s)	10+10
Assignment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
End Semester Examination	√	√	√	√	
Quiz (s)	√	√	√		
Assignment	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 305
Course title: Graph Theory
Pre-requisite(s): MA205
Co- requisite(s):
Credits: 4 L:3 T:1 P:0 C:4
Class schedule per week: 03 Lectures, 1 tutorial
Class: IMSc.
Semester / Level: V / 3
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives : This course enables the students to:

1.	cover basic concepts in graph theory and a variety of different problems in Graph Theory.
2..	come across a number of theorems and proofs. Theorems will be stated and proved formally using various techniques.
3.	gain the knowledge of Various graphs algorithms will also be taught along with its analysis.
4.	apply graph theory based tools in solving practical problems.

Course Outcomes: After the completion of this course, students will be able to:

CO1	have a strong background of graph theory..
CO2	Solve the problems of graph theory using graph algorithms
CO3	identify the real life problems in terms of graph theory
CO4	apply computer programs (e.g. SAGE) to study graphs.
CO5	apply graph theory in the areas of computer science, operation research, biology, chemistry, physics, sociology, and engineering

Syllabus

MA 305 Graph Theory 3-1-0-4

Module I

Introduction to Graphs: Definition of a Graph, Finite and Infinite Graphs, Incidence of vertices and edges, Types of Graphs, Sub Graphs, Digraphs, Bipartite Graphs, Isomorphism of Graphs, Degrees of Vertices, Handshaking Lemma, walks, Trail, Paths and Connectedness. [9L]

Module II

Matrix representation of Graphs: Adjacency Matrix, Incidence Matrix. Connectivity: Cut vertex, Cut edge, Vertex connectivity, and Edge connectivity. [9L]

Module III

Eulerian Graphs, Hamiltonian Graphs, Necessary condition for Hamiltonian Graph, Ore's Theorem, Dirac's Theorem, Operations on Graphs: Union of Graphs, Intersection of Graphs and Join of Graphs. [9L]

Module IV

Graph Colorings: Vertex Coloring, Chromatic number, Edge Coloring, Chromatic Index, Chromatic Polynomials. Planarity: Definition, Euler's Formula and its consequences, Kuratowski's Theorem and it's applications. [9L]

Module V

Trees: Definition, Directed Tree, Rooted Tree, Binary Tree, Characterization and Simple Properties, Diameter of graph, Radius of graph, Center of graph, Spanning trees, Minimal Spanning trees, Kruskal's, Prim's and Dijkstra's Algorithms. [9L]

Text Books:

1. **Arumugam, S**. *Invitation to graph theory*. Scitech Publications Ind, 2006.
2. **Balakrishnan, Rangaswami, and Kanna Ranganathan**. *A textbook of graph theory*. Springer Science & Business Media, 2012.
3. **West, Douglas Brent**. *Introduction to graph theory*. Vol. 2. Upper Saddle River: Prentice hall, 2001.
4. **B. K. Sarkar, S. K. Chakraborty**, *Combinatorics and Graph Theory*, Prentice Hall India Learning Private Limited, New Delhi, 2016.

Reference Books:

1. **Harary, Frank**. "*Graph theory"*. 1969.
2. **Bondy J. A. and Murty U. S. R**., *"Graph Theory"*, Springer, 2011
3. **Deo N.,** *"Graph Theory with Applications to Engineering and Computer Science"*, Prentice Hall India, 2004
4. **Deistel R.,** "Graph Theory", Springer (4th Ed.) 2010

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course outcome (co) attainment assessment tools & evaluation procedure

Direct assessment

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

Mapping of course outcomes onto program outcomes

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: MA 306
Course title: Special Functions
Pre-requisite(s): Ordinary differential equations
Credits: L:3 T:1 P:0 C:4
Class schedule per week: 3 lectures, 1 Tutorial
Class: IMSc.
Semester/level: V/ 3
Branch: Mathematics and Computing
Name of the Faculty:

Course Objectives_: This course is intended as a basic course enables the students to get the detailed idea about:

1.	Orthogonal set of functions, its orthogolization. Sturm-Lioville Problem, eigen functions and its properties.
2.	hypergeometric function, the most general of all the special functions.
3.	the Hermite polynomials and Laguerre polynomials with their properties.
4.	Chebyshev polynomials with their properties.

Course Outcomes: After completion of the course, the learners will be able to:

CO1.	Deal with the problem of evaluating the solution of differential equations arise in real world phenomenon where the solutions are not in terms of elementary functions , which leads to the series solutions, new functions as special functions.
CO2.	Use the Hermite polynomials and its result in solving problems related to quantum-mechanical harmonic oscillator. Use the Laguerre polynomials and its result in solving problems related to quantum-mechanical study of the hydrogen atom, transmission line theory and seismological investigations.
CO3	Use Chebyshev polynomials in polynomial approximations to arbitrary functions, and also in electrical circuit theory.
CO4.	use the principal results concerning special functions likely to be encountered in applications to the particular context in which they arise.
CO5.	equip the students with standard concepts and tools at an intermediate to advanced level that will serve them well towards tackling more advanced level of mathematics

Syllabus

MA306 **Special Functions** 3-1-0-4

Module I

Orthogonal Set of Functions: Introduction, Definitions, Orthogonal Functions, Gram-Schmidt Process of Orthogolization, Orthogonality with respect to Weight Function, Orthonormal set of Functions with respect to weight Function, Application of Orthogonality(Generalised Fourier Series and Fourier constants), Sturm-Lioville Problem, Eigen Functions, Properties of Eigen-Function and Eigen values.
[10L]

Module II

Hypergeometric Functions: Introduction, Hypergeometric Differential Equation, Simple and Quadratic Transformations of Hypergeometric Function, Generalised Hypergeometric Function, Integrals involving Generalised Hypergeometric Function, Some Special Generalised Hypergeometric Functions. [10L]

Module III

Hermite Polynomials: Introduction, Solution of Hermite's Differential Equation, Hermite Polynomials, Generating Function, Value of $H_n(x)$ and its Derivative at $x = 0$, Rodrigues Formula for $H_n(x)$, First Few Polynomials, Recurrence Relations for $H_n(x)$, lntegral Representation of Hermite Polynomial, Orthogonal Properties of $H_n(x)$. [9L]

Module IV

Laguerre Polynomials: Introduction, Solution of Laguerre's Differential Equation, Generating Function, Generating Function, Rodrigues Formula for $L_n(x)$, Recurrence Relations, Laguerre Polynomials for particular values of n and x, Orthogonal Property of $L_n(x)$, Integral relations of $L_n(x)$. [8L]

Module V

Chebyshev Polynomials: Introduction, Independent Solutions of Chebyshev's Equation, Expansion of $T_n(x)$ and $U_n(x)$, Generating Functions, Recurrence Relations, Evaluation of $T_n(x)$ and $U_n(x)$ for given values of n, Orthogonal Properties of $T_n(x)$ and $U_n(x)$, A brief Exposure of Advanced Special Function like, Elliptic Functions, Mathieu Functions, Spheroidal Functions etc. [8L]

Text Books:

1. W. W. BELL , Special Functions For Scientists And Engineers , D. Van Nostrand Company Ltd, 1968
2. Nico M. Temme, Special Functions: An Introduction to the Classical Functions of Mathematical Physics, John Wiley & Sons, Inc., 1996

Reference Books:

1. Special Functions and Their Applications. N. N. Lebedev. Translated from the revised Russian ed. (Moscow, 1963) by Richard A. Silverman. Prentice-Hall, Englewood Cliffs, N.J., 1965.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

<u>Course outcome (co) attainment assessment tools & evaluation procedure</u>

<u>Direct assessment</u>

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

<u>Mapping of course outcomes onto program outcomes</u>

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: MA 307

Course title: **Computational Linear Algebra**

Pre-requisite(s): **Basics of differential Calculus and integral Calculus**

Credits: **L:3 T:0 P:0 C:3**

Class schedule per week: **3 Lectures**

Class: IMSc.

Semester/level: **V/3**

Branch: **Mathematics and Computing**

Name of the Faculty:

Course Objectives : This course is intended as a basic course enables the students to get the detailed idea about:

1.	various methods and iterative process to solve linear system of equations
2.	the fundamental properties of eigenvalues, eigenvectors of matrix theory
3.	the principles behind the iterative algorithms for computing eigenvalues
4.	the basic ideas of QR algorithm

Course Outcomes: After the completion of this course, students will be able to

CO1	apply the computational techniques and algebraic skills to various types of research problems science and engineering
CO2	transform matrices into triangular, Hessenberg, tri-diagonal, or unitary form using elementary transformations arising from ODEs and PDEs
CO3	locate and estimate the eigenvalues of a square matrix using Gerschgorin bounds, power method, Rayleigh quotient iteration
CO4	compute the SVD, polar decomposition of singular matrices
CO5	apply various direct and iterative method to solve the system of equations.

Syllabus

MA307 **Computational Linear Algebra** **3-0-0-3**

Module I

Basic concept of a linear system of equations. Direct methods: Gauss elimination method, partial and complete pivoting, Gauss-Jordan method, LU decompositions, Cholesky method, Partition method, Vector and matrix norms, condition numbers, estimating condition numbers, significant digit, floating point arithmetic, analysis of round off errors. [8L]

Module II

Iterative methods: General iteration method, Jacobi and Gauss-Seidel iteration methods, Successive over relation method (SOR), convergence analysis of iterative methods and optimal relaxation parameter for the SOR method. [8L]

Module III

Gram-Schmidt orthonormal process, orthogonal matrices, Householder transformation, Givens rotations, QR factorization, round off error analysis of orthogonal matrices, stability of QR factorization. [6L]

Module IV

Solution of linear least squares problems, singular value decomposition (SVD), polar decomposition, Moore-Penrose inverse and rank deficient least squares problems. Reduction to Heisenberg and tri-diagonal forms. [6L]

Module V

Eigen values and Eigen vectors: Bounds on eigenvalues, Gerschgorin bounds, Jacobi, Givens, Householder's methods for symmetric matrices. Dominant and smallest Eigen values/Eigen vectors by power method, Rayleigh quotient iteration, explicit and implicit QR algorithms for symmetric and non-symmetric matrices, implementation of implicit QR algorithm, computing the SVD, sensitivity analysis of singular values and singular vectors, the Arnoldi and the Lanczos iterations. [12L]

Text Books:

1. G.W. Stewart: Introduction to Matrix Computations, Academic Press
2. M.K. Jain, S.R.K. Iyengar, R.K. Jain: Numerical Methods, Problems and Solutions, New Age International
3. S.S. Sastry: Introductory Methods of Numerical Analysis, PHI learning .
4. C. L. Byrne: Applied and Computational Linear Algebra, A First Course, CRC

Reference Books:

1. G.H. Golub, C.F.Van Loa: Matrix Computation, John Hopkins U. Press, Baltimore
2. J.W. Demmel: Applied Numerical Linear Algebra, SIAM, Philadelphia
3. D.S. Watkins: Fundamentals of Matrix Computations, Willey

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course outcome (co) attainment assessment tools & evaluation procedure

Direct assessment

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

Mapping of course outcomes onto program outcomes

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: MA 308
Course title: Difference Equations
Pre-requisite(s): Sequence and Series of numbers and functions.
Co- requisite(s): ---
Credits: L: 3 T: 0 P: 0 C:3
Class schedule per week: 3 Lectures
Class: IMSc
Semester / Level:V/ 3
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives: This course enables the students to understand

1	application of sequences and series of numbers and functions.
2	partial difference equations
3.	Discrete boundary value problem.
4.	Application with different engineering problem.
5.	Discrete mathematical models.

Course Outcomes: After the completion of this course, students will be able to

CO1.	apply the theory to study the qualitative theory of solutions of difference equations and partial difference equations of higher order.
CO2.	Apply the theory to study the quantitative and qualitative study of solutions of different discrete models in Engineering and Biology and Ecology.
CO3.	Difference between the qualitative and quantitative behaviour of solutions of the difference equations and the corresponding differential equations.
CO4	Apply the theory to study the solution in discrete boundary value problems.
CO5	Under discrete population dynamics.

Syllabus

MA308 **Difference Equations** **3-0-0-3**

Module 1

The Difference Calculus: Genesis of difference equations, Definitions, derivation of difference equations, existence and uniqueness theorem, Operators Δ and E, Elementary difference operators, factor polynomials, Operator Δ^{-1} and the sum calculus. [8L]

Module II

First Order difference equations: Introduction, General linear equations with examples, equations of the forms $y_{k+1}=R_k y_k$ and $y_{k+1}-y_k=(n+1)k^n$ with examples, Continued fractions, A general first-order equations: Geometrical methods and expansion techniques. [8L]

Module III

Linear Difference equations: Introduction, Linearly dependent functions, fundamental theorem for homogeneous equations, Inhomogeneous equations, second order equations, Sturm-Liouville difference equations. [8L]

Module IV

Linear Difference equations (Contd…): Homogeneous equations: Construction of difference equation having specified solutions, relationship between linear difference and differential equations.
Inhomogeneous equations: Method of undetermined coefficients and separation method.
The z-transform method. [8L]

Module V

Linear Partial Difference equations: Introduction, symbolic methods, Lagrange's and separation of variables, Laplace method, Particular solution, Simultaneous equations with constant coefficients.
[8L]

Text Books:

1. R. E. Mickens, Difference Equations: Theory, Applications and Advanced Topics, CRC Press, Third Edition, 2015.

Reference Books:

1. W. G. Kelley and Allan C. Peterson, Difference Equations: An Introduction with Applications, Academic Press, Second Edition, 2001
2. Saber Elaydi, An Introduction to Difference Equations, Third Edition, Springer, New York, 2005.
3. Kenneth S. Miller, An Introduction to the Calculus of Finite Differences and Difference Equations, Dover Publications, New York, 1960.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course outcome (co) attainment assessment tools & evaluation procedure

Direct assessment

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	√

Indirect assessment –

1. Student feedback on course outcome

Mapping of course outcomes onto program outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	1	2	2	3	3	2
CO2	3	3	3	2	2	1	1	2	3	2	2	3
CO3	3	3	3	3	1	1	1	2	3	2	2	3
CO4	3	2	2	3	1	1	1	1	2	2	2	3
CO5	3	3	2	2	1	1	1	1	2	2	2	3

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: CS322
Course title: Simulation and Modelling
Pre-requisite(s): Discrete Mathematics
Co- requisite(s):NIL
Credits: L: 3 T:0 P:0 C:3
Class schedule per week: 3 Lectures
Class: B. Tech/ IMSc
Semester / Level: V/3
Branch: CSE/IT/IMSc

Course Objectives : This course enables the students:

1.	To Characterise engineering systems in terms of their essential elements, purpose, parameters, constraints, performance requirements, sub-systems, interconnections and environmental context.
2.	To understand Engineering problem modelling and solving through the relationship between theoretical and mathematical
3.	To provide Mathematical modelling real world situations related to engineering systems development.
4.	To able Generate random numbers and random varieties using different techniques.
5.	To provide the knowledge of queuing theory to solve real life problem

Course Outcomes : After the completion of this course, students will be able to do the following:

CO1	Define basic concepts in modeling and simulation (M&S)
CO2	Classify various simulation models and give practical examples for each category
CO3	Analyze the behavior of a dynamic system and create an analogous model for a dynamic system.
CO4	Analyze and test random number variates and apply them to develop simulation models
CO5	Develop a real life model using queuing system

Syllabus

CS 322 **Simulation and Modelling** **3-0-0-3**

Module I

The concepts of a system, System Environment, Stochastic Activities, continuous and discrete systems, System Modeling, Types of models.System Studies: Subsystem, A Corporate Model, Environment segment, Production Segment, Management Segment, full Corporate Model, Types of System study, System Analysis, System Design, System Postulation. **[8 L]**

Module II

The technique of simulation, the Monte Carlo method, comparison of simulation and analytical methods, experimental nature of simulation, types of system simulation, numerical computation technique for continuous & discrete models, distributed lag models, cobweb models. Continuous system models, differential equations, analog computers & methods, hybrid computers, CSSLs, CSMP-III, Feedback Systems, Simulation of an Autopilot. **[8 L]**

Module III

Exponential Growth & decay models, modified exponential growth models, logistic curves, generalization of growth models, system dynamics diagrams, Simple system dynamics diagrams, multi–segment models, representation of time delays. **[8 L]**

Module IV

Evaluation of continuous probability functions, continuous uniformly distributed random numbers, a uniform random number numbers, generating discrete distributions, non-uniform continuously distributed random numbers, the rejection method. Random numbers Generators: Techniques for generating random numbers. Test for random numbers. Random vitiate Generation: Inverse transform technique, exponential distribution, uniform distribution. **[8 L]**

Module V

Queuing disciplines, measures of queues. Discrete events, representation of time, generation of arrival patterns, simulation of a telephone system, delayed calls, Simulation programming tasks, measuring utilization and occupancy. **[8 L]**

Text books:

1. Gordon Geoffrey, System Simulation, 2nd Edition, Pearson Education, 2007.
2. Banks J., Carson J. S. , Nelson B.L., Nicol D.M., Discrete-Event System Simulation, 4th Edn, Pearson Education, 2007.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course outcome (co) attainment assessment tools & evaluation procedure

Direct assessment

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	√

Indirect assessment –

1. Student feedback on course outcome

Mapping of course outcomes onto program outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	2	1	1	1	1	3	1	2
CO2	3	2	2	1	2	1	1	1	1	2	1	2
CO3	3	3	3	2	3	1	1	1	1	3	1	2
CO4	3	2	2	2	2	1	1	1	1	3	1	2
CO5	3	3	3	2	3	1	1	2	2	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: IT321
Course title: Bio Inspired Computing
Pre-requisite(s): Data Structure& Programming.
Co- requisite(s):
Credits: L: 3 T:0 P: 0 C:3
Class schedule per week: 3 Lectures
Class: B. Tech/ IMSc
Semester / Level: V/3
Branch: CSE/IT/IMSc

Course Objectives : This course enables the students:

1.	To understand the basic structure of cellular system.
2.	To understand the basic structure of Biological nervous systems.
3.	To know the basic structure of Biological immune system.
4.	To understand the artificial evolution of competing systems.

Course Outcomes: After the completion of this course, students will be able to:

CO1	Implement and apply evolutionary algorithms
CO2	Explain cellular automata and artificial life
CO3	Implement and apply neural systems
CO4	Explain developmental and artificial immune systems
CO5	Explain behavioral systems

Syllabus

IT321 Bio Inspired Computing 3-0-0-3

Module I
Evolutionary and Cellular Systems:
Foundations of evolutionary theory – Genotype – artificial evolution – genetic representations – initial population – fitness functions – selection and reproduction – genetic operators – evolutionary measures – evolutionary algorithms – evolutionary electronics – evolutionary algorithm case study Cellular systems – cellular automata – modeling with cellular systems – other cellular systems – computation with cellular systems – artificial life – analysis and synthesis of cellular systems. [8L]

Module II
Neural Systems:
Biological nervous systems – artificial neural networks – neuron models – architecture – signal encoding – synaptic plasticity – unsupervised learning – supervised learning – reinforcement learning – evolution of neural networks – hybrid neural systems – case study [8L]

Module III
Developmental and Immune Systems:
Rewriting systems – synthesis of developmental systems – evolutionary rewriting systems –evolutionary developmental programs Biological immune systems – lessons for artificial immune systems – algorithms and applications – shape space – negative selection algorithm – clonal selection algorithm - examples
[8L]

Module IV
Behavioral Systems:
Behavior is cognitive science – behavior in AI – behavior based robotics – biological inspiration for robots – robots as biological models – robot learning – evolution of behavioral systems – learning in behavioral systems – co-evolution of body and control – towards self reproduction – simulation and reality. [8L]

Module V
Collective Systems:
Biological self-organization – Particle Swarm Optimization (PSO) – ant colony optimization (ACO) – swarm robotics – co-evolutionary dynamics – artificial evolution of competing systems – artificial evolution of cooperation – case study [8L]

Text Books:

1. Floreano ,D. and Mattiussi ,C., "Bio-Inspired Artificial Intelligence", MIT Press, 2008.
2. Neumann ,F. and Witt ,C., “Bioinspired Computation in combinatorial optimization: Algorithms and their computational complexity”, Springer, 2010
3. Elben, A. E. and Smith ,J. E., “Introduction to Evolutionary Computing”, Springer, 2010.
4. Goldberg, D. E., “Genetic algorithms in search, optimization, and machine learning”, Addison-Wesley, 1989.
5. Haykin ,Simon O., “Neural Networks and Learning Machines”, Third Edition, Prentice Hall,2008.

