B. Tech. in Mathematics & Computing

Program Learning Objectives:	Program Learning Outcomes:
Program Goal 1: To learn and excel in rigor of Mathematics	**Program Learning Outcome 1a:** The students are equipped with a mixture of basic and advanced mathematics courses during the program **Program Learning Outcome 1b:** A rigorous training in all basic courses in Mathematics is obtained
Program Goal 2: To be able to apply the concepts of Mathematics in problems	**Program Learning Outcome 2a:** Students pursue application-oriented courses in the form of electives **Program Learning Outcome 2b:** Application skills of using mathematics is acquired.
Program Goal 3: To learn and excel in contemporary courses in Computer Science domain	**Program Learning Outcome 3 a:** Students are exposed to both hardware and software courses. **Program Learning Outcome 3 b:** Acquainted with advanced courses in computer science.
Program Goal 4: To be leader in the area where both Mathematics and computer science skills are required	**Program Learning Outcome 4:** Leadership skills are developed through overall exposure to various components

Sl. No.	Subject Code	SEMESTER I	L	T	P	C
1.	MA1101	Calculus and Linear Algebra	3	1	0	4.0
2.	CS1101	Foundations of Programming	3	0	3	4.5
3.	PH1101/PH1201	Physics	3	1	3	5.5
4.	CE1101/CE1201	Engineering Graphics	1	0	3	2.5
5.	EE1101/EE1201	Electrical Sciences	3	0	3	4.5
6.	HS1101	English for Professionals	2	0	1	2.5
TOTAL			**15**	**2**	**13**	**23.5**

Sl. No.	Subject Code	SEMESTER II	L	T	P	C
1.	MA1201	Probability Theory and Ordinary Differential Equations	3	1	0	4
2.	CS1201	Data Structure	3	0	3	4.5
3.	CH1201/CH1101	Chemistry	3	1	3	5.5
4.	ME1201/ME1101	Mechanical Fabrication	0	0	3	1.5
5.	ME1202/ME1102	Engineering Mechanics	3	1	0	4
6.	IK1201	Indian Knowledge System (IKS)	3	0	0	3
TOTAL			**15**	**3**	**9**	**22.5**

Sl. No.	Subject Code	SEMESTER III	L	T	P	C
1.	MA2101	Design and Analysis of Algorithms	3	0	2	4
2.	MA2102	Probability and Stochastic Processes	3	1	0	4
3.	MA2103	Optimization Techniques	3	0	0	3
4.	MA2104	Algebra	3	0	0	3
5.	MA2105	Discrete Mathematics	3	0	0	3
6.	HS21XX	HSS Elective - I	3	0	0	3
TOTAL			**18**	**1**	**2**	**20**

Sl. No.	Subject Code	SEMESTER IV	L	T	P	C
1.	MA2201	Introduction to Machine Learning	2	0	2	3
2.	MA2202	Real Analysis and Measure Theory	3	0	0	3
3.	MA2203	Numerical Linear Algebra	3	0	2	4
4.	MA2204	Computer Architecture and Organization	3	0	3	4.5
5.	MA2205	Database Management Systems	3	0	3	4.5
6.	XX22PQ	IDE - I	3	0	0	3
TOTAL			**17**	**0**	**10**	**22**

Sl. No.	Subject Code	SEMESTER V	L	T	P	C
1.	MA3101	Ordinary and Partial Differential Equations	3	0	0	3
2.	MA3102	Complex Analysis	3	0	0	3
3.	MA3103	Theory of Computation	3	0	0	3
4.	MA3104	Computer Networks	3	0	3	4.5
5.	MA3105	Operating Systems	3	0	3	4.5
6.	XX31PQ	IDE - II	3	0	0	3
TOTAL			**18**	**0**	**6**	**21**

Sl. No.	Subject Code	SEMESTER VI	L	T	P	C
1.	MA3201	Number Theory and Cryptography	3	0	0	3
2.	MA3202	Numerical Methods	3	0	2	4
3.	MA3203	Mathematical Statistics	3	0	0	3
4.	MA3204	Convex Optimization	3	0	2	4
5.	MA3205	Functional Analysis	3	0	0	3
6.	MA3206	Artificial Intelligence	3	0	2	4
TOTAL			**18**	**0**	**6**	**21**