Reference Books

1. Dorigo ,M. and Stutzle ,T., “Ant Colony Optimization”, A Bradford Book, 2004.
2. Ebelhart ,R. C. et al., “Swarm Intelligence”, Morgan Kaufmann, 2001.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course outcome (co) attainment assessment tools & evaluation procedure

Direct assessment

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

Mapping of course outcomes onto program outcomes

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	1	2	2	1	3	1	1	1	1
CO2	2	2	2	1	2	3	1	2	2	1	2	2
CO3	1	2	2	1	2	3	1	1	1	1	1	1
CO4	2	2	2	1	3	1	1	1	1	1	1	1
CO5	3	3	2	3	2	1	1	1	3	2	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: MA 313
Course title: Combinatorics
Pre-requisite(s):
Co- requisite(s):
Credits: L:3 T:1 P:0 C: 4
Class schedule per week: 3 Lectures 1 Tutorial
Class: IMSc.
Semester / Level: VI / 3
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives: This course enables the students:

1.	to become familiar with fundamental combinatorial structures that naturally appear in various other fields of mathematics and computer science.
2.	to learn how to prove the existence or non-existence of the object, compute the number of such objects, and understand their underlying structure.

Course Outcomes : After the completion of this course, students will be able:

CO1.	to model and analyze computational processes using analytic and combinatorial methods
CO2.	to know the limitations of computations and be able to identify infeasibilities and limitations of computational problems.
CO3.	apply counting techniques to solve combinatorial problems and identify, formulate, and solve computational problems in various fields.
CO4.	have a strong background on counting principles
CO5.	Apply counting techniques to solve real-world problems of sciences and engineering.

Syllabus

MA313 **Combinatorics** **3-1-0-4**

Module I

Introduction to Principles of Counting**,** The Fundamental of Counting, Multiplication Principle, Addition Rule, Mathematical Induction, Strong Mathematical Induction, Well-ordering Principle, Binomial Theorem, Pascal's Triangle, Multinomial Coefficient, **[9L]**

Module II

Permutations, Permutations with Repetitions, Circular Permutations, Ordered Sampling. Combinations, Combinations of n Different Objects, Combinations with Repetitions, The Pigeonhole Principle, Generalized Pigeonhole Principle, Derangements, Summation Method**.** **[10L]**

Module III

Concept of Congruences and its Elementary Properties, Congruences in one unknown, Complete Residue System, Reduced Residue System, Gauss Function, Mobius Function, Chinese Remainder Theorem, Combinatorial Assignments, Partition of Integers, Euler ϕ-Function, Inclusion-Exclusion Principle, Application of Inclusion-Exclusion Principle. [**10L]**

Module IV

Recurrence Relations: Order and Degree of Recurrence Relation, Linear Homogenous and Non-Homogeneous Recurrence Relations with Constant coefficients and their Solutions, Solution of Non-linear Homogenous and Non-homogeneous Recurrence Relations. [**8L**]

Module V

Generating Functions, Addition and Multiplication of two Generating Functions, Solution of Recurrence Relations using the method of Generating function, Partition by Generating Function, Generating Function for restricted Partitions. [**8L]**

Text Books:

1. **Ralph P. Grimaldi:** *Discrete and Combinatorial Mathematics – An applied introduction,* Pearson Addison Wesley, 5^{th} Edition, 2004.
2. **Bikash Kanti Sarkar and Swapan Kumar Chakraborty** : Combinatorics and Graph Theory, PHI, 2016.
3. **Kolman, Bernard, Robert C. Busby, and Sharon Ross.** *Discrete mathematical structures*. Prentice-Hall, Inc., 2003**.**

Reference Books:

1. **Rosen, Kenneth H**. *Handbook of discrete and combinatorial mathematics*. Chapman and Hall/CRC, 2017.
2. **Swapan Kumar Chakraborty and Bikash Kanti Sarkar**: *Discrete Mathematics*, Oxford Univ. Publication, 2010.
3. **Seymour Lipschuz and Mark Lipson**: Discrete Mathematics, Shaum's outlines, 2003.
4. **Liu, Chung Laung,** *Elements of Discrete mathematis*, Mcgraw Hill, 2^{nd} edition, 2001.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course outcome (co) attainment assessment tools & evaluation procedure

Direct assessment

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

Mapping of course outcomes onto program outcomes

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: MA314
Course title: Fuzzy Set Theory and Its Applications
Pre-requisite(s): Set theory and classical logic.
Credits: L:4 T:0 P:0 C:4
Class schedule per week: 4 Lectures
Class: IMSc.
Semester: VI/3
Branch: Mathematics and Computing
Course Co-ordinator:

COURSE DESCRIPTION:

1	Fuzzy Sets , operations and its properties of Fuzzy Sets. Types of Fuzzy Sets. Further Operations on Fuzzy Sets , Aggregation Operators, Fuzzy Measures and Measures of Fuzziness.
2	Fuzzy Relations and its Cardinality ,Operations on Fuzzy Relations, Properties of Fuzzy Relations, Fuzzy Cartesian product and Composition .Fuzzy Graphs.
3	The Extension Principle .Operations for Type 2 Fuzzy Sets. Algebraic Operations with Fuzzy Numbers. and Extended Operations for LR-Representation of Fuzzy Sets
4	Classical Logic and Fuzzy Logic.
5	Fuzzy Set Models in Inventory Control, Scheduling, Job-Shop Scheduling andTransportation Problem

Course Outcomes: After the completion of the course, the students will be able to:

CO1	learn about Fuzzy Sets ,operations on it, aggregation Operators and measures of fuzziness.
CO2	learn about Fuzzy Relations and Operations on Fuzzy Relations.
CO3	learn about The Extension Principle and Applications.
CO4	learn Fuzzy Logic and Approximate Reasoning.
CO5	apply Fuzzy Sets in various areas of application.

Syllabus

MA 314 FUZZY SET THEORY AND ITS APPLICATIONS 3-1-0-4

MODULE I: Fuzzy Sets-Basic Definitions

Classical Sets, Operations on Classical Sets, Properties of Classical (Crisp) Sets, Mapping of Classical Sets to Functions . Fuzzy Sets, Fuzzy Set Operations, Properties of Fuzzy Sets. Types of Fuzzy Sets. Further Operations on Fuzzy Sets . Algebraic Operation. Set-Theoretic Operations. Criteria for Selecting appropriate Aggregation Operators. Fuzzy Measures . Measures of Fuzziness. [9L]

MODULE II: Fuzzy Relations and Fuzzy Graphs

Cartesian Product, Crisp Relations, Cardinality of Crisp Relations, Operations on Crisp Relations , Properties of Crisp Relations ,Composition. Fuzzy Relations, Cardinality of Fuzzy Relations , Operations on Fuzzy Relations, Properties of Fuzzy Relations, Fuzzy Cartesian product and Composition .Fuzzy Graphs. [9L]

MODULE III: The Extension Principle and Applications

The Extension Principle . Operations for Type 2 Fuzzy Sets. Algebraic Operations with Fuzzy Numbers. Special Extended Operations. Extended Operations for LR-Representation of Fuzzy Sets . [9L]

MODULE IV: Fuzzy Logic and Approximate Reasoning

Classical Logic: Tautologies, Contradictions, Equivalence, Exclusive or and Exclusive Nor, Logical Proofs, Deductive Inferences, Fuzzy Logic, Approximate Reasoning, Other Forms of the Implication Operation. Linguistic Variables, Fuzzy Logic, Fuzzy (Rule-Based) Systems. Graphical Techniques of Inference. [9L]

MODULE V : Applications

Fuzzy Approach to the Transportation Problem, Fuzzy Set Models in Inventory Control. Fuzzy Sets in Scheduling. Job-Shop Scheduling with Expert Systems. A Method to Control Flexible Manufacturing Systems. Scheduling Courses, Instructors and Classrooms. [9L]

TEXT BOOK

1. **H.-J. Zimmermann**, Fuzzy Set Theory and Its Applications, Springer Science +Business Media, LLC, Fourth Edition, 2001.
2. **Timothy J. Ross**, Fuzzy Logic with Engineering Applications, Second edition, John Wiley and Sons, 2004.

REFERENCE BOOK/ARTICLE

1. **Klir, G.J. and Yuan, Bo**. *Fuzzy sets and Fuzzy Logic, Theory and Applications*, Prentice Hall of India, 2002.
2. **Yen, John. and Langari, Reza**. *Fuzzy Logic – Intelligence, Control and Information,* 1999.
3. **L. A. Zadeh** , “Fuzzy Sets,” *Information and Control*, vol. 8, pp. 338–353, 1965.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Semester Examination	25
End Semester Examination	50
Quiz (s)	10+10
Assignment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
End Semester Examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	2	2	2	2	3	3	3
CO2	3	3	3	3	2	2	2	2	2	3	3	3
CO3	3	3	3	3	2	2	3	3	3	3	3	3
CO4	3	3	3	3	2	2	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA315
Course title: Financial Mathematics
Pre-requisite(s): Probability and Random variable
Credits: L:3 T:1 P:0 C:4
Class schedule per week: 3 lectures 1 tutorial
Class: IMSc.
Semester/level: VI/3
Branch: Mathematics and Computing
Name of the Faculty:

Course Objectives: This course enables the students to understand

1.	the basic securities, organization of financial markets, the concept of interest rates, present and future value of cash flow.
2.	the basic property of option, no arbitrage principle, short selling, put-call parity.
3.	the concept of option pricing using single and multi-period binomial pricing models and the limiting case of Cox-Ross-Rubinstein (CRR) Model as a famous Black-Scholes formula for option pricing.
4.	the derivatives forwards, futures and swaps and their pricing.
5	the portfolio construction at the overall plan level, taking into account investor objectives and the practical challenges of implementation.

Course Outcomes: After the completion of this course, students will be able to

CO 1	describe and explain the fundamental features of a *financial* instruments.
CO 2	understand difference between the risky and risk-free assets.
CO 3	acquire knowledge of how forward contracts, futures contracts, swaps and options work, how they are traded and how they are priced.
CO 4	evaluate the price of option using Binomial model.
CO 5	demonstrate a clear understanding of financial research planning, methodology and implementation.

Syllabus

MA315 **Financial Mathematics** **3-1-0-4**

Module I

Overview of Financial Engineering: Financial markets and instruments, interest rates, present and future values of cash flows, risk-free and risky assets. [8L]

Module II

Options: call option, put option, expiration date, strike price/exercise price, European, American option and exotic options, put-call parity, a basic properties of options. [9L]

Module III

Basic theory of option pricing: single and multi-period binomial pricing models, Cox-Ross-Rubinstein (CRR) model, American option in binomial model, Black-Scholes formula for option pricing as a limit of CRR Model. [9L]

Module IV

Forwards, futures and swaps : forward and futures contract, pricing of forward and futures, swaps, plain vanilla interest rate swaps, currency swaps, pricing swaps, pricing a commodity swap, pricing an interest rate swap. [9L]

Module V

Mean-variance portfolio theory: Markowitz model of portfolio optimization and capital asset pricing model (CAPM). [10L]

Text books:

1. J Cvitanic and F. Zapatero, Introduction to the Economics and Mathematics of Financial Markets, Prentice. -Hall of India, 2007.
2. M. Capinski and T. Zastawniak, Mathematics for Finance: An Introduction to Financial Engineering, 2nd Ed., Springer, 2010.
3. J. C. Hull, Options, Futures and Other Derivatives, 8th Ed., Pearson India/Prentice Hall, 2011.

Reference books:

1. S. Roman, Introduction to the Mathematics of Finance: From Risk Management to Options Pricing, Springer India, 2004.
2. S. R. Pliska, Introduction to Mathematical Finance: Discrete Time Models, Blackwell, 1997.
3. S. N. Neftci, Principles of Financial Engineering, Academic Press/Elsevier India, 2009.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Semester Examination	25
End Semester Examination	50
Quiz (s)	10+10
Assignment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	✓	✓	✓		
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	1	1	1	1	2	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	1	3	2
CO4	2	2	3	3	1	1	2	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 316
Course title: Statistical Quality Control and Reliability
Pre-requisite(s): Basics of statistics and probability
Co- requisite(s): ---NIL
Credits: L: 3 T: 1 P: 0 C:4
Class schedule per week: 3 Lectures, 1 tutorial.
Class: IMSc
Semester / Level: VI/3
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives: This course enables the students to get the detailed idea about:

1.	Meaning and uses of statistical quality control (SQC)
2.	Real life industrial applications of different control charts
3.	Real life industrial applications of different sampling inspection plans
4.	Reliability functions for several time to failure probability distributions
5.	Hypothesis testing in the context of reliability

Course Outcomes: After completion of the course, the learners will be able to:

CO1	Apply the concept of SQC in business and industrial applications
CO2	Prepare appropriate control charts both for qualitative and quantitative characteristics
CO3	Design an appropriate sampling inspection plan for a real life problem
CO4	Choose an appropriate time to failure probability distribution and estimate its reliability for complete and censored samples
CO5	Set up and test an appropriate hypothesis in the context of reliability; also compute confidence intervals

Syllabus

MA316 **Statistical Quality Control and Reliability** **3-1-0-4**

Module I

Meaning and uses of SQC, chance and assignable causes of variation, process and product control, control charts, Chebyshev's inequality and its applications in SQC, 3σ and 6σ limits. **[9L]**

Module II

Control charts for quantitative characteristics, mean and range chart, standard deviation or σ chart, : Control charts for qualitative characteristics, p chart, d chart, control chart for number of defects per unit (c chart), cumulative sum (CUSUM) chart modified control chart. **[9L]**

Module III

Acceptance Quality Level (AQL), Lot Tolerance Proportion Defective (LTPD), Process Average Fraction Defective (PAFD), Consumer's risk, Producer's risk, Rectifying Inspection Plans, Average Outgoing Quality Limit (AOQL), Operating Characteristic (OC) curve, Average Sample Number (ASN), Dodge And Romig rectifying sampling inspection plans, single sampling, double sampling plan, sequential sampling **[9L]**

Module IV

Reliability function, Applications of Exponential, Gamma, normal, lognormal, Weibull distributions in reliability and estimation of their parameters, reliability estimation with complete and censored samples. **[9L]**

Module V

Testing of hypothesis and confidence intervals in the context of reliability; reliability of series, parallel and standby systems. **[9L]**

Text Books:

1. S.C. Gupta and V. K. Kapoor, Fundamentals of Applied Statistics, Sultan Chand & Sons, 2002
2. S. K. Sinha and B. K. Kale, Life Testing and Reliability Estimation, Wiley Eastern Ltd, 1980

Reference Books:

1. D. Montgomery, Statistical Quality Control: A Modern Introduction, John Wiley & Sons , 2009
2. I. Bazovsky, Reliability Theory and Practice, Prentice Hall Inc. Englewood Cliffs, New Jersey, 1961

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

<u>Course Outcome (CO) Attainment Assessment tools & Evaluation procedure</u>

<u>Direct Assessment</u>

Assessment Tool	% Contribution during CO Assessment
Mid Semester Examination	25
End Semester Examination	50
Quiz (s)	10+10
Assignment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	✓	✓	✓		
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

<u>Mapping of Course Outcomes onto Program Outcomes</u>

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	1	1	1	1	2	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	1	3	2
CO4	2	2	3	3	1	1	2	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 317
Course title: Wavelet Transform
Pre-requisite(s):
Co- requisite(s): ---
Credits: L: 3 T: 0 P: 0 C:3
Class schedule per week: 3 Lectures
Class: IMSc.
Semester / Level: VI/ 3
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives: This course enables the students to understand

1.	Fourier analysis, discrete and fast Fourier transforms, Fourier series
2.	inversion of Fourier transform, different features of Fourier transform, Shannon's sampling theorem, Heisenberg's uncertainty principle
3.	continuous, discrete, integral wavelet transform, orthogonal wavelets, multi-resolution analysis, reconstruction of wavelets and applications
4.	Haar's simple wavelets, simple approximation, approximation with simple wavelet. Two dimensional wavelets, two dimensional approximations with step functions

Course Outcomes: After the completion of this course, students will be able to

CO1	apply the theory of wavelet to specific research problems in mathematics or other fields
CO2	use Haar wavelet to solve boundary value problems for ODEs and PDEs
CO3	learn fourier transformation technique to solve problem.
CO4	gain an understanding to approximate solutions with the use of wavelet based methods to diverse situations in mathematical contexts
CO5	demonstrate a depth of understanding in advanced mathematical analysis based on wavelet theory

Syllabus

MA317 **<u>Wavelet Transform</u>** **3-0-0-3**

Module I

Basic Fourier analysis, inner products and orthogonal projections, discrete and fast Fourier transforms, Fourier series for periodic functions [8L]

Module II

Fourier transform, convolution and inversion of Fourier transform different features of Fourier transform, Fourier transforms with several variables, Shannon's sampling theorem, Heisenberg's uncertainty principle. [8L]

Module III

Isometric isomorphism between L_1 and $L_2[0, 2\pi]$, Basic wavelets (Haar/Shannon/Daubechies), continuous wavelet transform, discrete wavelet transform, integral wavelet, orthogonal wavelets, multi-resolution analysis, reconstruction of wavelets and applications. [8L]

Module IV

Haar's simple wavelets, simple approximation, approximation with simple wavelet. Ordered fast Haar wavelet transform, in-place fast Haar wavelet transform, in-place fast inverse Haar wavelet transform [8L]

Module V

Two dimensional wavelets, two dimensional approximations with step functions, two dimensional fast Haar wavelet transform applications of wavelets [8L]

Text Books:

1. Y. Nievergelt: Wavelets Made Easy, Birkhauser, Boston, 1999
2. R. S Pathak:The wavelet transform, Atlantis Press
3. Bachman, G. Narici, L., Beckenstein, E.: Fourier and Wavelet Analysis, Springer, 2005
4. Koorniwinder, T.H., Wavelet: An Elementary Treatment of Theory and Applications, World Scientific Publication,1993

Reference Books:

1. R.M. Rao and A.S. Bopardikar:Wavelet Transforms: Introduction to theory and applications, Adison Wesley
2. C.K. Chui: An Introduction to Wavelets, Academic Press 1992
3. Chan, A. K., Peng C.: Wavelets for Sensing Technology, Artech House 2003
4. Daubechies, I.: Ten Lectures in Wavelets, SIAM 1992

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Semester Examination	25
End Semester Examination	50
Quiz (s)	10+10
Assignment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	✓	✓	✓		
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	1	1	1	1	2	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	1	3	2
CO4	2	2	3	3	1	1	2	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 318
Course title: Artificial Neural Network
Pre-requisite(s): Matrix operations (some linear algebra) , some multivariate calculus and basic probability theory, mathematical optimization, partial derivatives, linear regression to logistic regression.
Credits: L: 3 T: 0 P: 0 C:3
Class schedule per week: 3 Lectures
Class: IMSc.
Semester / Level: VI/ 3
Branch: Mathematics and Computing
Name of Teacher:

Course objectives: In this course the students will be introduced to

1.	various neural network models and algorithms, adaptive behavior, associative learning, competitive dynamics and biological mechanisms.
2.	understand the structure, design, and training of various types of neural networks
3.	apply them to the solution of problems in a variety of domains.

Course Outcomes: After the completion of the course, the students will be able to:

CO1.	Describe fundamental concepts of biological and artificial neurons.
CO2.	Describe functional aspects of single layer perceptron and multi-layer perceptron
CO3.	Use various ANN learning algorithms in real life problems.
CO4.	Understand various associative memory network models for pattern recognition, time-series analysis.
CO5.	Describe functionalities of RBF and SOM network

Syllabus

MA318 **Artificial Neural Network** **3-0-0-3**

Module I

Introduction of Neural Networks and Human Brain, Biological and Artificial Neuron, Models of a Neuron, Different types of Activation functions, Perceptron Model, Adaline Model, Neural Networks viewed as Directed Graphs, Network Architectures, characteristics of Neural Networks. [6L]

Module II

Learning Processes: Error-Correction Learning, Memory–Based Learning, Hebbian Learning, Competitive learning, Boltzmann Learning, Learning with a teacher (supervised),Learning without a teacher (unsupervised).Learning Tasks: Pattern Association, Pattern Recognition and Function Association. [8L]

Module III

Single Layer Perceptron: Introduction, Unconstrained Optimization Techniques: Method of Steepest Descent, Newton's Method, Gauss Newton Method, Least Mean Square Algorithm. Perceptron, Perceptron Convergence Theorem (Statement only). Multiple Layer Perceptron: Back-Propagation Algorithm, XOR Problem.

ART1: Architecture of ART1, Special Features of ART1 Models and ART1 Algorithm, ART2: Architecture of ART2, ART2 Algorithm. [10L]

Module IV

Bidirectional Associative Memory(BAM), Radial Basis Function Networks: Cover's theorem on the seperability of patterns, Separating Capacity of a surface, Interpolation Problem, Micchelli's theorem. Neurodynamical Models: Additive Model, Hopfield Model, Relation between the Stable States of the Discrete and Continuous versions of the Hopfield Model. The Discrete Hopfield Model as a Content-Addressable Memory. Brain –State-In-A-Box Model, Lyapunov Function of the BSB Model, Dynamics of the BSB model. [8L]

Module V

Principal Component Analysis: Introduction, Some intuitive Principles of Self-Organization, Principal Component Analysis. Self-Organizing Maps: Introduction, Two Basic Feature-Mapping Models, Self-Organizing Map, Properties of the Feature Map. [8L]

Text Book:

1. Haykin Simon, Neural network, Addison Wesley Longman Pvt. Ltd, Delhi.

Reference books:

1. Jacek M. Zurada, Introduction to Artificial Neural Systems, Jaico Publishing House.
2. Rajasekaran and Pai G.A. V. Neural Networks, Fuzzy logic and Genetic Algorithm, Prentice Hall of India.
3. Laurence Faucett, Fundamentals of Neural Networks, Architectures, Algorithms and Applications.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course outcome (co) attainment assessment tools & evaluation procedure

Direct assessment

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

Mapping of course outcomes onto program outcomes

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code:IT 322
Course title: **Cloud Computing**
Pre-requisites: Operating System, Computer Networks
Co- requisite(s): NIL
Credits: L: 3 T: 0 P: 0 C:3
Class schedule per week: 3 Lectures
Class: B. Tech/IMSc
Semester / Level: VI/3
Branch: CSE/IT/IMSc

Course Objectives: This course enables the students:

1.	Understand the elements of distributed computing and core aspects of cloud Computing.
2.	Understand the concepts and aspects of virtualization and application of virtualization technologies in cloud computing environment
3.	Understand the architecture and concept of different cloud models: IaaS, PaaS, SaaS and gain comprehensive knowledge of different types of clouds.
4.	Be familiar with application development and deployment using services of different cloud computing technologies provider: Google app Engine, Amazon Web Services (AWS) and Microsoft Azure.
5.	Understanding the key security, compliance, and confidentiality challenges in cloud computing.

Course Outcomes: After the completion of this course, students will be able to:

CO1	Recall the various aspects of cloud computing and distributed computing
CO2	Understand the specifics of virtualization and cloud computing architectures.
CO3	Develop and deploy cloud application using services of different cloud computing technologies provider: Google app Engine, Amazon Web Services (AWS) and Microsoft Azure.
CO4	Evaluate the security and operational aspects in cloud system design, identify and deploy appropriate design choices when solving real-world cloud computing problems.
CO5	Provide recommendations on cloud computing solutions for a Green enterprise.

Syllabus

IT322 **Cloud Computing** **3-0-0-3**

Module I

Introduction: Essentials, Benefits and need for Cloud Computing - Business and IT Perspective - Cloud and Virtualization - Cloud Services Requirements - Cloud and Dynamic Infrastructure - Cloud Computing Characteristics Cloud Adoption. **[8 L]**

Module II

Principles of Parallel and Distributed Computing: Eras of computing, Parallel vs. Distributed computing, Elements of parallel computing, Elements of distributed computing, Technologies for distributed computing **[8 L]**

Module III

Virtualization: Introduction, Characteristics of virtualized environments, Taxonomy of virtualization techniques, Virtualization and cloud computing, Pros and cons of virtualization, Technology examples.
Storage virtualization:Storage Area Networks - Network-Attached storage - Cloud Server Virtualization - Virtualized Data Centre. **[8 L]**

Module IV

Cloud computing architecture: Introduction, Cloud reference model, Types of clouds, Economics of the cloud, Open challenges **[8 L]**

Module V

Cloud platforms in industry and Cloud applications : Amazon web services, Google app engine, Microsoft azure, Observations, Scientific applications, Scientific, Business and Consumer applications **[8 L]**

Text Book:

1. Buyya Raj Kumar, Vecchiola Christian & Thamarai S. Selvi, “Mastering Cloud Computing”, McGraw Hill Publication, New Delhi, 2013.

Reference Books:

1. Velte T., Velte A. and Elsenpeter R., “Cloud Computing: A Practical Approach”, McGraw Hill, India.
2. Buyya R., Broberg J., “Cloud Computing: Principles and Paradigms”, Wiley.
3. Hwang K., Fox G. and Dongarra J., “Distributed and Cloud Computing, From Parallel Processing to the Internet of Things”, Morgan Kaufmann, 2012.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

<u>Course Outcome (CO) Attainment Assessment tools & Evaluation procedure</u>

<u>Direct Assessment</u>

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓		
Quiz (s)	✓	✓	✓		
Assignment				✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

<u>Mapping of Course Outcomes onto Program Outcomes</u>

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	1	1	3	3	2	3	2
CO2	2	2	3	2	2	1	1	3	3	2	3	2
CO3	3	3	3	2	2	1	1	2	2	2	3	2
CO4	3	3	3	2	2	1	1	2	2	2	3	2
CO5	2	3	3	2	2	1	1	3	3	2	3	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: CS325
Course title: Database Modeling
Pre-requisite(s): DBMS
Co- requisite(s):
Credits: L:3 T:0 P: 0 C:3
Class schedule per week: 3 Lectures
Class: B. Tech/ IMSc
Semester / Level: VI/3
Branch: CSE/IT/IMSc

Course Objective: This course enables the students:

1.	Learn and practice data modeling using the entity-relationship and developing database designs.
2.	Understand the use of Structured Query Language (SQL) and learn SQL syntax.
3.	Understanding the basic principles of modeling of database using UML and apply normalization techniques to normalize the database system.
4.	Learn Multidimensional schemas suitable for data warehousing. And learn the Difference between OLTP (Online Transaction Processing) and OLAP (Online Analytical Processing).
5.	To demonstrate the principles behind the logical database design and Data Warehouse Modeling.

Course Outcomes: After the completion of this course, students will be to:

CO1	Explain the features of database management systems and Relational database and design the ER-models to represent simple database application scenarios.
CO2	Apply the SQL-the standard language to relational tables, populate relational database and formulate SQL queries on data.
CO3	Applying UML, it collects the requirements and prepare their scenarios and design. And understand the functional dependencies and design of the database.
CO4	Design a data mart or data warehouse for any organization. And Develop a skill to write queries using DMQL.
CO5	Analyze the existing design of a database and data warehouse and apply concepts of normalization to design an optimal database.

Syllabus

CS325 **Database Modeling** **3-0-0-3**

Module I

Database Design and Entity- Relational Model

Introduction to Data and Database Management, The Database Life Cycle, Conceptual Data Modeling, Fundamental ER Constructs, Mapping Cardinalities and Constraints, Relational Data model (Relational Algebra, Tuple and Domain Relational Calculus), Network Model, Hierarchical Model, Alternative Conceptual Data Modeling Notations, Advanced ER Construct, Summary. **[8 L]**

Module II

Requirement Analysis and Conceptual Data Modeling

Introduction, Requirements Analysis, Conceptual Data Modeling, View Integration, Entity Clustering for ER Models, Transforming Rules and SQL Constructs, Transformation Steps, Summary. **[8 L]**

Module III

The Unified Modeling Language (UML) and Normalization

Class Diagrams, Activity Diagrams, Rules of Thumb for UML Usage, Functional Dependencies, Fundamentals of Normalization, Design of Normalized Tables, Normalization of Candidate Tables Derived from ER Diagrams, 1NF, 2NF, 3NF, BCNF, Fourth and Fifth Normal Forms. Determining the Minimum set of 3NF Tables, Summary. **[8 L]**

Module IV

Business Intelligence

Overview of Data Warehousing, Logical Design, The Exponential Explosion of views, Decision Support system. Overview of Online Analytical Processing (OLAP), View Size Estimation, Selection of Materialized Views, View Maintenance, Query Optimization, Forecasting, Overview of Data mining and Text Mining, Summary. **[8 L]**

Module V

Logical Database Design

Requirements Specification, Logical Design, CASE Tools for Logical Database Design, generating a Database from a Design, Database Support, Collaborative Support, Distributed Development, Application Life Cycle tooling Integration, Design Compliance Checking, Reporting, Modeling a Data Warehouse, Semi-Structured Data, XML, Summary. **[8 L]**

Textbooks:

1. Teorey ,T. J., Lightstone,S., and Nadeau ,T.,"Database Modeling and Design: Logical Design", Fourth Edition, Morgan Kaufmann Publishers, 2006

Reference books:

1. Elmasri,R., and Navathe ,S.B.,"Fundamentals of Database Systems,"Sixth Edition,Pearson,2015.
2. Silberschatz ,A., Korth ,H. F., and Sudarshan ,S.,"Database System Concepts," Sixth Edition, Mc Graw Hill Education,2010.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓		
Quiz (s)	✓	✓	✓		
Assignment				✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	1	1	1	1	1	1	2
CO2	2	3	1	1	1	1	1	1	1	1	1	2
CO3	2	3	1	3	3	1	1	1	1	1	1	2
CO4	3	1	1	1	2	1	1	2	1	1	1	2
CO5	2	2	1	2	3	1	1	1	1	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA404
Course title: Mathematical Epidemiology
Pre-requisite(s): Differential Equations
Co- requisite(s): Disease Dynamics
Credits: L: 3 T: 0 P: 0 C:3
Class schedule per week: 03 Lectures
Class: IMSc
Semester / Level: VII /4
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives: This course enables the students

1.	to understand the qualitative behaviour of linear and non-linear dynamical systems
2.	to develop infectious disease deterministic and stochastic models
3.	to formulate spatial epidemic models
4.	to perform stability analysis of different types of epidemic models
5.	to make predictions regarding the severity/non-severity of disease on basis of mathematical analysis.

Course Outcomes: After the completion of this course, students will be able to

CO1.	develop the skills to formulate the transmission dynamics that exists among different compartments
CO2.	demonstrate the basics of stability theory of differential equations in epidemiological models
CO3.	propose and analyze eco-epidemic models
CO4.	make predictions regarding the epidemic transmission and control
CO5.	demonstrate the applicability of mathematical modelling in simulating problems of epidemic

Syllabus

MA404 Mathematical Epidemiology 3-0-0-3

Module I

Qualitative analysis of linear and nonlinear systems: Existence, uniqueness and continuity of solutions, Diagonalization of linear systems, fundamental theorem of linear systems, the phase paths of linear autonomous plane systems, complex eigenvalues, multiple eigenvalues, stability theorem,linearization of nonlinear dynamical systems (two, three and higher dimension), Stability: (i) asymptotic stability (Hartman's theorem), (ii) global stability (Lyapunov's second method). [8L]

Module II

Deterministic Epidemic Models: Deterministic model of simple epidemic, Infection through vertical and horizontal transmission, General epidemic- Kermack-Mckendrick Threshold Theorem, Recurrent epidemics, Seasonal variation in infection rate, allowance of incubation period, Simple model for the spatial spread of an epidemic. [8L]

Module III

Non Constant Total Population Model in Epidemic: Introduction, Parasite-host system, SIS, SIR and SIRS type model. [8L]

Module IV

Stochastic Epidemic Models: Introduction, stochastic simple epidemic model, Yule-Furry model (pure birth process), expectation and variance of infective, calculation of expectation by using moment generating function. [8L]

Module V

Eco-Epidemiology: Introduction, host-parasite-predator systems, viral infection on phytoplankton zooplankton (prey-predator) system. [8L]

Text Books:

1. Lawrence Perko, Differential Equations and Dynamical Systems, Springer, 2008.
2. N.T. J. Bailey, TheMathematical Theory of Infectious Diseases and its Application, London, Griffin, 1975.
3. J.D. Murray, Mathematical Biology, Springer and Verlag, 1990.
4. Vincenzo Capasso, Lecture Notes in Mathematical Biology (Vol. No. 97)- Mathematical Structures of Epidemic Systems, Springer Verlag, 1993.

Reference Books:

1. Busenberg and Cooke, Vertically Transmitted Diseases- Models and Dynamics, Springer Verlag, **1993**
2. Eric Renshaw, Modelling Biological Populations in Space and Time, Cambridge Univ. Press, 1990.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓		
Quiz (s)	✓	✓	✓		
Assignment				✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 405
Course title: Mathematical Modeling
Pre-requisite(s): MA 106, MA 201, MA301, MA311
Credits: L:3 T:0 P:0 C:3
Class schedule per week: 3 lectures
Class: IMSc/ MSc
Semester/level: VII / 4
Branch: Mathematics and Computing/ Mathematics
Name of the Faculty:

Course Objectives : This course enables the students to get the detailed idea about:

1.	models, properties of models, model classification and characterization, steps in building mathematical models.
2.	analytic methods of model fitting
3.	Discrete Probabilistic Modeling
4.	Modeling with a Differential Equations
5	Simulation Modeling – Discrete-Evvnt Simulation, Continuous Simulation, Monte-Carlo simulation

Course Outcomes: After completion of the course, the learners will be able to:

CO1.	learn different approach of mathematical modelling
CO2	perform a task of model fitting using different mathematical methods in least expensive ways.
CO3.	get an understanding of solving and validating proposed mathematical models with different physical behavior of the problems.
CO4.	apply the principles of mathematical modelling to solve a variety of practical problems in sciences and engineering.
CO5.	equip the students with standard concepts and tools at an intermediate to advanced level that will serve them well towards tackling more advanced level of mathematics

Syllabus

MA405 **Mathematical Modeling** 3-0-0-3

Module I

Introduction Models, reality, Properties of models, model classification and characterization, steps in building mathematical models, sources of errors, dimensional analysis. Modeling using Proportionality, Modeling using Geometric similarity; graphs of a functions as models. [8L]

Module II

Model Fitting – Fitting models to data graphically, Analytic methods of model fitting, Applying the least square criterion, Experimental Modeling – High order polynomial models, Cubic Spline models. [8L]

Module III

Discrete Probabilistic Modeling –Probabilistic modeling with discrete system; Modeling components & System Reliability; Linear Regression. Discrete Optimization Modeling – Linear Programming – Geometric solutions, Algebraic Solutions, Simplex Method and Sensitivity Analysis [8L]

Module IV

Modeling with a Differential Equations – Population Growth, Graphical solutions of autonomous differential equations, numerical approximation methods-- Euler's Method and R.K. Method. Modeling with systems of Differential Equations – Predator Prey Model, Epidemic models, Euler's method for systems of Differential equations. [8L]

Module V

Simulation Modeling – Discrete-Evvnt Simulation, Generating random numbers; Simulating probabilistic behavior; Simulation of Inventory model and Queueing Models using C program. Other Types of simulation—Continuous Simulation, Monte-Carlo simulation. Advantages, disadvantages and pitfalls of simulation Case Study: Case Studies for various aspects of Modeling to be done. [8L]

Text Books:

1. Frank R. Giordano, Mawrice D Weir, William P. Fox, A first course in Mathematical Modeling 3rd ed3 2003. Thomson Brooks/Cole, Vikas Publishing House (P) Ltd.
2. J.D. Murray, Mathematical Biology – I, 3rd ed2 2004, Springer International Edition.
3. J.N. Kapoor, Mathematical Models in Biology and Medicine, 1985, East West Press, N. Delhi

Reference Book:

4. Sannon R.E, System Simulation: The Art and Science, 1975, Prentice Hall, U.S.A
5. Simulation Modeling and Analysis-Averill M. Law & W. David kelton;Tata McGrawHill

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

<u>Course Outcome (CO) Attainment Assessment tools & Evaluation procedure</u>

<u>Direct Assessment</u>

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

<u>Mapping of Course Outcomes onto Program Outcomes</u>

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA406
Course title: Fuzzy Mathematical Programming
Pre-requisite(s): MA314
Credits:L:3 T:0 P:0 C:3
Class schedule per week: 3 lectures
Class: IMSc /MSc
Semester: VII/ 4
Branch: Mathematics and Computing/ Mathematics
Course Co-ordinator:

Course Description:

1	Fuzzy Set Theory: Basic terminology and definition. Membership Function. Examples to generate membership functions. Distance approach, True- valued approach, payoff function.
2	Fuzzy Decision and Fuzzy Operators. Fuzzy Arithmetic:Addition of Fuzzy Numbers, Subtraction of Fuzzy Numbers, Multiplication of Fuzzy Numbers,Division of Fuzzy Numbers,Triangular and Trapezoidal Fuzzy Numbers. Fuzzy Linear programming Models:Linear Programming Problem with Fuzzy Resources: Verdegay's Approach. Werner's approach..
3	Linear Programming with Fuzzy Resources and objective. Zimmermann's Approach.. A regional resource allocation problem. Chana's Approach. An optimal system design Problem.
4	Linear Programming with Fuzzy parameters in the objective function. Interactive Fuzzy Linear Programming, Introduction, Discussion of zimmermann's, Werners'sChanas's and Verdegay's Approaches. Interactive Fuzzy Linear Programming - I. Problem Setting The Algorithm of IFLP-I. Interactive Fuzzy Linear Programming - II.The Algorithm of IFLP-II
5	Linear Programming with Imprecise Coefficients. Linear Programming with Imprecise Objective. Coefficients and Fuzzy Resources.

Course Outcomes: After the completion of the course, the students will be able to:

CO1	learn about various terminologies important in fuzzy mathematicalprogramming.
CO2	learn about Fuzzy Decision and Fuzzy Operators in fuzzy mathematical programming.
CO3	learn about Linear Programming with Fuzzy Resources and objective
CO4	learn Linear Programming with Fuzzy parameters in the objective function
CO5	learn about Linear Programming with Imprecise Coefficients.