Sl. No.	Subject Code	SEMESTER VII	L	T	P	C
1.	HS41XX	HSS Elective - II	3	0	0	3
2.	XX41PQ	IDE - III	3	0	0	3
3.	MA41XX	Departmental Elective – I	3	0	0	3
4.	MA41XX	Departmental Elective – II	3	0	0	3
5.	MA4198	Summer Internship*	0	0	12	3
6.	MA4199	Project – I	0	0	12	6
TOTAL						**21**

*** For specific cases of internship after 6th Semester, the performance evaluation would be made on joining the VIIth Semester and graded accordingly in the VIIth Semester:**

Note :

a) (i) Summer internship (*) period of at least 60 days' (8 weeks) duration begins in the intervening vacation between semester VI and VII that may be done in industry / R&D / Academic Institutions including IIT Patna. The evaluation would comprise **combined grading based on host supervisor evaluation, project internship report after plagiarism check and seminar presentation at the Department (DAPC to coordinate)** with equal weightage of each of the three components stated herein.

a) (ii) Further, on return from internship, students will be evaluated for internship work through combined grading based on host supervisor evaluation, project internship report after plagiarism check, and presentation evaluation by the parent department with equal weightage of each component.

b) (i) In the VIIth semester, students can opt for a semester long internship on recommendation of the DAPC and approval of the Competent Authority.

b) (ii) On approval of semester long internship, at the maximum two courses (properly mapped/aligned syllabus) at par with institute electives may be opted from NPTEL and / or SWAYAM and the other two more should be done at the institute through course overloading in any other semester (either before or after the internship) and/or during following summer semester.

b) (iii) The candidates opting two courses from NPTEL and / or SWAYAM would be required to appear in the examination at the Institute as scheduled in the Academic Calendar.

Sl. No.	Subject Code	SEMESTER VIII	L	T	P	C
1.	MA42XX	Departmental Elective – III	3	0	0	3
2.	MA42XX	Departmental Elective – IV	3	0	0	3
3.	MA42XX	Departmental Elective – V	3	0	0	3
4.	MA4299	Project – II	0	0	16	8
TOTAL						**17**
GRAND TOTAL (Semester I to VIII)			**168**			

ELECTIVE GROUPS

Sl. No.	Course Code	Department Elective I	L	T	P	C
1.	MA4101	Advanced Algorithms	3	0	0	3
2.	MA4102	Cryptography and Network Security	3	0	0	3
3.	MA4103	Rings and Modules	3	0	0	3

Sl. No.	Course Code	Department Elective II	L	T	P	C
1.	MA4104	Deep Learning	2	0	2	3
2.	MA4105	Fields and Galois theory	3	0	0	3
3.	MA4106	Mathematical Finance	3	0	0	3

Sl. No.	Course Code	Department Elective III	L	T	P	C
1.	MA4201	Topology	3	0	0	3
2.	MA4206	Control Theory	3	0	0	3
3.	MA4207	Finite Element Analysis	3	0	0	3
4.	MA4208	Introduction to Coding Theory	3	0	0	3
5.	MA4209	Portfolio Theory and Risk Management	3	0	0	3

Sl. No.	Course Code	Department Elective IV	L	T	P	C
1.	MA4210	Differential Geometry	3	0	0	3
2.	MA4211	Introduction to Mathematical Biology	3	0	0	3
3.	MA4212	Statistical Decision Theory	3	0	0	3
4.	MA4213	Applied Computational Techniques	3	0	0	3

Sl. No.	Course Code	Department Elective V	L	T	P	C
1.	MA4214	Deep Learning for Computer Vision	2	0	2	3
2.	~~MA4212~~ MA4215	Discrete Differential Geometry	3	0	0	3
3.	MA4216	Integral Equations and Calculus of Variations	3	0	0	3

IDE - I (Available to students other than Dept. of M&C)

Sl. No.	Code	Course Name	L	T	P	C
1.	MA2206	Introduction to Numerical Methods	3	0	0	3
2.	MA2207	Complex Analysis	3	0	0	3

IDE - II (Available to students other than Dept. of M&C)

Sl. No.	Code	Course Name	L	T	P	C
1.	MA3106	An Introduction to Computational Commutative Algebra	3	0	0	3
2.	MA3107	Partial Differential Equations	3	0	0	3

IDE - III (Available to students other than Dept. of M&C)

Sl. No.	Code	Course Name	L	T	P	C
1.	MA4112	Number Theory and Algebra	3	0	0	3
2.	MA4113	Theory of Relativity	3	0	0	3