Syllabus

MA 406 **FUZZY MATHEMATICAL PROGRAMMING** **3-0-0-3**

MODULE I:
Fuzzy Set Theory:Basic Terminlogy and Definition.Support,α-level set,normality,convexity and Concavity,Extension Principle,Compatibility of extension principle with α-cuts,relation,Decomposability, Decomposition Theorem.Basic Fuzzy operations:Inclusion,Equality,Complementation,Intersection,union,AlgebraicProduct,Algebraic Sum,Difference.Membership Function.A survey of functional forms.Examples to generate membership functions.:Distance approach,True- valued approach,payoff function. [8L]

MODULE II
Fuzzy Decision and Fuzzy Operators:Fuzzy Decision,Max-Min operator,compensatory operators.Fuzzy Arithmetic:Addition of Fuzzy Numbers,Subtraction of Fuzzy Numbers,Multiplication of Fuzzy Numbers,Division of Fuzzy Numbers,Triangular and Trapezoidal Fuzzy Numbers.Fuzzy Linear programming Models:Linear Programming Problem with Fuzzy Resources:Verdegay's Approach.The knox Production Mix selection Problem.A tranportation Problem.Werner's approach.The Knox Production-Mix selection Problem. An Air Pollution Regulation Problem. [8L]

MODULE III:
Linear Programming with Fuzzy Resources and objective. Zimmermann's Approach. The knox Production-Mix Selection Problem. A regional resource allocation problem. Chana's Approach. An optimal system design Problem. An aggregate Production Planning Problem. [8L]

MODULE IV:
Linear Programming with Fuzzy parameters in the objective function. Linear Programming with all fuzzy coefficients. A Production scheduling problem. Interactive Fuzzy Linear Programming, Introduction, Discussion of zimmermann's, Werners'sChanas's and Verdegay's Approaches. Interactive Fuzzy Linear Programming - I. Problem Setting The Algorithm of IFLP-I. Example: The Knox Production-Mix. Selection Problem.Interactive Fuzzy Linear Programming - II.The Algorithm of IFLP-II. [8L]

MODULE V:
Linear Programming with Imprecise Coefficients. Lai and Hwang's Approach. Buckley's Approach. Example: A Feed Mix (Diet) Problem. Negi's Approach. Fuller's Approach . Other Problems . Linear Programming with Imprecise Objective. Coefficients and Fuzzy Resources . Example: A Bank Hedging Decision Problem. [8L]

Text Books
1. **Young-Jou Lai -Lai Hwang**, Fuzzy Mathematical Programming: Methods and Applications, Springer-Verlag Berlin Heidelberg,1992.
2. **H.-J. Zimmermann**, Fuzzy Set Theory and Its Applications, Springer Science+Business Media, LLC, Fourth Edition,2001.

Reference Book
1. **Jagdeep Kaur and Amit Kumar**, An introduction to Fuzzy Linear Programming Problems: Theory, Methods and Applications (Studies in Fuzziness and Soft Computing),1st ed.2016Edition.
2. **Klir,G.J. and Yuan, Bo.** *Fuzzy sets and Fuzzy Logic, Theory and Applications*, Prentice Hall of India, 2002.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	√	√	√	√	√
End Semester Examination	√	√	√	√	√
Quiz (s)	√	√	√	√	√
Assignment	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	2	3	3	3	3	3
CO2	3	3	3	3	3	2	2	2		3	3	3
CO3	3	3	3	3	3	2	3	3	3	3	3	3
CO4	3	3	3	3	3	2	3	3	3	3	3	3
CO5	3	3	3	3	3	2	3	3	3	3	3	3

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA407
Course title: Survey Sampling
Pre-requisite(s): Basics of Probability and Statistics
Credits: L:3 T:0 P:0 C:3
Class schedule per week: 3 lectures
Class: IMSc/MSc
Semester/level: VII / 4
Branch: Mathematics and Computing/ Mathematics
Name of the Faculty:

Course Objectives : This course will enable the students to understand:

1.	Sampling unit, Sampling frame and Sampling design, along with the various methods of primary data collection
2.	Sampling and Non-sampling errors
3.	Simple Random Sampling, Stratified Sampling, and various others Probability Sampling Designs
4.	Methods of Estimation of Population Parameters (such as Population Mean and Population Variance)
5.	Two-phase (or Double) Sampling and estimation of optimum sample sizes using Cost Function Analysis
6.	Probability Proportional to Size (PPS) sampling, Midzuno Sampling design, Ordered and unordered estimators

Course Outcomes : After completion of the course, the students will be able to:

CO1	Differentiate between Sampling and Non-sampling errors.
CO2	Gain an understanding of various methods of primary data collection.
CO3	Gain an understanding of various Probability Sampling Designs.
CO4	Describe the various procedures for Estimation of Population Parameters (such as Population Mean and Population Variance).
CO5	Gain an understanding of Two-phase Sampling and demonstrate the procedure for estimation of optimum sample sizes using Cost Function Analysis.

Syllabus

MA407 **<u>Survey Sampling</u>** **3-0-0-3**

Module I

Concept of Population and Sample, Primary and Secondary data, Methods of Collecting Primary data, Sampling unit, Sampling frame, Sampling design, Census and Sample Surveys, Sampling and Non-sampling errors. [8L]

Module II

Simple Random Sampling, Stratified Sampling, Advantages of Stratification, Allocation of sample size in different strata, Systematic Sampling, Cluster Sampling, Two-stage sampling. [8L]

Module III

Concept of Study variable and Auxiliary variable, Estimation of population mean and variance using Ratio, Product and Regression Methods of Estimation, Methods for obtaining unbiased estimators. [8L]

Module IV

Concept of Two-phase (or Double) Sampling, Double Sampling for Ratio and Regression Estimators, Cost function Analysis. [8L]

Module V

Probability Proportional to Size (PPS) sampling, Inclusion Probabilities, Horvitz-Thompson estimator, Yates-Grundy form, Midzuno Sampling design, Ordered and Unordered estimators. [8L]

Text Books:

1. W.G. Cochran: Sampling Techniques, John Wiley and Sons, 3rd Edition, 1977.
2. P.V. Sukhatme, B.V. Sukhatme, S. Sukhatme and C. Ashok: Sampling Theory of Surveys with Applications, Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi, 1984.
3. D. Singh and F.S. Choudhary: Theory and Analysis of Sample Survey Designs, Wiley Eastern, 1986.

Reference Books:

1. M.N. Murthy: Sampling Theory and Methods, Statistical Publishing Society, 1979.
2. S.C. Gupta and V.K. Kapoor: Fundamentals of Applied Statistics, Sultan Chand and Sons, 1994.
3. S. Singh: Advanced Sampling Theory with Applications, Kluwer Academic Publishers, 2004.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 408
Course title: Theory of Elasticity
Pre-requisite(s): Nil
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C:3
Class schedule per week: 3 Lectures
Class: IMSc/ MSc
Semester / Level: VII / 4
Branch: Mathematics and Computing/Mathematics
Name of Teacher:

Course Objectives: This course enables the students to understand:

1.	The classical theory of linear elasticity for two and three-dimensional state of stress, Tensorial character of stress and strain.
2.	The solutions for selected problems of Elasticity in rectangular and polar coordinate as well as torsion of prismatic bars.
3.	The plane problems, Problems of Axi-symmetric stress distribution; Problems in Polar coordinates-simple radial stress distribution and problems on wedges.
4.	The semi-inverse and inverse methods, Torsion of non-circular sections, Strain energy method-strain energy density, and Complex variable technique: complex stress functions.

Course Outcomes : After the completion of this course, students will be able to:

CO1	analyze the motion of particles in elastic medium.
CO2	understand the deformation of elastic body.
CO3	determine the motion of elastic body in different coordinates system.
CO4	to find the solution of some engineering problem like strips, beams, membrane and plate problems.
CO5	demonstrate a depth of understanding in advanced mathematical topics which will serve them well towards tackling real world problems of science and engineering.

Syllabus

MA408 **Theory of Elasticity** **3-0-0-3**

Module I
Stress and Strain components at a point; Equations of equilibrium; Stress-Strain relationships, Generalized Hooke's Law; Strain compatibility relations; Boundary conditions; Uniqueness theorem and Superposition principles; other theorems-double suffix notation is adopted. [8L]

Module II
Transformation of stress and strain at a point, their tensorial character; characteristic equations of stress and strain tensors and invariants- octahedral shear stress. [8L]

Module III
Plane problems of elasticity in rectangular and polar coordinates-stress function approach; Solution by Polynomials; Displacements in simple cases; Problems of Axi-symmetric stress distribution; Problems in Polar coordinates-simple radial stress distribution and problems on wedges. [8L]

Module IV
Semi-inverse and inverse methods; Torsion of non-circular sections. Strain energy method – strain energy density; Variational principle. Applications to strips, beams, membrane and plate problems. [8L]

Module V
Complex variable technique-complex stress functions, stresses and displacements in terms of complex potentials, boundary conditions. [8L]

Text Books:

1. Timoshenko S., Theory of Elasticity, McGraw-Hill Companies, (1970).
2. Timoshenko S. and Goodier J.N., Theory of Elasticity, McGraw-Hill, Inc., New York, (1951).

Reference Books:

1. William S. Slaughter, The Linearized theory of elasticity, (2002).
2. Sokolonikoff I.S., The Mathematical Theory of Elasticity, McGraw-Hill, New York, (1956).
3. Sadhu Singh, Theory of Elasticity, Khanna Publishers, (2003).
4. Chow and Pagano, Elasticity for Engineers.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: **MA409**
Course title: Design of Experiments
Pre-requisite(s): Basics of Sampling Theory
Credits: L:3 T:0 P:0 C:3
Class schedule per week: 3 Lectures
Class: IMSc
Semester / Level: VII/4
Branch: Mathematics and Computing
Name of Teacher:

Course Objectives : This course will enable the students to understand:

1.	Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA)
2.	Layout and Analysis of various Experimental Designs such as CRD, RBD, and LSD
3.	Analysis of Missing plots
4.	Design and Analysis of Factorial Experiments
5.	Confounding in Factorial Experiments and Analysis of Balanced Incomplete Block Design (BIBD)

Course Outcomes : After completion of the course, the students will be able to:

CO1.	Gain an understanding of Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA).
CO2.	Gain an understanding of basic principles of Experimental Design, and to analyze the various Experimental Designs (such as CRD, RBD, and LSD).
CO3.	Demonstrate the analysis of Missing plots.
CO4.	Describe the procedure for designing and analysis of Factorial Experiments.
CO5.	Gain an understanding of Main effects, Interaction effects, and Confounding in Factorial Experiments.

Syllabus

MA409 Design of Experiments 3-0-0-3

Module I

Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA), Fixed, Random and Mixed effects Models, ANOVA for one-way and two-way Classified Data. [8L]

Module II

Basic principles of Design of Experiments; Layout and Analysis of Completely Randomized Design (CRD), Randomized Block Design (RBD) and Latin Square Design (LSD). [8L]

Module III

Missing plot technique, Estimation of missing plots by minimizing error sum of squares in Randomized Block Design (RBD) and Latin Square Design (LSD) with one and /or two missing observations. [8L]

Module IV

Factorial Experiments, Description of 2^2, 2^3 and 2^n factorial experiments, Main effects and Interaction effects, Confounding in symmetrical factorial experiments (2^2 series). [8L]

Module V

Connectedness and Orthogonality of Block Designs, Analysis of Balanced Incomplete Block Design (BIBD). [8L]

Text Books:

1. W.G. Cochran and D.R. Cox: Experimental Designs, John Wiley, 1957.
2. D.C. Montgomery: Design and Analysis of Experiments, John Wiley and Sons, 8th Edition, 2013.

Reference Books:

1. S.C. Gupta and V.K. Kapoor: Fundamentals of Applied Statistics, Sultan Chand and Sons, 1994.
2. M.N. Das and N.C. Giri: Design and Analysis of Experiments, New Age Publication, 2nd Edition, 1986.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 410
Course title: Differential Geometry
Pre-requisite(s): Vector Analysis
Co- requisite(s): ---
Credits: L: 3 T: 0 P: 0 C:3
Class schedule per week: 3 Lectures
Class: IMSc/MSc
Semester / Level: VII/4
Branch: Mathematics and Computing/Mathematics
Name of Teacher:

Course Objectives

This course enables the students to understand

1.	differential geometry of curves, their fundamental properties like torsion, curvature etc. along with their different forms
2.	differential geometry of surfaces, their different properties, along with their different forms
3.	curvilinear coordinates on a surface and fundamental magnitudes on a surface
4.	different forms of curves and surfaces, along with their diverse properties through the use of differential calculus

Course Outcomes

After the completion of this course, students will be able to

CO1.	develop different properties associated with curves and surfaces
CO2	use differential forms to perform calculus on curves and surfaces
CO3.	apply the theory of differential geometry to specific research problems in mathematics or other fields.
CO4.	gain an understanding to solve problems with the use of differential geometry to diverse situations in mathematical contexts
CO5.	demonstrate a depth of understanding in advanced mathematical topics in relation to geometry of curves and surfaces

Syllabus

MA410 Differential Geometry 3-0-0-3

A) Geometry of Curves

Module I

Curves, curves in n- dimensional space with examples, plane curve, space curve, properties of plane curve and space curve, arc-length, parameterization of curves, regular curve, tangent, principal normal, binormal, curvature, torsion, screw curvature, TNB frame, fundamental planes, Serret-Frenet formulae. [8L]

Module II

Intrinsic equations, existence and uniqueness theorems, contact between curves and surfaces, osculating plane, Locus of centre of curvature, spherical curvature, osculating sphere, spherical indicatrix of tangent, normal and binormal, involutes, evolutes, Bertrand curves. [8L]

B) Geometry of Surfaces

Module III

Surfaces, different forms of surfaces, smooth surface, tangent plane, normal line.
Length of curves on surfaces, curvilinear coordinates on a surface, parametric curves on a surface, first fundamental form, first order magnitudes. [8L]

Module IV

Normal to the surface, second Fundamental form, second order magnitudes.
Derivatives of normal to the surface, Weingarten Relations, curvature of normal section, principal and normal curvature, Meunier's theorem, mean curvature, Gauss curvature, lines of curvature, Rodrigue's formula, Euler's theorem. [8L]

Module V

Gauss formulae, Gauss characteristic equation, Mainardi – Codazzi equations. Introduction to geodesics on surfaces, equations of geodesics [8L]

Text Books

1. C.E. Weatherburn, Differential Geometry of Three Dimensions, English Language Book Society and Cambridge University Press, 1964.
2. T. J Willmore, An Introduction to Differential Geometry, Oxford University Press, 1999.

Reference Books

1. Andrew Pressley– Elementary Differential Geometry, Springer-Verlag, 2001, London (Indian Reprint 2004).
2. Manfredo P. Do Carmo– Differential Geometry of Curves and Surfaces, Prentice-Hall, Inc., Englewood, Cliffs, New Jersey, 1976.
3. Barrett O'Neill– Elementary Differential Geometry, 2nd Ed., Academic Press Inc., 2006.
4. William C. Graustein, Differential Geometry, Dover Publications, Inc., New York, 1966.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓		
Quiz (s)	✓	✓	✓		
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: CA532
Course title: Data Mining and Warehousing
Pre-requisite(s):
Co- requisite(s):
Credits: L:3 T:0 P:0 C:3
Class schedule per week: 03
Class: MCA/IMSc
Semester / Level: III,VII/5
Branch: MCA/IMSc

Course Objectives : This course enables the students:

1.	Examine the types of the data to be mined and apply pre-processing methods on raw data.
2.	To introduce the basic concepts of Data Warehouse and Data Mining techniques
3.	Apply the techniques of clustering, classification, association finding, feature selection and visualization to real world data
4.	Prepare students for research in the area of data mining and related applications and Enhance students communication and problem solving skills
5.	Provide the students with practice on applying data mining solutions using common data mining software tool /programming languages.

Course Outcomes : After the completion of this course, students will be able to:

1.	Illustrate the fundamentals of data mining systems as well as issues related to access and retrieval of data at scale.
2.	Explain the various data mining functionalities and data warehousing techniques.
3.	Apply the various data mining techniques to solve classification, clustering and association rule mining problems.
4.	Analyze and choose among different approaches of a data mining task.
5.	Design and evaluate data mining models to be used in solving real life problems, keeping in view social impacts of data mining.

Syllabus

CA532 **Data Mining and Warehousing** **3-0-0-3**

MODULE – I

Data Mining: Introduction, Relational Databases, Data Warehouses, Transactional databases, Advanced database Systems and Application, Data Mining Functionalities, Classification of Data Mining Systems, Major Issues in Data Mining.

Data Processing: Data Cleaning, Data Integration and Transformation, Data Reduction. [6L]

MODULE – II

Data Warehouse: Introduction, A Multidimensional data Model, Data Warehouse Architecture, Data Warehouse Implementation, Data Cube Technology, From Data Warehousing to Data Mining. Data Cube Computation and Data Generalization [6L]

MODULE – III

Mining Association Rules in Large Databases: Association Rule Mining, Single – Dimensional Boolean Association Rules, Multilevel Association Rules from Transaction Databases, Multi Dimensional Association Rules from Relational Databases, From Association Mining to Correlation Analysis. [8L]

MODULE – IV

Classification and Prediction: Classification & Prediction, Issues Regarding Classification & Prediction, Classification by decision Tree Induction, Bayesian Classification, Classification by Back propagation, Classification based on concepts & Association Rule Analysis, Other Classification Methods, Prediction, Classification Accuracy. [8L]

MODULE – V

Cluster Analysis: Introduction, Types of Data in Cluster Analysis, A Categorization of Major Clustering Methods, Partitioning Method - k- Medoids Algorithm, CLARANS, Hierarchical Methods - BIRCH, ROCK Density-Based Methods - DBSCAN, Outlier Analysis. [8L]

Text books:

1. Jiawei Han & Micheline Kamber "Data Mining Concepts & Techniques", Publisher Harcourt India. Private Limited, 2nd Edition.

Reference books:

1. Gupta G.K. "Introduction to Data Mining with case Studies", PHI, New Delhi, 2006.
2. Berson A. & Smith S.J. "Data Warehousing Data Mining", COLAP, TMH, New Delhi, 2004.
3. Dunham H.M. & Sridhar S. "Data Mining", Pearson Education, New Delhi, 2006.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓		
Quiz (s)	✓	✓	✓		
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 416
Course title: Statistical Inference
Pre-requisite(s): Basics of Probability and Statistics
Credits: L:3 T:0 P:0 C: 3
Class schedule per week: 3 lectures
Class: **IMSc/MSc**
Semester/level: **VIII/4**
Branch: **Mathematics and Computing** / Mathematics
Name of the Faculty:

Course Objectives : This course will enable the students to understand:

1.	Point Estimation and Interval Estimation
2.	Confidence Interval on Mean, Variance and Proportion
3.	Testing of Hypotheses on the Mean(s) and Variance(s)
4.	Testing for Goodness of Fit
5.	Testing of Independence of Attributes

Course Outcomes : After completion of the course, the students will be able to:

CO1	differentiate between Point Estimate and Interval Estimate and gain an understanding of various methods of Point Estimation.
CO2	describe the various properties of Estimators along with their importance in Estimation Theory.
CO3	gain an understanding of Confidence Interval, Confidence Limits and various concepts related to the Testing of Hypothesis.
CO4	Describe the various steps involved in Testing of Hypothesis problem.
CO5	Demonstrate the use of Chi-square distribution to conduct Tests of (i) Goodness of Fit, and (ii) Independence of Attributes.

Syllabus

MA416 **Statistical Inference** **3-0-0-3**

Module I

Theory of Estimation: Introduction, Point Estimation and Interval Estimation, Methods of Estimation: Method of Maximum Likelihood, Method of Moments; Properties of Estimators: Unbiasedness, Consistency, Efficiency, Sufficiency; Minimum Variance Unbiased Estimator (MVUE), Cramer-Rao Inequality, Minimum Variance Bound (MVB) Estimator, Bayes Estimators. [8L]

Module II

Confidence Interval (CI) Estimation: Introduction, CI on Mean and Variance of a Normal Distribution, CI on a Proportion, CI on the difference between Means for Paired Observations, CI on the ratio of Variances of Two Normal Distributions, CI on the difference between Two Proportions. [8L]

Module III

Tests of Hypotheses: Introduction, Statistical Hypotheses, Type-I and Type-II Errors, One-Sided and Two-Sided Hypotheses, Tests of Hypotheses on the Mean of a Normal Distribution; Variance Known as well as Unknown Cases, Tests of Hypotheses on the Variance of a Normal Distribution, Tests of Hypotheses on a Proportion. [8L]

Module IV

Tests of Hypotheses on the Means of Two Normal Distributions; Variances Known as well as Unknown Cases, The Paired t-Test, Tests for Equality of two Variances, Tests of Hypotheses on two Proportions. [8L]

Module V

Testing for Goodness of Fit, Contingency Table Tests, Neyman-Pearson Theory of Testing of Hypotheses, Uniformly Most Powerful Tests, Likelihood Ratio Tests, Unbiased Tests. [8L]

Text Books:

1. B.K. Kale: A First Course on Parametric Inference, Narosa Publishing House, 1999.
2. E.L. Lehmann: Theory of Point Estimation, John Wiley and Sons, 1998.
3. S.C. Gupta and V.K. Kapoor: Fundamentals of Mathematical Statistics, Sultan Chand and Sons, 2007.

Reference Books:

1. A.M. Goon, M.K. Gupta, B. Dasgupta: Fundamental of Statistics, Vol. I, II, World Press, 2001.
2. V.K. Rohatgi and A.K. Ehsanes Saleh: An Introduction to Probability and Statistics, John Wiley and Sons, Inc. 2003.
3. G. Casella and R.L. Berger: Statistical Inference, Cengage Learning, 3rd Edition, 2008.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA418
Course title: Mechanics
Pre-requisite(s): Nil
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C:3
Class schedule per week: 3 Lectures
Class: IMSc/MSc
Semester / Level: VIII/4
Branch: Mathematics and Computing/ Mathematics
Name of Teacher:

Course Objectives: This course enables the students to understand:

1.	Motion in different curves under central forces.
2.	The general equation of motion, Compound pendulum, D'Alembert's Principle.
3.	The variational methods, Lagrange and Hamilton's equations of motion, Small oscillations.
4.	Hamilton's principle, Fermat's principle, Principle of least action, Jacobi theory.

Course Outcomes : After the completion of this course, students will be able to:

CO1	solve the problem of central forces and mechanical systems.
CO2	analyze the motion and shape of orbits in planetary motion.
CO3	determine the solution of isoperimetric and Brachistochrone's problems.
CO4	analyze the motion in n-dimensional space.
CO5	demonstrate the strength of mathematics in modelling and simulating real world problems of science and engineering

Syllabus

MA418 Mechanics 3-0-0-3

Module I

Motion of a particle in two dimensions. Velocities and accelerations in cartesian, polar, and intrinsic coordinates. Tangential and normal accelerations. Motion of a particle on a smooth or rough curve. [8L]

Module II

Equation of motion referred to a set of rotating axes, Motion of a projectile in resisting medium. Motion of a particle in a plane under different laws of resistance. [8L]

Module III

Central forces, Stability of nearly circular orbits. Motion under the inverse square law, Kepler's laws, Time of describing an arc and area of any orbit, slightly disturbed orbits. D'Alembert's principle, The general equations of motion, Motion about a fixed axis, Compound pendulum. [8L]

Module IV

Functional, Euler's equations, Isoperimetric problems (Brachistochrone's problem), Functional involving higher order derivatives. Hamilton's principle, Derivation of Lagrange's equations, Generalized coordinates, Holonomic dynamical systems: derivation of Lagrange's equations of motion; Lagrange's function and equation in terms of L. Hamilton's function H and derivatives of Hamilton's equation of motion in terms of Hamiltonian variables. [8L]

Module V

Principle of least action, Fermat's principle, Small oscillations, Lagrange and Poisson Brackets, Contact transformation, Elements of Hamilton Jacobi theory. [8L]

Text Books:

1. Ray M., A text book on Dynamics, S Chand & Company LTD, New Delhi (1982).
2. Gregory R.D., Classical Mechanics, First South Asian Edition, Cambridge Univ. Press (2008).
3. Ramsey A.S., Dynamics Part II, Cambridge Uni Press (1961).

Reference Books:

1. Synge J.L. and Griffith B. A., Principles of Mechanics, McGraw-Hill (1970).
2. Goldstein H., Classical Mechanics, Addison-Wesley Publishing Company (1970)
3. Loney S.L., An Elementary Treatise on the Dynamics of Particle and of Rigid Bodies, Cambridge Uni Press (1913).

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA419
Course title: Mathematical Ecology
Pre-requisite(s): Differential Equations
Co- requisite(s): Basics of Ecology and Environment
Credits: L: 3 T: 0 P: 0 C:3
Class schedule per week: 3 Lectures
Class: IMSc / MSc
Semester / Level: VIII/4
Branch: Mathematics and Computing/ Mathematics
Name of Teacher:

Course Objectives : This course enables the students

1.	to understand linear and nonlinear system of differential equations and qualitative behaviour of their solutions
2.	to study different types of growths associated with population dynamics
3.	to learn basics required to develop single species, interacting, cooperative and age –structured populations
4.	to analyze the population model systems in the presence of exploitation and harvesting
5.	to compare the stability behaviour of different population ecosystems

Course Outcomes : After the completion of this course, students will be able to

CO1	acquire the skills required to formulate the interactive dynamics that exists between different populations of ecosystems through mathematical models
CO2	assess and articulate the modelling techniques appropriate for a given ecological system
CO3	make predictions of the behaviour of a given ecological system based on analysis of its mathematical model
CO4	do comparative analysis about the stability behaviour between different population ecosystems
CO5	demonstrate the strength of mathematics in simulating real world problems of ecology and environment

Syllabus

MA419 **Mathematical Ecology** **3-0-0-3**

Module I

Autonomous linear and nonlinear systems of differential equations: Equilibrium Solutions, Eigenvalues, Stability analysis, Lyapunov's functions, Phase Plane analysis, Routh – Hurwitz criterion, **[8L]**

Module II

Single Species Models: Exponential, logistic and Gompertz growths, Bifurcations, Harvest models, Bifurcations and Break points, Constant Rate Harvesting, Fox Surplus Yield Model, Allee Effect. **[8L]**

Module III

Interacting Population Models: Lotka Volterra predator-prey models, plane analysis, General predator prey models and their equilibrium solutions, existence of cycles, Bendixson- Dulac's negative criterion, Hopf bifurcation theorem, Bifurcation diagrams, Functional responses, Periodic orbits, Poincare – Bendixson theorem, Freedman and Wolkowicz model. **[8L]**

Module IV

Competition Models: Lotka – Volterra Competition model, Competition Models with Unlimited growth, exploitation competition models, Mutualism models with various types of mutualisms. **[8L]**

Module V

Exploited Population Models: Harvest models with optimal control theory, open access fishery, sole owner fishery, Pontryagin's maximum principle

Structured Population Models: Formulation of spatially and age structured models. **[8L]**

Text Books:

1. Mark Kot, Elements of Mathematical Ecology, Cambridge University Press, 2001.
2. Lawrence Perko, Differential Equations and Dynamical Systems, Springer, 2008.

Reference Books:

1. Nisbet and Gurney, Modelling Fluctuating Populations, John Wiley & Sons, 1982.
2. John Pastor, Mathematical Ecology of Populations and Ecosystems, Wiley – Blackwell Publishers, 2008.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 427
Course title: MULTIPLE CRITERIA DECISION MAKING
Pre-requisite(s): Optimization including Linear Programming Problem and Non Linear Programming ,concavity,convexity
Credits: L:3 T:0 P:0 C:3
Class schedule per week: 3 Lectures
Class: IMSc/ MSc
Semester: VIII/4
Branch: Mathematics and Computing/ Mathematics
Course Co-ordinator:

Course Description:

1	Introduction to binary relations and preference , Optimality condition. Pareto optimal or efficient solutions.
2	Introduction, Satisfying solution. Goal settings, Preference ordering and optimality in satisfying solution. Mathematical program and interactive methods. Compromise solutions and interactive methods.
3	About a value function.
4	Learning to Construct general value functions.
5	Domination structures and non-dominated solutions

Course Outcomes: After the completion of the course, the students will be able to:

CO1	learn about what is Pareto optimal or efficient solutions.
CO2	learn about Goal setting and compromise solution.
CO3	learn the Concept of Value Function.
CO4	learn the basic techniques for constructing value functions.
CO5	learn about the Domination structures and non-dominated solutions.

Syllabus

MA 427 MULTIPLE CRITERIA DECISION MAKING 3-0-0-3

Module-I:

Introduction

The needs and basic elements. Binary Relations: Preference as a Binary Relation, Characteristics of Preferences, Optimality condition. Pareto optimal or efficient solutions: Introduction, General Properties of Pareto Optimal Solutions, Conditions for Pareto Optimality in the outcome space, Conditions for Pareto Optimality in the Decision Space. [8L]

Module -II:

Goal setting and compromise solution

Introduction, Satisfying solution. Goal settings, Preference ordering and optimality in satisfying solution. Mathematical program and interactive methods. Compromise solutions. Basic concepts. General properties of compromise solutions. Properties related to p. Computing compromise solutions, interactive methods. [8L]

Module -III:

Value Function.

Revealed preference from a value function. Condition for value functions to exist. Additive and Monotonic value functions and preference separability. Conditions for Additive and monotonic value functions. Structure of preference separability and value functions. [8L]

Module -IV :

Some basic techniques for constructing value functions.

Constructing general value functions. Constructing indifference curves (surfaces).Constructing the tangent planes and gradients of value functions. Constructing the value function. Constructing the additive value functions. A first method for constructing the additive value function. A second method for constructing the additive value function. Approximation method. Approximation method: A general concept. Approximation for additive value functions. Eigen weight vectors for additive value functions. Least distance approximations. [8L]

Module -V:

Domination structures and non-dominated solutions.

Introduction, Domination structures. Constant dominated cone structures. C. A characterization of n-points and their polars. General properties of N-points . Cone convexity and N-points. N points in decision space. Existence properness and duality questions. Local and global N-points in domination structures. Interactive approximation for N-points with information from domination structures.

[8L]

Text books:

1. Po-Lung Yu, Multiple-Criteria Decision Making: concepts, Techniques and Extensions, plenum Press, 1st edition,1985.

2. Evangelos Triantaphyllou ,Multi-Criteria Decision Making Methods: A comparative study, Kluwer Academic Publishers,2000.

Reference:

1. Enrique Ballestero and Carlos Romero, Multiple Criteria Decision Making and its Applications to economic problems, Kluwer Academic Publishers, 1998.

2. Milan Zeleny , Multiple Criteria Decision Making, McGraw-Hill, 1982

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Seminar before a committee	10
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	√	√	√	√	√
End Semester Examination	√	√	√	√	√
Quiz (s)	√	√	√	√	√
Assignment	√	√	√	√	√

Indirect Assessment

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO1	3	3	3	3	2	2	2	3	2	3	2	2
CO2	3	3	3	2	2	2	2	2	3	3	2	2
CO3	3	3	3	2	2	2	2	2	3	3	2	2
CO4	2	2	3	3	2	2	2	2	3	3	2	2
CO5	2	2	3	3	2	2	2	2	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: CA584
Course title: Web Programming
Pre-requisite(s):
Co-requisite(s):
Credits: L:3 T:0 P:0 C:3
Class schedule per week: 03
Class: MCA/IMSc
Semester / Level: IV,VIII/5
Branch: MCA/IMSc

Course Objectives : This course enables the students:

CO1	To appreciate problems of traditional web designing techniques.
CO2	To understand the basics of the MVC architecture
CO3	To understand ASP.NET's implementation of the MVC model
CO4	To understand how to leverage the model for medium to large projects
CO5	To optimize the performance and rendering of web sites for different types of clients.

Syllabus

CA584 **Web Programming** **3-0-0-3**

MODULE -I

MVC, Asp.NET MVC, ORMs, Entity Framework, Models, Database Contexts, Adding Controllers, Views, Filtering, Searching related entitites. [8L]

MODULE -II

ViewBag, View Model, Complex Filtering, Data Validation, Annotations, Sorting, Paging, Routing Configurations, Many to many relationships with the Entity Framework, Partial Views. [8L]

MODULE -III

Authentication, Authorization, ASP.NET Identity, Role Management, User management, Password management. [8L]

MODULE -IV

CSS Fundamentals, Selectors, Inheritance, Cascading, Box Model, Advanced CSS, Animations. [8L]

MODULE -V

Designing Responsive web sites, Media Queries, Developing for mobiles and Tablets. [8L]

Text books:

1. Naylor L., "ASP.NET MVC with Entity Framework and CSS", 1st Edition, Apress, 2017.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Seminar before a committee	10
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	√	√	√	√	√
End Semester Examination	√	√	√	√	√
Quiz (s)	√	√	√	√	√
Assignment	√	√	√	√	√

Indirect Assessment

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3	1	1	2	3	3	1	2
CO2	3	3	3	2	2	1	1	2	2	2	1	2
CO3	3	2	2	1	3	2	1	2	1	1	1	2
CO4	2	3	3	2	2	1	2	2	2	2	1	2
CO5	3	3	3	1	2	1	1	2	2	2	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 503
Course title: Statistical Computing
Pre-requisite(s):Basics of statistics, probability and algorithms
Co- requisite(s): ---NIL
Credits: 3 L: 3 T: 0 P: 0 C:3
Class schedule per week: 3 Lectures
Class: IMSc / MSc
Semester / Level: IX/ 5
Branch: Mathematics and Computing/ Mathematics
Name of Teacher:

Course Objectives: This course enables the students to get the detailed idea about

1.	Concept of randomness; its types with applications
2.	Pseudo random generator and statistical tests of randomness
3.	Generating random variables from different probability distributions
4.	Fitting statistical models and verifying their goodness of fit
5.	Sampling algorithms and outlier analysis

Course Outcomes: After completion of the course, the learners will be able to

CO1.	Classify randomness and explore the real life applications
CO2.	Develop a new random number generator
CO3.	Simulate variates from different probability distributions
CO4.	Learn to fit various statistical models like time series models and regression models to real life numerical data
CO5.	Select an appropriate sampling algorithm for a real life population and also detect influential observations (outliers) in data and analyses them

Syllabus

MA503 Statistical Computing -0-0-3

Module I

Understanding randomness, concepts of genuine and false randomness with applications, concept of Kolmogorov's complexity and its applications. [8L]

Module II

Pseudo Random Number Generators (PRNG) including Linear Congruential Generators, Feedback Shift register method, Statistical tests of randomness with applications. [8L]

Module III

Generating random variables from different probability distributions both discrete and continuous, inverse cdf technique, acceptance sampling method. [8L]

Module IV

Modeling in Statistics: regression models, time series models, probability models, goodness of fit tests, graphical statistics. [8L]

Module V

Sampling algorithms, Markov Chain Monte Carlo. Metropolis-Hastings algorithm, Gibbs Sampling algorithm with applications, Outlier Analysis. [8L]

Text Books:

1. William J. Kennedy and James, E. Gentle "Statistical Computing", Marcel Dekker Inc,
2. D. Kundu and A. Basu, Statistical Computing: Existing Methods and Recent Development, Alpha Science International Ltd,

Reference Books:

1. James E. Gentle, Computational Statistics, Springer, 2009
2. S. Chakraborty et. al. A Treatise on Statistical Computing and its Allied Areas, Notion Press

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

<u>Course Outcome (CO) Attainment Assessment tools & Evaluation procedure</u>

<u>Direct Assessment</u>

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

<u>Mapping of Course Outcomes onto Program Outcomes</u>

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA504
Course title: Finite Element Methods
Pre-requisite(s):
Co- requisite(s): ---
Credits: L: 3 T: 0 P: 0 C:3
Class schedule per week: 3 Lectures
Class: IMSc / MSc
Semester / Level: IX/ 5
Branch: Mathematics and Computing / Mathematics
Name of Teacher:

Course Objectives : This course enables the students to understand

1.	The Methods of weighted residuals, collocations, least squares method.
2.	Variational Methods.
3.	Linear, quadratic and higher order elements.
4.	Interpolation functions, numerical integration, and modelling considerations.

Course Outcomes : After the completion of this course, students will be able to

CO1	determine the solution of engineering problems.
CO2	choose the appropriate methods to solve the physical problems.
CO3	solve the problems of differential equations using FEM.
CO4	determine the solution of initial and boundary value problems.
CO5	demonstrate the strength of mathematics in modelling and simulating real world problems

Syllabus

MA504 **Finite Element Methods** 3-0-0-3

Module I

Introduction to finite element methods, comparison with finite difference, methods Initial and Eigen value problems, Integral Relations, Functional, Base Functions, The Variational symbol, Formulation of Boundary value problems. Methods of weighted residuals, collocations, least squares method.

[8L]

Module II

Variational Methods of approximation-the Rayleigh-Ritz Method, the method of Weighted Residuals (Gelarkin's Method). Applications to solving simple problems of ordinary differential equations.

[8L]

Module III

Linear, quadratic and higher order elements in one dimensional and assembly, solution of assembled system. [8L]

Module IV

Simplex elements in two and three dimensions, quadratic triangular elements, rectangular elements, serendipity elements and isoperimetric elements and their assembly. Discretization with curved boundaries. [8L]

Module V

Interpolation functions, numerical integration, and modelling considerations. Solution of two dimensional partial differential equations under different Geometric Conditions. [8L]

Text book:

1. Reddy J.N., Introduction to the Finite Element Methods, Tata McGraw-Hill (2003)

Reference Books:

1. Bathe K.J., Finite Element Procedures, Prentice-Hall (2001).
2. Cook R.D., Malkus D.S. and Plesha M.E., Concepts and Applications of Finite Element analysis, John Wiley (2002).
3. Thomas J.R. Hughes, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis (2000).
4. George R. Buchanan, Finite Element Analysis (1994).

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA505
Course title: Calculus of Variations and Optimal Control
Pre-requisite(s): Some background on basic optimization, differential equations, mechanics
Co- requisite(s): ---
Credits: L: 3 T:0 P:0 C:3
Class schedule per week: 3 Lectures
Class: IMSc. / MSc
Semester / Level: IX / 5
Branch: Mathematics and Computing / Mathematics
Name of Teacher:

Course Objectives: This course enables the students to understand

1.	the theory of optimizing a functional, typically integral starting with the basic problem of brachistochrone in the calculus of variations.
2.	Knowledge to solve a class of optimization problem in which the function(s) to be optimized under definite integral are restricted with constraint(s)
3.	Learn to establish the necessary conditions for local minimizers using Legendre, Jacobi's and Weierstrass's conditions. solve problems with transversality condition
4.	Solve optimal control problems

Course Outcomes: After the completion of this course, students will be able to

CO1	understand the calculus of variation and optimal control and their related theories.
CO2	handle a class of optimization problem in which the function(s) to be optimized under definite integral are restricted with constraint(s)
CO3	solve optimal control problem using dynamic programming
CO4	apply calculus of variation and optimal control in the areas of optimization
CO5	apply the knowledge of calculus of variation and optimal control to solve a wide range of real world problems of science and engineering

Syllabus

MA505 **Calculus of Variations and Optimal Control** **3-0-0-3**

Module I

Introduction to calculus of variation, the brachistochrone problem, Fundamental Lemma, Necessary condition for an extremum, Euler-Lagrange equation for the function of single and several variables, Variational problems in parametric form and with undetermined end points. [8L]

Module II

Simple isoperimetric problems with single and multiple constraints, application of the problems. [8L]

Module III

Functionals depending on the higher derivatives of the dependent variables, Euler- Poisson equation, Legendre necessary condition, Jacobi's necessary condition**,** Weierstrass's necessary condition, a weak extremum, a strong extremum, transversality condition in general case. [8L]

Module IV

Preliminary Introduction to optimal control problem, necessary condition for optimal control, Linear regulator, Pontryagin minimum principle and state inequality constraints, Hamilton-jacobi-bellman equation. [8L]

Module V

Solving optimal control problem using dynamic programming, structure and properties of optimal control system, various types of constraints, singular solutions, minimum time problem, Bang –bang Controls. [8L]

Text Books:

1. Mike Mesterton, Gibbons, A primer on the calculus of variations and optimal control theory, American Mathematical Society, 2009
2. A. S. Gupta, Calculus of Variations with Applications, Hall of India, 1996.
3. D. S. Naidu: Optimal Control Systems, CRC Press, 2002
4. D. E. Kirk: Optimal Control Theory: An Introduction, Prentice Hall, 2004

Reference Books:

1. R Weinstock, Calculus of Variations with Applications to Physics and Engineering, Dover Publications, 1974
2. D Liberson, calculus of variation and optimal control theory: a concise introduction, Princeton University press, 2011
3. M Athans, and P L Falb, Optimal control: An introduction to the theory and its applications, Dover books on engineering, 2006

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 506
Course title: Advanced Difference Equations
Pre-requisite(s): Sequence and Series of numbers and functions.
Co- requisite(s): ---
Credits: L: 3 T: 0 P: 0 C:3
Class schedule per week: 3 Lectures
Class: IMSc/ MSc
Semester / Level: IX / 5
Branch: Mathematics and Computing / Mathematics
Name of Teacher:

Course Objectives : This course enables the students to understand

1.	application of sequences and series of numbers and functions.
2.	stability theory of difference equations
3.	partial difference equations
4.	applications of partial difference equations in problems of engineering.