Sl. No.	Subject Code	SEMESTER I	L	T	P	C
1.	MA1101	Calculus and Linear Algebra	3	1	0	4.0
2.	CS1101	Foundations of Programming	3	0	3	4.5
3.	PH1101/PH1201	Physics	3	1	3	5.5
4.	CE1101/CE1201	Engineering Graphics	1	0	3	2.5
5.	EE1101/EE1201	Electrical Sciences	3	0	3	4.5
6.	HS1101	English for Professionals	2	0	1	2.5
TOTAL			**15**	**2**	**13**	**23.5**

Course Number	MA1101
Course Credit (L-T-P-C)	3-1-0-4
Course Title	Calculus and Linear Algebra
Learning Mode	Lectures and Tutorials
Learning Objectives	To provide the essential knowledge of basic tools of Differential Calculus, Integral Calculus, Vector spaces and Matrix Algebra.
Course Description	This course provides a foundation for Calculus and Linear Algebra. Topics related to properties of single and two variable functions along with their applications will be discussed. In addition fundamentals of linear algebra and matrix theory with applications will also be discussed.
Course Content	**Differential Calculus (12 Lectures)**: Limit and continuity of one variable function (including ε-δ definition). Limit, continuity and differentiability of functions of two variables, Tangent plane and normal, Change of variables, chain rule, Jacobians, Taylor's Theorem for two variables, Extrema of functions of two or more variables, Lagrange's method of undetermined multipliers. **Integral Calculus (10 Lectures)**: Riemann integral for one variable functions, Double and Triple integrals, Change of order of integration. Change of variables, Applications of Multiple integrals such as surface area and volume. **Vector Spaces (12 Lectures)**: Vector spaces (over the field of real numbers), subspaces, spanning set, linear independence, basis and dimension. Linear transformations, range and null space, rank-nullity theorem, matrix of a linear transformation. **Matrix Algebra (8 Lectures)**: Elementary operations and their use in getting the rank, inverse of a matrix and solution of linear simultaneous equations, Orthogonal, symmetric, skew-symmetric, Hermitian, skew-Hermitian, normal and unitary matrices and their elementary properties, Eigenvalues and Eigenvectors of a matrix, Cayley-Hamilton theorem, Diagonalization of a matrix.
Learning Outcome	Students completing this course will be able to: 1. Understand various properties of functions such as limit, continuity and differentiability. 2. Learn about integrations in various dimension and their applications. 3. learn about the concept of basis and dimension of a vector space. 4. define Linear Transformations and compute the domain, range, kernel, rank, and nullity of a linear transformation. 5. compute the inverse of an invertible matrix. 6. solve the system of linear equations. 7. Apply linear algebra concepts to model, solve, and analyze real-world problems.
Assessment Method	Quiz /Assignment/ MSE / ESE

Textbooks:

1. Thomas, G. B., Hass, J., Heil, C. and Weir M. D., "Thomas' Calculus", 14th Ed., Pearson Education, 2018
2. Kreyszig, E., "Advanced Engineering Mathematics", 10th Ed., Wiley India Pvt. Ltd, 2015

Reference Books:

1. Jain, R. K. and Iyenger, S. R. K., "Advanced Engineering Mathematics", 5th Ed., Narosa Publishing House, 2017
2. Axler, S., "Linear Algebra Done Right", 3rd Ed., Springer Nature, 2015
3. Strang, G., "Linear Algebra and Its Applications" 4th Ed., Cengage India Private Limited, 2005