Course Outcomes: After the completion of this course, students will be able to

CO1	handle different types of systems: Autonomous (time-invariant) systems, Linear periodic systems.
CO2	apply the theory of difference equations in different midel: Markov Chains, Absorbing Markov Chains, A Trade model.
CO3	apply the theory to study the quantitative and qualitative study of solutions of different discrete models in Engineering and Biology and Ecology.
CO4	differenciate between the qualitative and quantitative behaviour of solutions of the difference equations and the corresponding differential equations.
CO5	apply the theory to study the qualitative theory of solutions of difference equations and partial difference equations of higher order.

Syllabus

MA 506 # Advanced Difference Equations **3-0-0-3**

Module 1

Introduction and Applications of Difference Equations: Introduction, Mathematics: Summing series, Fibonacci numbers, Chebyshev polynomials, Newton method. Perturbation Techniques: expansion of ϵ, slowly varying amplitude and phase. The Logistic equation: Introduction, The two-cycle, higher cycles, Physical systems: Modeling and time scales, Law of cooling, second-order chemical reaction, rate of dissolution, heat equation. Biological Sciences: Single-species Population models, Harvesting, red blood cell production, Ventilation column and bold CO_2 levels, Simple epidemic model, waves of disease.

[8L]

Module II

Systems of Linear Difference equations: Autonomous (time-invariant) systems: The discrete analogue of the Putzer algorithm, Development of the algorithm for A^n, The Basic theory, The Jordan form: diagonalizable matrices, The Jordan form, Block-Diagonal matrices, Linear periodic systems, Applications in Markov Chains, Absorbing Markov Chains, A Trade model, The Heat equation. [8L]

Module III

Stability Theory: Initial value problems for linear systems, Stability of linear systems, Phase plane analysis for linear systems, Fundamental matrices and Floquet Theory, Stability of Nonlinear systems. Applications of Floquet theory in Engineering problems. Lyapunov's Direct or Second method: Applications to models in one species with two age classes, Host-parasitoid systems, A business cycle model, Nicholson-Bailey model and Floor Beetle case study. [8L]

Module IV

The Self-Adjoint Second Order Linear Equations: Introduction, Sturmian Theory, Green's functions, Disconjugacy, The Riccatti equation. The Sturm-Liouville Problem: Introduction, Finite Fourier analysis, Nonhomogeneous problem. Discrete Calculus of Variations: Introduction, Necessary conditions for Disconjugacy, Sufficient conditions for disconjugacy. Boundary Value Problems for Nonlinear Equations: Introduction, The Lipschitz case, Existence of solutions, Boundary value problems for Differential equations. [8L]

Module V

Partial Difference Equations: Discretization of Partial Differential Equations, Solutions of partial difference equations. Numerical Solutions of Partial Difference Equations: Convergence and consistency of solutions of initial-value problems, Initial-Boundary value problems, The Lax theorem, Examples. Computational Interlude-Review of computational results, HW0.0.1, Implicit Scheme, Neumann boundary conditions. Stability: Analysis of stability, Finite Fourier series and stability, Examples, Consistency and stability of some parabolic equations and hyperbolic equations. Dispersion and Dissipation: Introduction, Dispersion and dissipation for difference equations, Artificial Dissipation.

[8L]

Text Books:

1. W. G. Kelley and Allan C. Peterson, Difference Equations: An Introduction with Applications, Academic Press, Second Edition, 2001.
2. Saber Elaydi, An Introduction to Difference Equations, Third Edition, Springer, New York, 2005.
3. J.W.Thomas, Numerical Partial Differential equations, Springer, 1995.
4. R. E. Mickens, Difference Equations: Theory, Applications and Advanced Topics, CRC Press, Third Edition, 2015.

Reference Books:

1. Kenneth S. Miller, An Introduction to the Calculus of Finite Differences and Difference Equations, Dover Publications, New York, 1960.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA507
Course title: Computational Fluid Dynamics
Pre-requisite(s): Partial Differential Equations
Credits: L:3 T:0 P:0 C:3
Class schedule per week: 3 lectures
Class: IMSc/ MSc
Semester/level: IX/5
Branch: Mathematics and Computing / Mathematics
Name of the Faculty:

Course Objectives: This course enables the students to understand

1.	the basis of finite difference method to solve the partial differential equation.
2.	the uses of Finite Volume method and limitation of finite difference method.
3.	the analysis, applications and limitations of numerical schemes.
4.	the numerical approach to solve compressible Euler equations.
5	the numerical approach to solve the incompressible Navier-Stokes equations.

Course Outcomes: After the completion of this course, students will be able to

CO 1	learn the background and get an introduction for the use of numerical methods to solve partial differential equations.
CO 2	apply the concepts of finite difference and finite volume methods to solve the fluid mechanics problem and other real word problems
CO 3	analyse the consistency, stability and convergence analysis of numerical schemes.
CO 4	choose appropriate numerical methods to solve the fluid flow problem.
CO 5	understand the limitation of numerical methods and various techniches in actual implementation.

Syllabus

MA507 **Computational Fluid Dynamics** **3-0-0-3**

Module I

Basic equations of fluid dynamics: General form of a conservation law; Equation of mass conservation; Conservation law of momentum; Conservation equation of energy. Incompressible form of the Navier-Stokes equations, 2D incompressible Navier-Stokes equations, Stream function-vorticity formulation, Mathematical and physical classification of PDEs.

[6L]

Module II

Basic Discretization techniques: Finite Difference Method (FDM); The Finite Volume Method (FVM) and conservative discretization. Analysis and Application of Numerical Schemes: Consistency; Stability; Convergence; Fourier or von Neumann stability analysis; Modified equation; Application of FDM to wave, Heat, Laplace and Burgers equations.

[15L]

Module III

Integration methods for systems of ODEs: Linear multistep methods; Predictor-corrector schemes; The Runge Kutta schemes. **[6L]**

Module IV

Numerical solution of the compressible Euler equations: Mathematical formulation of the system of Euler equations; Space centred schemes; upwind schemes for the Euler equations flux vector and flux difference splitting. **[6L]**

Module V

Numerical solution of the incompressible Navier-Stokes equations: Stream function vorticity formulation; Primitive variable formulation. Pressure correction techniques like SIMPLE, SIMPLER and SIMPLEC.

[7L]

Text Books:

1. Richard Pletcher, John Tannehill and Dale Anderson, Computational Fluid Mechanics and Heat Transfer 3e', CRC Press, 2012.
2. H.K. Versteeg and W. Malalasekera, An introduction to computational fluid dynamics: The finite volume method 3e, Pearson Education, 2007.
3. Charles Hirsch, Numerical Computation of Internal and External Flows, Vol.1 (1988) and Vol.2 (1990), John Wiley & Sons.

Reference Books:

1. Pradip Niyogi, S.K. Chakrabarty, M.K. Laha, Introduction to computational fluid dynamics, Pearson Education India, 1985.
2. J. H. Fergiger and M. Peric, Computational Methods for Fluid Dynamics, Springer, 2002.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 508
Course title: Qualitative Theory of Differential equations
Pre-requisite(s): Basics of Ordinary and Partial Differential Equations
Co- requisite(s): ---
Credits: L: 3 T: 0 P: 0 C:3
Class schedule per week: 3 Lectures
Class: IMSc/ MSc
Semester / Level: IX/5
Branch: Mathematics and Computing/ Mathematics
Name of Teacher:

Course Objectives : This course enables the students to understand

1.	the advanced theory of ordinary and partial differential equations
2.	the concept of Existence and uniqueness of solutions of differential equations.
3.	the concept of stability theory of differential equations.
4.	Green's functions of boundary value problems.

Course Outcomes: After the completion of this course, students will be able to

CO1	handle and analyse the problems related to ordinary and partial differential equations.
CO2	study the qualitative behaviour of solutions of ordinary and partial differential equations
CO3	handle the partial differential equations in theory of Biological, Ecological systems and different engineering problems.
CO4	use of Green's functions in the study of qualitative behaviour of solutions of boundary value problems.
CO5	enhance and develop the ability of using the language of mathematics in analysing the real world problems of sciences and engineering.

Syllabus

MA508 **Qualitative Theory of Differential equations** **3-0-0-3**

Module 1

Systems of Ordinary Differential Equations: Existence, uniqueness and continuity, Gronwall Inequality Linear Systems and Phase Space Analysis: Introduction, Existence and uniqueness of Linear Systems, Linear homogeneous and non homogeneous systems, Linear Systems with Constant coefficients, Jordan Canonical form, Autonomous Systems- Phase space-two dimensional systems. [8L]

Module II

Existence Theory: Existence theory for systems of first order equations, uniqueness and continuation of solutions. Stability of linear and almost linear systems: Introduction, Definition of stability, linear systems, almost linear systems, conditional stability. [8L]

Module III

Lyapunov's Second method: Lyapunov's theorems, Proofs of Lyapunov's theorems, Invarient sets and stability, global asymptotic stability, nonautonomous systems. [8L]

Module IV

Sturm-Liouville Systems, Eigen values and Eigen functions, Singular Sturm-Liouville Systems.
Method of separation of variables: Separation of variables, The vibrating string problem, Existence and uniqueness of solutions of the vibrating string problem, heat equation, heat conduction problem, Existence and uniqueness of solutions of heat conduction problem.
Elliptic Equations: Elliptic equations with Dirichlet, Neumann and Cauchy boundary conditions, Maximum and minimum principles, Dirichlet and Neumann problems for a rectangle, Green's function for Laplace equations. [8L]

Module V

Green's function and Boundary Value Problems: Introduction, Properties of green's function, Method of Green's functions, Dirichlet's Problem for Laplace Operator, Dirichlet's problem for Helmholtz operator, Method of Eigen functions, Higher-Dimensional Problems, Neumann Problem. [8L]

Text Books:

1. F. Brauer and J. A. Nohel, The Qualitative Theory of Ordinary Differential equations, Dover Publications, New York, 1989.
2. Tyn Myint U and Debnath Loknath, Linear partial Differential Equations for Scientists and Engineers, Birkhauser, 4th Edition, 2007.

Reference Books:

1. Ravi P. Agarwal and Donal O'Regan, An Introduction to Ordinary Differential Equations, Universitext, Springer, 2008.
2. Ravi P. Agarwal and Donal O'Regan, Ordinary and Partial Differential equations, With Special Functions, Fourier Series and Boundary Value Problems, Universitext, Springer, 2009.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 523
Course title: Computational Mathematics
Pre-requisite(s):
Co- requisite(s): ---
Credits: L: 3 T: 0 P: 0 C:3
Class schedule per week: 3 Lectures
Class: IMSc/MSc
Semester / Level: IX, III/5
Branch: Mathematics and Computing/Mathematics
Name of Teacher:

Course objectives: This course is intended as an advance course enables the students to get the detailed idea about:

1.	Partial differential equations
2.	boundary value problem
3.	Calculus of Variations
4.	Eigen values and eigen vectors of Matrices
5.	Numerical method: Finite difference method
6.	Introduction to finite element method

Course Outcomes: After completion of the course, the learners will be able to:

CO1.	formulate the continuous physical systems using mathematical notations as partial differential equations since most entities in the real world are dependent of several independent entities and handle real dynamic problems with diversity and complexity which leads to boundary value problem
CO2.	gain an understanding of eigen value problem and gain skills in modelling and solving eigen value problem.
CO3.	handle huge amount of problems in science and engineering physics where one has to minimize the energy associated to the problem under consideration.
CO4.	solve problems involving differential equations, ordinary and partial with regular as well as irregular boundaries.
CO5.	demonstrate a depth of understanding in advanced mathematical topics and enhance and develop the ability of using the language of mathematics in Science and engineering

Syllabus

MA 523 **Computational Mathematics** **3-0-0-3**

Module I

Partial Differential Equations:

Classification of partial differential equations. Its characteristics and reduction to canonical forms. Solution of higher order p.d.e with variable co-efficients by Monge's method. Boundary value Problems. Laplac's equation in different co-ordinate systems. Two-dimensional heat conduction equation. Vibrating membrane. [8L]

Module II

Eigen values and eigen vectors of Matrices:

Basic properties of eigen values and eigen vectors. The power method. The Rayleigh quotient. Inverse iteration. Jacobi's methods, Given and Household's methods. Leverriar – Faddeeva method. Sylvester's expansion theorem and Computation of f(A). [8L]

Module III

Numerical method: Finite difference method for parabolic, elliptic and hyperbolic equations. Explicit and implicit schemes. Convergence and Stability of schemes. [8L]

Module IV

Calculus of Variations:

The Euler equation of Variations, the extrema of integrals under constraints. Sturm-Liouville Problems. Hamilton's principle and Lagrange's equations. [8L]

Module V

Introduction to finite element method.

Concept of functionals. Rayleigh Ritz and Galerkin's Techniques. Finite element method for one dimensional problems. Application to two dimensional problems. [8L]

Test Books:

1. Advanced Engineering Mathematics – E. Kreyszig
2. Linear Partial Differential Equations for Scientists and Engineers, Lokenath Debnath and Tyn Myint U., Fourth Edition, Birkhauser, Boston.
3. I.N.Sneddon, Elements of Partial Differential Equations, **McGraw Hill, NewYork, 2006.**
4. J.N. Reddy , An Introduction to the Finite Element Method ; McGraw Hill Energy and variational Methods in Applied mechanics .

Reference Books:

1. J D Hoffman, Numerical Methods for Engineers and Scientists, **McGraw Hill Inc., NewYork, 2001.**
2. O.C. Zienkiewicz , The Finite Element Method,
3. J N Reddy , Energy and variational Methods in Applied mechanics .

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	3	2	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% =3

COURSE INFORMATION SHEET

Course code: CA630
Course title: NETWORK SECURITY AND CRYPTOGRAPHY
Pre-requisite(s):
Co- requisite(s):
Credits: L:3 T:1 P:0 C:3
Class schedule per week: 03 Lectures, 1 tutorial
Class: MCA/IMSc
Semester / Level: VI, IX/6
Branch: MCA/IMSc

Course Objective : This course enables the students

1.	To Learn Basic Concepts of Cryptography and Network Security and Apply them in various Real life Application
2.	To Learn Basic Concepts of Mathematical Foundations of Cryptography.
3.	To Learn different Symmetric and Asymmetric Cryptography techniques.
4.	To Learn Basic Concepts of Internet Security Protocols.
5.	To Learn Basic Concepts of Network Security.

.
Course Outcomes : After the completion of this course, students will :

1.	Understand the basic concept of Cryptography and Network Security and their mathematical models, and to be familiar with different types of threats
2.	Learning and applying various Ciphering Techniques.
3.	Apply Symmetric and Asymmetric Cryptographic Algorithms and Standards in Networks.
4.	Examine the issues and structure of Authentication Service and Electronic Mail Security
5.	To explain and classify different malicious programs, worms and viruses, and to learn the working and design principles of Firewalls

Syllabus

CA630 **Cryptography and Network Security** **3-1-0-4**

Module I

Foundations – Protocol Building Blocks - Basic Protocols - Intermediate Protocols - Advanced Protocols - Zero-Knowledge Proofs - Zero-Knowledge Proofs of Identity -Blind Signatures - Identity-Based Public-Key Cryptography. **[8L]**

Module II

Key Length - Key Management – Public Key Cryptography versus Symmetric Cryptography - Encrypting Communications Channels - Encrypting Data for Storage - Hardware Encryption versus Software Encryption - Compression, Encoding, and Encryption - Detecting Encryption – Hiding and Destroying Information. **[8L]**

Module III

Information Theory - Complexity Theory - Number Theory - Factoring - Prime Number Generation - Discrete Logarithms in a Finite Field - Data Encryption Standard (DES) – Lucifer - Madryga - NewDES - GOST – 3 Way – Crab – RC5 - Double Encryption - Triple Encryption - CDMF Key Shortening - Whitening. **[8L]**

Module IV

Pseudo-Random-Sequence Generators and Stream Ciphers – RC4 - SEAL - Feedback with Carry Shift Registers - Stream Ciphers Using FCSRs - Nonlinear-Feedback Shift Registers - System-Theoretic Approach to Stream-Cipher Design - Complexity-Theoretic Approach to Stream-Cipher Design - N-Hash - MD4 - MD5 - MD2 - Secure Hash Algorithm (SHA) - OneWay Hash Functions Using Symmetric Block Algorithms - Using Public-Key Algorithms - Message Authentication Codes

[8L]

Module V

RSA - Pohlig-Hellman - McEliece - Elliptic Curve Cryptosystems -Digital Signature Algorithm (DSA) - Gost Digital Signature Algorithm - Discrete Logarithm Signature Schemes - Ongchnorr-Shamir - Cellular Automata - Feige-Fiat-Shamir -Guillou-Quisquater - Diffie-Hellman - Station-to-Station Protocol -Shamir's Three-Pass Protocol - IBM Secret-Key Management Protocol - MITRENET - Kerberos - IBM Common Cryptographic Architecture. **[8L]**

Text Books:

1. Schneier Bruce, "Applied Cryptography: Protocols, Algorithms, and Source Code in C", 2nd Edition, John Wiley & Sons, Inc, 1996.
2. Mao Wenbo, "Modern Cryptography Theory and Practice", Pearson Education, 2004.
3. Kahate Atul, "Cryptography and Network Security", Tata McGrew Hill, 2003.

Reference Book:

1. Stallings William, "Cryptography & Network Security Principles and Practice", Pearson Education.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	1	1	1	1	1	1	2
CO2	1	3	3	1	1	1	1	2	1	1	1	2
CO3	2	2	3	3	1	1	1	1	2	1	1	2
CO4	2	2	1	3	1	1	1	1	1	1	1	2
CO5	1	1	1	1	1	1	1	1	2	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: CA538
Course title: SOFT COMPUTING
Pre-requisite(s):
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C:3
Class schedule per week: 03Lectures
Class: MCA/IMSc
Semester / Level: V,IX/5
Branch: MCA/IMSc

Course Objective: This course enables the students:

CO1	To know the basic functions of different AI branches.
CO2	To understand the functionalities of neural networks .
CO3	To know the application of fuzzy logic.
CO4	To understand the basic functionalities of optimizations through soft computing.
CO5	To find the basic functions of soft computing.

Syllabus

CA538 **SOFT COMPUTING** **3-0-0-3**

MODULE – I

Introduction to Artificial Intelligence System, Neural Network, Fuzzy Logic & Genetic Algorithm. Fuzzy Set Theory: Fuzzy Versus Crisp, Crisp Set, Fuzzy Set, Crip Relation, Fuzzy Relations.

[8L]

MODULE – II

Fuzzy System: Crisp Logic, Predicate Logic, Fuzzy Logic, Fuzzy Rule Based System, Defuzzification Methods, and Applications. [8L]

MODULE – III

Genetic Algorithms, Basic Concepts, Creation Of Offspring, Working Principle, Encoding, Fitness Function, Reproduction.

Genetic Modeling, Inheritance Operations, Cross Over, Inversion And Deletion, Mutation Operator, Bit Wise Operators, Generation Cycle, Convergence Of Genetic Algorithm, Application, Multi-Level Optimization, Real Life Problems, Difference And Similarities Between GA And Other Traditional Methods, Advanced In GA. [8L]

MODULE – IV

Fundamentals Of Neural Networks, Basic Concepts Of Neural Network, Human Brain, Model Of An Artificial Neuron, Neural Network Architectures, Characteristic Of Neural Networks, Learning Method, Taxonomy Of Neural Network Architectures, History Of Neural Network Research, Early Neural Network Architectures, Some Application Domains. [8L]

MODULE – V

Back Propagation Network Architecture Of Back Propagation Network, Back Propagation Learning, Illustration, Applications, Effect Of Tuning Parameters Of The Back Propagation Neural Network, Selection Of Various Parameters In BPN, Variations Of Standard Back Propagation Algorithm.

Associative Memory And Adaptive Resonance Theory, Autocorrelations, Hetrocorrelators , Multiple Training Encoding Strategy, Exponential BAM, Associative Memory For Real Coded Pattern Pairs, Applications, Introduction To Adaptive Resonance Theory, ARTI, Character Recognition Using ARI1

[8L]

Text Book:

1. Rajasekharan S. & Vijayalakshmi G. A. “Neural Network Fuzzy Logic and Gentic Algorithm Synthesis and Applications”, Prentice Hall of India PLT, Pai, 2004.

Reference Book:

1. Jang Jyh Shing R, Sun C. T., Mizutani E. “Neuro Fuzzy and Soft Computing –A Computational Approach to Learning and Machine Intelligence”, Prentice Hall of India, 1997.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

<u>Course Outcome (CO) Attainment Assessment tools & Evaluation procedure</u>

<u>Direct Assessment</u>

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

<u>Mapping of Course Outcomes onto Program Outcomes</u>

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1	1	2	1	2	2	1	2	2
CO2	3	3	2	1	1	1	2	1	1	2	1	2
CO3	3	2	1	3	3	1	1	1	1	1	2	2
CO4	3	1	2	1	2	2	2	2	1	1	1	2
CO5	2	2	1	2	3	2	2	1	2	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

Detail Course Structures
of
OPEN ELLECTIVES (OE)

COURSE INFORMATION SHEET

Course code: MA 428
Course title: Numerical and Statistical Methods
Pre-requisite(s): NIL
Co- requisite(s): ---NIL
Credits: L: 3 T: 0 P: 0 C:3
Class schedule per week: 03 Lectures
Class: MCA
Semester / Level: I/4
Branch: Computer Science and Engineering
Name of Teacher:

Course Objectives : This course enables the students to :

1.	derive appropriate numerical methods to solve algebraic, transcendental equations and linear system of equations
2.	approximate a function using various interpolation techniques and solve numerically linear system of equations
3.	find the derivative at a point numerically and numerical solution of initial value problems
4.	understand the concepts in probability theory, the properties of probability distributions
5.	understand estimation of mean, variance and proportion, the concepts of statistical hypothesis

Course Outcomes : After the completion of this course, students will be able to

CO 1	solve algebraic, transcendental equation and linear system of equations using an appropriate numerical method arising in various engineering problems
CO 2	Solve linear system of equtions
CO 3	evaluate derivative at a value using an appropriate numerical method in various research problems, solve differential equation numerically
CO 4	learn basic probability axioms, rules and the moments of discrete and continuous random variables as well as be familiar with common named discrete and continuous random variables.
CO 5	find the point and interval estimates, analyse data statistically and interpretation of the results

Syllabus

MA 428 Numerical and Statistical Methods (3-0-0-3)

Module I

Errors and their computation: absolute, relative and percentage. Solution of algebraic & transcendental equations: Bisection method, False position method, Secant method, Newton's Raphson method, Iterative method, Error analysis and convergence study. [6L]

Module II

Interpolation with equal & unequal intervals: Introduction, finite differences-forward, backward & central difference tables, Newton's formula for interpolation, Gauss's central difference interpolation formula, divided difference and their properties- Newton's divided differences formula, Lagrange's interpolation formula, Inverse interpolation. Numerical solution of linear system of equations: Direct Method-Gauss elimination, Gauss-Jordan, LU decomposition methods. Iterative Methods-Gauss-Jacobi and Gauss Seidel methods. [10L]

Module III

Numerical differential & integration: Introduction, derivatives using forward and backward difference formula, Numerical Integration-Trapezoidal rule, Simpson's 1/3 & 3/8 rules, Weddle's rule. Numerical solution of ordinary differential equations: Taylor Series method, Euler's method, Modified Euler's method, Runge-Kutta methods of 2nd and 4th order. [8L]

Module IV

Concepts of Probability: Experiment and Sample Space, Events and Operations with Events, Probability of an Event, Basic Probability Rules, Applications of Probability Rules, Conditional Probability, random variable: continuous and discrete**,** Mean, Variance and Standard Deviation of a Random Variable. Binomial Experiments: Structure of a Binomial Experiment, Binomial Probability Distribution, Use of Binomial Probability Table. Properties of a Normal Curve, Normal Probability Distribution, Areas Under a Normal Curve. Approximating a Binomial Probability, The Normal Theorem and the Central Limit Theorem. [8L]

Module V

Estimation of Population Parameters: Parameter and Statistic, Point and Interval Estimation, Interval Estimation of Three Common Parameters. Hypothesis Testing for a Single Population: Concept of a Hypothesis, Tests Involving a Population Mean, Tests Involving a Population Proportion, Tests Involving a Population Standard Deviation. Concepts of a Bivariate Data Set, Correlation Coefficient, The Regression line. [8L]

Text Books:

1. S.S.Sastry-Introductory Methods of Numerical Analysis-PHI, Private Ltd., New Delhi.
2. N.Pal & S. Sarkar- Statistics: Concepts and Applications, PHI, New Delhi-2005.

Reference Books:

1 R.V.Hogg et.al- Probability and Statistical Inference, 7th Edn, Pearson Education, New Delhi-2006.

2. R.L.Burden & J.D.Faires- Numerical Analysis, Thomson Learning-Brooks/Cole, Indian Reprint, 2005.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
End Semester Examination	√	√	√	√	√
Quiz (s)	√	√	√	√	√
Assignment	√	√	√	√	√
Seminar	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	3	3	3	2	2
CO2	3	3	3	3	1	1	1	3	3	3	2	2
CO3	3	3	3	3	1	1	1	3	3	3	2	2
CO4	3	3	3	3	1	1	1	3	3	3	2	2
CO5	3	3	3	3	1	1	1	3	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA 429
Course title: Numerical and Statistical Methods
Pre-requisite(s): NIL
Co- requisite(s): ---NIL
Credits: L: 3 T: 0 P: 0 C:1.5
Class schedule per week: 03 Lectures
Class: MCA
Semester / Level: I/4
Branch: Computer Science and Engineering
Name of Teacher:

Syllabus

List of Assignments:

1. Find a simple root of $f(x)=0$ using bisection method. Read the end points of the interval (a,b) in which the root lies, maximum number of iterations n and error tolerance eps.
2. Find a simple root of $f(x)=0$ using Regula-Falsi method. Read the end points of the interval (a,b) in which the root lies, maximum number of iterations n and error tolerance eps.
3. Find a simple root of $f(x)=0$ using Newton Raphson method. Read any initial approximation x_0, maximum number of iterations n and error tolerance eps.
4. Solution of a system of $n \times n$ linear equations using Gauss elimination method with partial pivoting.
5. Matrix inversion and solution of $n \times n$ system of equations using Gauss-Jordan method.
6. Program to solve a system of equation using Gauss-Seidel iteration method. Order of the matrix is n, maximum number of iterations $niter$, error tolerance is eps and the initial approximation to the solution vector is x_0.
7. Program for Lagrange and Newton divided difference interpolation.
8. Program for Newton's forward and backward interpolation.
9. Program for Gauss's central difference interpolation (both backward and forward).
10. Program to evaluate the integral of $f(x)$ between the limits a to b using Trapezoidal rule of integration based on n subintervals or $n+1$ nodal points. The values of a,b and n are to be read. The program is tested for $f(x)=1/(1+x)$.
11. Program to evaluate the integral of $f(x)$ between the limits a to b using Simpson's rule of integration based on $2n$ subintervals or $2n+1$ nodal points. The values of a,b and n are to be read and the integrand is written as a function subprogram. The program is tested for $f(x)=1/(1+x)$.
12. Program to solve an IVP, $dy/dx = f(x), y(x_0) = y_0$ using Euler method. The initial value x_0, y_0 the final value x_f and the step size h are to be read. The program is tested for $f(x,y) = -2xy^2$.
13. Program to solve an IVP, $dy/dx = f(x), y(x_0) = y_0$ using the classical Runge-Kutta fourth order method with step size h, $h/2$ and also computes the estimate of the truncation error. Input parameters are: initial point, initial value, number of intervals and the step length h. Solutions with h, $h/2$ and the estimate of the truncation error are available as output. The right hand side The program is tested for $f(x,y) = -2xy^2$.

COURSE INFORMATION SHEET

Course code: MA 430
Course title: Discrete Mathematical Structure
Pre-requisite(s):
Co- requisite(s):
Credits: 4 L:3 T:0 P:0
Class schedule per week: 03
Class: MSc/MCA
Semester / Level:I/4
Branch: Mathematics/ MCA
Name of Teacher:

Course Objectives : This course enables the students:

A.	To study the methods of reasoning, which includes algebra of propositions, such as compound propositions, truth tables, and tautologies.
B.	To study the recurrence relations, supported by recursive sequences, a tool for the analysis of computer programs. In addition, the generating function, a useful mode for representing sequences efficiently by coding the terms of a sequence as coefficients of powers of a variable in a power series, and its applications in solving recurrence relations will be incorporated here.
C.	To study the discrete structures which are built using sets and their operations; Matrix representation of relations, Digraphs, Classification of Functions and their representation, Discrete Numeric Functions, Growth of Functions.
D.	To study algebraic structures in respect to computer science, because of its variability in applications to computing techniques, in particular programming languages.
E	To study basic graph terminologies and important concepts in graph theory such as types of graphs, storage representation and operations. Also to study here special types of graphs like Eulerian and Hamiltonian.

Course Outcomes : After the completion of this course, students will be able to:

1.	be conversant with the rules of logic to understand and reason with statements
2.	understand about recursion and its use to sequences and also about generating functions and their applications in solving recurrence relations.
3.	handle many of the discrete structures emerged which are indeed useful in Computer Science with the help of set theory approach.
4.	familiar with group theory and its utility. It has variability in applications to computing techniques, such as group codes, coding binary information, decoding , and error correction.
5.	be conversant with important concepts in graph theory such as types of graphs, storage representation and operations. Also to study here special types of graphs like Eulerian and Hamiltonian

Syllabus

MA 430 Discrete Mathematical Structure 3-0-0-3

Module I

Mathematical logic and Mathematical Reasoning, Compound Statements, Propositional Equivalences, Predicates and Quantifiers,Methods of Proof, Mathematical Induction, Well-ordering principle, Recursive Definition and Algorithms. (8L)

Module II

Relations, Properties/Classification of Relations, Closure operations on Relations, Matrix representation of Relations, Digraphs, Partial ordered set, Linearly Ordered Set ,Hasse Diagram, Isomorphism, Isomorphic Ordered Sets, Supremum, Infimum, Well ordered set. (12L)

Module III

Recurrence Relations, Classification of Recurrence Relations and their solutions by Characteristic Root method, Generating function and their various aspects, Utility of Generating function in solving Recurrence Relations (5L)

Module IV

Binary Operations, Groups, Product and Quotients of Groups,Semi group, Products and Quotients of Semi groups, Permutation Group, Composition of Permutation, Inverse Permutation, Cyclic Permutation, Transposition, Even and Odd Permutation, Coding of Binary Information and Error Correction, Decoding and Error Correction. (8L)

Module V

Introduction to Graph, Graph Terminologies and their representation, Connected & Disconnected graphs, Isomorphic Graph, Euler & Hamilton graphs.

Introduction to Trees, Versatility of Trees, Tree traversal, Spanning Trees, Minimum Spanning Tree. (7L)

Text Books:

1. **Mott , Abraham & Baker** : Discrete Mathematics for computer scientist & mathematicians PHI, 2nd edition 2002.
2. **ROSS & WRIGHT :** Discrete Mathematics PHI 2nd edition , 1988.
3. **Swapan Kumar Chakraborty and BikashKantiSarkar**: Discrete Mathematics, Oxford Univ. Publication, 2010.
4. **Kolman, Rusby, Ross**: Discrete Mathematics Structures, PHI, 5thed, 2005.

Reference Book:

5. **BikashKantiSarkar and Swapan Kumar Chakraborty**:Combinatorics and Graph Theory, PHI, 2016.
6. **Seymour Lipschuz and Mark Lipson**: Discrete Mathematics, Shaum'soutlines, 2003.
7. **C.L.LIU :** Elements of Discrete maths, Mcgraw Hill, 2nd edition, 2001.
8. **Johnsonbaugh, R.,:** Discrete Mathematics, 6th Ed., Maxwell, Macmillan International

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
End Semester Examination	50
Quiz (s)	10+10+10
Assignment	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Seminar before a committee	✓	✓	✓	✓	✓
End Semester Examination	✓	✓	✓	✓	✓
Quiz (s)	✓	✓	✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1	1	2	1	2	2	1	2	2
CO2	3	3	2	1	1	1	2	1	1	2	1	2
CO3	3	2	1	3	3	1	1	1	1	1	2	2
CO4	3	1	2	1	2	2	2	2	1	1	1	2
CO5	2	2	1	2	3	2	2	1	2	3	1	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

Detail Course Structures
of
Foundation Sciences

COURSE INFORMATION SHEET

Course code: MA 103
Course title: Mathematics I
Pre-requisite(s): Basic Calculus, Basic Algebra
Co- requisite(s): ---
Credits: L: 3 T: 1 P: 0 C:4
Class schedule per week: 3 Lectures, 1 Tutorial.
Class: BTech
Semester / Level: I / 1
Branch: All
Name of Teacher:

Course Objectives: This course enables the students to understand :

1.	infinite sequences and series
2.	theory of matrices including elementary transformations, rank and its application in consistency of system of linear equations, eigenvalues, eigenvectors etc.
3.	multivariable functions, their limits, continuity, partial differentiation, properties and applications of partial derivatives.
4.	integrals of multivariable functions viz. double and triple integrals with their applications
5.	properties like gradient, divergence, curl associated with derivatives of vector point functions and integrals of vector point functions

Course Outcomes: After the completion of this course, students will be able to

CO1	decide the behaviour of sequences and series using appropriate tests.
CO2	handle problems related to the theory of matrices including elementary transformations, rank and its application in consistency of system of linear equations, eigenvalues, eigenvectors etc.
CO3	get an understanding of partial derivatives and their applications in finding maxima - minima problems
CO4	apply the principles of integrals (multivariable functions viz. double and triple integrals) to solve a variety of practical problems in engineering and sciences
CO5	get an understanding of gradient, divergence, curl associated with derivatives of vector point functions and integrals of vector point functions and demonstrate a depth of understanding in advanced mathematical topics, enhance and develop the ability of using the language of mathematics in engineering

Syllabus

MA103 Mathematics – I 3-1-0-4

MODULE – I: Sequences and Series

Sequences, Convergence of Sequence. Series, Convergence of Series, Tests for Convergence: Comparison tests, Ratio test, Cauchy's root test, Raabe's test, Gauss test, Cauchy's Integral test, Alternating series, Leibnitz test, Absolute and Conditional Convergence. **[9 L]**

MODULE – II: Matrices

Rank of a Matrix, elementary transformations, Row - reduced Echelon form. Vectors, Linear Independence and Dependence of Vectors. Consistency of system of linear equations. Eigenvalues, Eigenvectors, Cayley - Hamilton theorem. **[9 L]**

MODULE – III: Advance Differential Calculus

Function of several variables, Limit, Continuity, Partial derivatives, Euler's theorem for homogeneous functions, Total derivatives, Chain rules, Jacobians and its properties, Taylor series for function of two variables, Maxima – Minima, Lagrange's method of multipliers. **[9 L]**

MODULE – IV: Advance Integral Calculus

Beta and Gamma functions: definition and properties.
Double integrals, double integrals in polar coordinates, Change of order of integration, Triple Integrals, cylindrical and spherical coordinate systems, transformation of coordinates, Applications of double and triple integrals in areas and volumes. **[9 L]**

MODULE – V: Vector Calculus

Scalar and vector point functions, gradient, directional derivative, divergence, curl, vector equations and identities. Line Integral, Work done, Conservative field, Green's theorem in a plane, Surface and volume integrals, Gauss – divergence theorem, Stoke 's theorem. **[9 L]**

Text Books:

1. M. D. Weir, J. Hass and F. R. Giordano: Thomas' Calculus, 11th edition, Pearson Educations, 2008E.
2. H. Anton, I. Brivens and S. Davis, Calculus, 10th Edition, John Wiley and sons, Singapore Pte. Ltd., 2013.
3. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint,2010.

Reference Books:

1. M. J. Strauss, G. L. Bradley And K. J. Smith, Calculus, 3rd Ed, Dorling.Kindersley (India) Pvt. Ltd. (P Ed), Delhi, 2007.
2. David C. Lay, Linear Algebra and its Applications (3rd Edition), Pearson Ed. Asia, Indian Reprint, 2007.
3. Robert Wrede & Murray R. Spiegel, Advanced Calculus, 3rd Ed., Schaum's outline series, McGraw-Hill Companies, Inc.,2010.
4. D. G. Zill and W.S. Wright, Advanced Engineering Mathematics, Fourth Edition, 2011.

COURSE INFORMATION SHEET

Course code: MA 107
Course title: Mathematics II
Pre-requisite(s):
Co- requisite(s): Mathematics - I
Credits: L: 3 T: 1 P: 0 C:4
Class schedule per week: 3 Lectures, 1 Tutorial.
Class: BTech
Semester / Level: II / 1
Branch: All
Name of Teacher:

Course Objectives: This course enables the students to understand

1.	various methods to solve linear differential equations of second and higher order
2.	special functions viz. Legendre's and Bessel's and different properties associated with them
3.	diverse mathematical techniques for solving partial differential equations of first order and higher order, along with their applications in wave and heat equations using Fourier series
4.	the theory of functions of a complex variable, complex differentiation and integration
5	about random variables and elementary probability distribution.

Course Outcomes: After the completion of this course, students will be able to

CO1	investigate the occurrence of differential equations in science and engineering and use methods available for their solutions.
CO2	gain an understanding on complex variable functions and using their properties in real life problems.
CO3	construct appropriate probability models in solving real world problems
CO4	demonstrate a depth of understanding in advanced mathematical topics
CO5	enhance and develop the ability of using the language of mathematics in engineering

Syllabus

MA107 **MATHEMATICS – II** **3-1-0-4**

MODULE – I: Ordinary Differential Equations – I

Linear differential equations, Wronskian, Linear independence and dependence of solutions, Linear differential equations of 2^{nd} and higher order with constant coefficients, Operator method, Legendre's and Euler – Cauchy's form of linear differential equation, Method of variation of parameters. **[9 L]**

MODULE – II: Ordinary Differential Equations – II

Ordinary and singular points of differential equation, Power and Frobenius' series solutions. Bessel's differential equation, Bessel function of first kind and its properties. Legendre's differential equation, Legendre's polynomial and its properties. **[9 L]**

MODULE – III: Fourier series and Partial Differential Equations

Fourier series: Euler formulae for Fourier series, Dirichlet conditions, Half range Fourier series.

Partial Differential Equations: Linear partial differential equations, Lagrange's method. Method of separation of variables and its application in solving one dimensional wave and heat equations.

[9L]

MODULE – IV: Complex Variable-Differentiation & Integration

Function of a complex variable, Limit, Continuity, Differentiability, Analyticity, Analytic functions, Cauchy – Riemann equations. Harmonic functions, Harmonic Conjugate.
Cauchy's theorem, Cauchy's Integral formula, Taylor and Laurent series expansions. Singularities and its types, Residues, Residue theorem. **[9L]**

MODULE – V: Applied Probability

Discrete and continuous random variables, cumulative distribution function, probability mass and density functions, expectation, variance, moment generating function. Introduction to Binomial, Poisson and Normal Distribution. **[9L]**

Text Books:

1. E. Kreyszig, Advanced Engineering Mathematics, 9^{th} Edition, John Wiley & Sons, 2006.
2. D. G. Zill and W.S. Wright, Advanced Engineering Mathematics, Fourth Edition, 2011.
3. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7^{th} Ed., McGraw Hill, 2004.
4. R.K. Jain and S.R.K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing, 3^{rd} Ed, 2009
5. R. A . Johnson, I. Miller and J. Freund: Probability and Statistics for Engineers, PHI
6. S. C. Gupta and V.K . Kapoor.: Fundamental of Mathematical Statistics, Sultan Chand and Sons

Reference Books:

1. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9^{th} Edition ., Wiley India, 2009.
2. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
3. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
4. G. F. Simmons, Differential Equations with Applications and Historical Notes, TMH, 2^{nd} ed., 2003.
5. P. L. Meyer: Introductory Probability and Statistical Applications, Oxford & IBH.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Semester Examination	25
End Semester Examination	50
Quiz (s)	10+10
Assignment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√				√
End Semester Examination	√	√	√		√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	1	1	1	1	3	3	2	2
CO2	3	3	3	2	1	1	1	1	3	3	2	2
CO3	3	3	3	2	1	1	1	1	3	3	2	2
CO4	2	2	3	3	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	1	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3

COURSE INFORMATION SHEET

Course code: MA108
Course title: Mathematics III
Pre-requisite(s): 10+2 Mathematics
Co- requisite(s): ---
Credits: L: 3 T: 1 P: 0 C:4
Class schedule per week: 3 Lectures, 1 Tutorial.
Class: IMSc.
Semester / Level: II / 1
Branch: Physics and Chemistry
Name of Teacher:

Course Objectives: This course enables the students to understand :

1.	infinite sequences and series
2.	theory of matrices including elementary transformations, rank and its application in consistency of system of linear equations, eigenvalues, eigenvectors etc.
3.	multivariable functions, their limits, continuity, partial differentiation, properties and applications of partial derivatives.
4.	integrals of multivariable functions viz. double and triple integrals with their applications
5.	properties like gradient, divergence, curl associated with derivatives of vector point functions and integrals of vector point functions

Course Outcomes: After the completion of this course, students will be able to

CO1	decide the behaviour of sequences and series using appropriate tests.
CO2	handle problems related to the theory of matrices including elementary transformations, rank and its application in consistency of system of linear equations, eigenvalues, eigenvectors etc.
CO3	get an understanding of partial derivatives and their applications in finding maxima - minima problems
CO4	apply the principles of integrals (multivariable functions viz. double and triple integrals) to solve a variety of practical problems in engineering and sciences
CO5	get an understanding of gradient, divergence, curl associated with derivatives of vector point functions and integrals of vector point functions and demonstrate a depth of understanding in advanced mathematical topics, enhance and develop the ability of using the language of mathematics in engineering

Syllabus

MA108 **Mathematics – III** **3-1-0-4**

MODULE – I: Sequences and Series

Infinite Sequences, Convergence of Sequences, Infinite series, Convergence of Infinite Series, Tests for Convergence: Comparison tests, Ratio test, Cauchy's root test, Raabe's test, Logarithmic Test, Gauss test, Cauchy's Integral test, Alternating series, Leibnitz test, Absolute and Conditional Convergence.

[9 L]

MODULE – II: Matrix Theory

Types of Matrix, Elementary Transformations, Rank of a Matrix, Row - reduced Echelon form, Normal From, Vectors, Linear Independence and Dependence of Vectors, System of linear equations.

Introduction to Linear Transformations, Eigenvalues, Eigenvectors, Cayley - Hamilton theorem, Diagonolisation, Quadratic forms and its different properties. **[9 L]**

MODULE – III: Differential Calculus

Function of several variables, Limit, Continuity, Partial derivatives, Euler's theorem for homogeneous functions, Total derivatives, Chain rules, Jacobians and its properties, Taylor series for function of two variables, Maxima – Minima, Lagrange's method of multipliers. **[9 L]**

MODULE – IV: Integral Calculus

Beta and Gamma function along with their properties.

Double integrals, double integrals in polar coordinates, Change of order of integration, Triple Integrals, cylindrical and spherical coordinate systems, transformation of coordinates, Applications of double and triple integrals in areas and volumes. [**9L]**

MODULE – V: Vector Analysis

Space curves, Vector valued functions, derivative of vector valued functions, tangent, normal and binormal, curvature, torsion, Frenet Formulae.

Point functions, scalar and vector point functions, gradient, directional derivative, divergence, curl, vector equations and identities. Line Integral, Work done, Conservative field, Green's theorem in a plane, Surface and volume integrals, Gauss – divergence theorem, Stoke's theorem. **[9 L]**

Text Books:

1. E. Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.

2. H. Anton, I. Brivens and S. Davis, Calculus, 10^{th} Edition, John Wiley and sons, Singapore Pte. Ltd., 2013.

3. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11^{th} Reprint,2010.

Reference Books:

1. M. J. Strauss, G. L. Bradley And K. J. Smith, Calculus, 3^{rd} Ed, Dorling.Kindersley (India) Pvt. Ltd. (P Ed), Delhi, 2007.

2. M. D. Weir, J. Hass and F. R. Giordano: Thomas' Calculus, 11^{th} edition, Pearson Educations, 2008.

3. S.C. Malik and S. Arora, Mathematical Analysis, New Age International, 1992.

4. David C. Lay, Linear Algebra and its Applications (3rd Edition), Pearson Ed. Asia, Indian Reprint, 2007.

5. D. G. Zill and W.S. Wright, Advanced Engineering Mathematics, Fourth Edition, 2011.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course outcome (co) attainment assessment tools & evaluation procedure

Direct assessment

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

Mapping of course outcomes onto program outcomes

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: MA207
Course title: Mathematics IV
Pre-requisite(s): Mathematics - III
Co- requisite(s): ---
Credits: L: 3 T: 1 P: 0 C:4
Class schedule per week: 3 Lectures, 1 Tutorial.
Class: IMSc
Semester / Level: IV / 2
Branch: Physics and Chemistry
Name of Teacher:
Course Objectives: This course enables the students to understand

1.	various methods to solve linear differential equations of second and higher order
2.	special functions viz. Legendre's and Bessel's and different properties associated with them
3.	diverse mathematical techniques for solving partial differential equations of first order and higher order, along with their applications in wave and heat equations using Fourier series
4.	the theory of functions of a complex variable, complex differentiation and integration
5	infinite series (Taylor and Laurent series) for complex variable function, the theory of residues with applications to evaluation of integrals

Course Outcomes: After the completion of this course, students will be able to

CO1	investigate the occurrence of differential equations in science and engineering and the methods available for their solutions.
CO2	formulate any real life problem in terms of special functions associated with differential equations.
CO3	gain an understanding of solving problems associated with partial differential equations
CO4	gain an understanding on complex variable function, analytic functions and their properties using different theorems and demonstrate a depth of understanding in advanced mathematical topics
CO5	enhance and develop the ability of using the language of mathematics in science and engineering

Syllabus

MA207 MATHEMATICS – IV 3-1-0-4

MODULE – I: Ordinary Differential Equations

Linear differential equations, Wronskian, Linear independence and dependence of solutions, Linear differential equations of second and higher order, Operator method, Euler – Cauchy's differential equation, Legendre's linear differential equation, Method of variation of parameters, Simultaneous linear differential equations with constant coefficients. **[9L]**

MODULE – I: Series Solution and Special Functions

Power series, ordinary and singular points of differential equation, Power and Frobenius series solutions Bessel's differential equation and its series solution, Bessel function of first kind and its properties, Legendre's differential equation and its series solution, Legendre's polynomial and its properties, **[9L]**

MODULE – III: Fourier Series and Partial Differential Equations

Fourier series, Euler formulae for Fourier series for length of interval 2π, Dirichlet conditions, Fourier series for arbitrary length of interval, Half range Fourier series.

Linear and quasi – linear partial differential equations, Lagrange's method, Linear – partial differential equations with constant coefficients, Method of separation of variables and its application in solving one dimensional wave and heat equations **[9L]**

MODULE – IV: Complex Analysis - I

Function of a complex variable, Limit, Continuity, Differentiability, Analyticity, Analytic functions, Cauchy – Riemann equations (Cartesian and Polar form), Harmonic functions, Harmonic Conjugate, Complex Integration, Cauchy's theorem, Cauchy's Integral formula, Cauchy's Integral Formula for derivatives, Cauchy's inequality, Morera's theorem **[9L]**

MODULE – V: Complex Analysis - II

Power series, Radius of convergence, Taylor and Laurent series for complex variable functions, Singularities and its types, Residues, Residue theorem and its applications in evaluation of real integrals of types $\int_0^{2\pi} f(\cos\theta, \sin\theta)\, d\theta$ and $\int_{-\infty}^{\infty} f(x)\, dx$, Conformal Mapping, Bilinear Transformations. **[9L]**

Text Books:

1. E. Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. S. L. Ross, Differential Equations, 3rd Ed., Wiley India, 1984.
3. D. G. Zill and W.S. Wright, Advanced Engineering Mathematics, Fourth Edition, 2011.
4. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7th Ed., McGraw Hill, 2004.
5. R.K. Jain and S.R.K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing, Third Edition, 2009

Reference Books:

1. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9thEdition ., Wiley India, 2009.
2. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
3. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
4. G. F. Simmons, Differential Equations with Applications and Historical Notes, TMH, 2nd ed., 2003.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

Course outcome (co) attainment assessment tools & evaluation procedure

Direct assessment

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

Mapping of course outcomes onto program outcomes

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: MA104
Course title: MATHEMATICS FOR ARCHITECTS
Pre-requisite(s): Basic Algebra, Basic Calculus
Co- requisite(s): ----
Credits: L: 3 T: 0 P: 0 C:3
Class schedule per week: 3 Lectures
Class: B. Arch.
Semester / Level: I/I
Branch: Architecture
Name of Teacher:

Course Objectives : This course enables the students:

1.	Basics concepts of matrices, including rank, eigenvalues and eigenvectors of the matrix
2.	Determination of consistency and inconsistency of system of linear equations using rank of matrices
3.	Application of single variable derivatives and integrals in determining different properties of a curve
4.	Introduction to multi variable functions, partial derivatives and different properties associated with them their
5.	Applications of multi variable calculus in determining maxima – minima and double integrals for two variable functions
6.	Analysis of data using different statistical techniques

Course Outcomes : After the completion of this course, students will be:

CO1	To understand the basics of matrices, statistics, differential and integral calculus
CO2	To apply the mathematical skills to specific problems of single variable arising in architecture
CO3	To apply the mathematical skills to specific problems of multi-variable arising in architecture
CO4	To demonstrate the usage of calculus in determining shape, symmetry, pattern etc. of architectural designs
CO5	To gain an understanding to establish connectivity between mathematics and architecture through analysis of data.

Syllabus

MA104 MATHEMATICS FOR ARCHITECTS 3-0-0-3

Module 1: Matrices

Real and Complex Matrices, Elementary Transformations, Rank of a Matrix, Row – reduced Echelon form, Consistency and inconsistency for system of linear equations using rank method, Characteristic equation, Eigenvalues and Eigen vectors, Cayley – Hamilton Theorem. [8L]

Module 2: Single Variable Calculus

Successive differentiation, Leibnitz's Theorem, Indeterminate forms, Concavity, Convexity, Point of Inflection, Taylor and Maclaurin series for functions of one variable, Maxima and Minima for functions of one variable.

Definite Integrals, Reduction Formula, Applications of definite integrals in finding length of curves, area between curves, area of the surfaces of revolution. [8L]

Module 3: Multi Variable Calculus - I

Function of several variables, Limit and Continuity for functions of two variables, Partial derivatives, Euler's Theorem for Homogeneous functions, Chain Rules, Total Differential Coefficient, Change of variables. **[8L]**

Module 4: Multi Variable Calculus -II

Jacobian, Properties of Jacobians, Taylors and Maclaurin series for function of two variables, Maxima - Minima for function of two variables, Lagrange's method of multipliers. [8L]

Module 5: Statistics

Measures of Central Tendency, Measures of Dispersion, Moments, Skewness, Kurtosis Correlation, Methods to find Coefficient of Correlation, Regression, Linear Regression, Lines of Regression, Regression coefficients, Nonlinear Regression, Curve fitting, Method of Least Squares. [8L]

Text Books

1. M.D. Weir, J. Hass and F. R. Giordano: Thomas' Calculus, 12th edition, Pearson Educations, 2008.
2. E. Kreyszig, Advanced Engineering Mathematics, Wiley International, 9th edition, 2006.
3. S.C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand Publications, 11th Edition, 2014.

Reference books:

1. M.R. Spiegel and L.R. Stephens, Schaum's outline of Statistics, 5th Edition, 2010.
2. H. Anton, I Brivens, S. Davis, Calculus, 10th Edition, John Wiley and Sons, Singapore Pvt. Ltd., 2013.
3. H. Schneider and G.P. Barker, Matrices and Linear Algebra, Dover's Publications, New York, 1973.

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

<u>Course outcome (co) attainment assessment tools & evaluation procedure</u>

<u>Direct assessment</u>

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

<u>Mapping of course outcomes onto program outcomes</u>

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: MA 203
Course title: Numerical Methods
Pre-requisite(s): NIL
Co- requisite(s): ---NIL
Credits: L: 2 T: 0 P: 0 C:2
Class schedule per week: 2 Lectures
Class: BTech
Semester / Level: III / 2
Branch: ALL
Name of Teacher:
Course Objectives: This course enables the students to

1.	derive appropriate numerical methods to solve algebraic and transcendental equations
2.	derive appropriate numerical methods to solve linear system of equations
3.	approximate a function using various interpolation techniques
4.	to find the numerical solution of initial value problems and boundary value problems

Course Outcomes: After the completion of this course, students will be able to

CO 1	solve algebraic and transcendental equation using an appropriate numerical method arising in various engineering problems
CO 2	solve linear system of equations using an appropriate numerical method arising in computer programming, chemical engineering problems etc.
CO 3.	Approximate a function using an appropriate numerical method in various research problems
CO 4	evaluate derivative at a value using an appropriate numerical method in various research problems
CO 5	solve differential equation numerically

Syllabus

MA 203 **Numerical Methods** **2-0-0-2**

Module I: Errors and Nonlinear Equations

Error Analysis: Definition and sources of errors, propagation of errors, floating-point arithmetic
Solution of Nonlinear equations: Bisection method, Regula-Falsi method, Secant method, Newton-Raphson method and its variants, General Iterative method. [05L]

Module II: System of Linear Equations

Gauss-Elimination, Gauss-Jordan, LU-Decomposition, Gauss-Jacobi and Gauss- Siedel methods to solve linear system of equations and Power method to find least and largest eigenvalues. [05L]

Module III: Interpolation

Lagrange's interpolation, Newton's divided differences interpolation formulas, inverse interpolation, interpolating polynomial using finite differences. [05L]

Module IV: Differentiation and Integration

Differentiation using interpolation formulas, Integration using Newton-Cotes formulas: Trapezoidal rule, Simpson's rule [05L]

Module V: Solution of Ordinary Differential Equations

Euler's method, modified Euler's method, Runge - Kutta Methods of second and fourth order to solve initial value problems. [05L]

Text Books:

3. Jain M.K, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age Publications, 2004.
4. S.S. Sastry, Introductory Methods of Numerical Analysis, PHI.
5. E. Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.

Reference Books:

3. S.C. Chapra and R. P. Canale, Numerical Methods for Engineers, McGraw Hill, 1985.
4. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, Seventh Edition, 2003.
5. R. W. Hamming: Numerical Methods for Scientists and Engineers, Second Edition, Dover

Course delivery methods	
Lecture by use of boards/lcd projectors/ohp projectors	√
Tutorials/assignments	√
Seminars	
Mini projects/projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of nptel materials and internets	√
Simulation	

<u>Course outcome (co) attainment assessment tools & evaluation procedure</u>

<u>Direct assessment</u>

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –
1. Student feedback on course outcome

<u>Mapping of course outcomes onto program outcomes</u>

Course outcome	Program outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATION SHEET

Course code: MA 204
Course title: Numerical Methods Lab
Pre-requisite(s): NIL
Co- requisite(s): ---NIL
Credits: L: 0 T: 0 P: 2 C:1
Class schedule per week: 2 Sessionals
Class: BE
Semester / Level: III / UG
Branch: ALL
Name of Teacher:

List of Assignment

1. Find a simple root of $f(x)=0$ using bisection method. Read the end points of the interval (a,b) in which the root lies, maximum number of iterations n and error tolerance eps.
2. Find a simple root of $f(x)=0$ using Regula-Falsi method. Read the end points of the interval (a,b) in which the root lies, maximum number of iterations n and error tolerance eps.
3. Find a simple root of $f(x)=0$ using Newton Raphson method. Read any initial approximation x_0, maximum number of iterations n and error tolerance eps.
4. Solution of a system of $n\times n$ linear equations using Gauss elimination method with partial pivoting. The program is for 10×10 system or higher order system.
5. Matrix inversion and solution of $n\times n$ system of equations using Gauss-Jordan method. If the system of equations is larger than 15×15 change the dimensions of the float statement.
6. Program to solve a system of equation using Gauss-Seidel iteration method. Order of the matrix is n, maximum number of iterations $niter$, error tolerance is eps and the initial approximation to the solution vector is x_0. If the system of equations is larger than 10×10 change the dimension in float.
7. Program to find the largest Eigen value in magnitude and the corresponding Eigen vector of a square matrix A of order n using power method.
8. Program for Lagrange interpolation.
9. Program for Newton divided difference interpolation.
10. Program for Newton's forward and backward interpolation.
11. Program for Gauss's central difference interpolation (both backward and forward).
12. Program to evaluate the integral of $f(x)$ between the limits a to b using Trapezoidal rule of integration based on n subintervals or $n+1$ nodal points. The values of a,b and n are to be read. The program is tested for $f(x)=1/(1+x)$.
13. Program to evaluate the integral of $f(x)$ between the limits a to b using Simpson's rule of integration based on $2n$ subintervals or $2n+1$ nodal points. The values of a,b and n are to be read and the integrand is written as a function subprogram. The program is tested for $f(x)=1/(1+x)$.
14. Program to solve an IVP, $dy/dx = f(x), y(x_0)=y_0$ using Euler method. The initial value x_0, y_0 the final value x_f and the step size h are to be read. The program is tested for $f(x,y)=-2xy^2$.
15. Program to solve an IVP, $dy/dx = f(x), y(x_0)=y_0$ using the classical Runge-Kutta fourth order method with step size h, $h/2$ and also computes the estimate of the truncation error. Input parameters are: initial point, initial value, number of intervals and the step length h. Solutions with h, $h/2$ and the estimate of the truncation error are available as output. The right hand side The program is tested for $f(x,y)=-2xy^2$.