Course Number	CS1101
Course Credit	3-0-3-4.5
Course Title	**Foundations of Programming**
Learning Mode	Offline
Learning Objectives	• To understand the fundamental concepts of programming • To develop the basic problem-solving skills by designing algorithms and implementing them. • To learn about various data types, control statements, functions, arrays, pointers, and file handling. • To achieve proficiency in debugging and testing a C program
Course Description	This introductory course provides a solid foundation in programming principles and techniques. Designed for students with little to no prior programming experience, it covers fundamental concepts such as variables, data types, control structures, functions, and basic data structures. Students will learn to write, debug, and execute programs using a high-level programming language. Emphasis is placed on developing problem-solving skills, logical thinking, and the ability to write clear and efficient code. By the end of the course, students will be equipped with the essential skills needed to pursue more advanced studies in computer science and software development.
Course Outline	Introduction and Programming basics, Expressions Control and Iterative statements, Functions, Arrays, Recursion vs. Iteration Pointers, 2D-Array with pointers, Structures, String, Dynamic memory allocation, File handling, Contemporary programming languages, and applications **Practical component**: Lab to be conducted on a 3-hour slot weekly. It will be conducted with the theory course so the topics for problems given in the lab are already initiated in the theory class.
Learning Outcome	• Understanding of Basic Syntax and Structure in C language • Proficiency in Data Types, Operators, and Control Structures • Function Implementation and learn to use them appropriately • Efficient Use of Arrays and Strings • Pointer Utilization • Ability to perform dynamic memory allocation and deallocation using malloc (), calloc (), realloc (), and free () functions. • Structured data management with structures and unions • Exposure of file Handling • Learning debugging and error Handling
Assessment Method	Internal (Quiz/Assignment/Project), Mid-Term, End-Term

Suggested Reading

- Knuth, Donald E. The art of computer programming, volume 4A: combinatorial algorithms, part 1. Pearson Education India, 2011.
- P.J. Deitel and H.M. Deitel, C How To Program, Pearson Education (7th Edition)
- Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice−Hall
- A. Kelley and I. Pohl, A Book on C, Pearson Education (4th Edition)
- K. N. King, C PROGRAMMING A Modern Approach, W. W. Norton & Company

Course Number	**PH1101/PH1201**
Course Credit	3-1-0-4
Course Title	Physics
Learning Mode	Lectures and Tutorials
Learning Objectives	Complies with Program Goals 1 and 2
Course Description	This course deals with fundamentals in Classical mechanics, Waves and Oscillations and Quantum Mechanics. As a prerequisite, the mathematical preliminaries such as coordinate systems, vector calculus etc will be discussed in the beginning.
Course Outline	Orthogonal coordinate systems (Plane polar, Spherical, Cylindrical), concept of generalised coordinates, generalised velocity and phase space for a mechanical system, Introduction to vector operators, Gradient, divergence, curl and Laplacian in different co-ordinate systems. Central force problem and its applications. Rigid body rotation, vector nature of angular velocity, Finding the principal axes, Euler's equations; Gyroscopic motion and its application; Accelerated frame of reference, Fictitious forces. Potential energy and concept of equilibrium, Lennard-Jones and double-well potentials, Small oscillations, Harmonic oscillator, damped and forced oscillations, resonance and its different examples, oscillator states in phase space, coupled oscillations, normal modes, longitudinal and transverse waves, wave equation, plane waves, examples two- and three-dimensional waves. Michelson-Morley experiment, Lorentz transformation, Postulates of special theory of relativity, Time dilation and length contraction, Applications of special theory of relativity.
Learning Outcome	Complies with PLO 1a, 2a, 3a
Assessment Method	Quiz, Assignments and Exams

Suggested Readings:

Textbooks:

1. Engineering Mechanics, M. K. Harbola, 2nd ed., Cengage, 2012
2. D. Kleppner and R. J. Kolenkow, An introduction to Mechanics, Tata McGraw-Hill, New Delhi, 2000.
3. I. G. Main, Oscillations and Waves
4. H. G. Pain, The Physics of Vibrations and Waves, 1968
5. Frank S. Crawford, Berkeley Physics Course Vol 3: Waves and Oscillations, McGraw Hill, 1966.

References:

1. R. P. Feynman, R. B. Leighton and M. Sands, The Feynman Lecture in Physics, Vol I, Narosa Publishing House, New Delhi, 2009.
2. David Morin, Introduction to Classical Mechanics, Cambridge University Press, NY, 2007.
3. P. C. Deshmukh, Foundations of Classical Mechanics, Cambridge University Press, 2019

Course code	**CE1101/CE1201**
Course Credit (L-T-P-C)	1-0-3-2.5
Course Title	**Engineering Graphics**
Learning Mode	Lectures and Practical
Learning Objectives	Complies with PLO-1a 1. The course on engineering drawing is designed to introduce the fundamentals of technical drawing as an important form of conveying information. 2. Apply principles of engineering visualization and projection theory to prepare engineering drawings, using conventional and modern drawing tools. 3. Practice drawing orthographic projections, isometric views, and sectional views, of simple and combined solids in different orientations.
Course Description	This course will introduce drawing as a tool to represent a complex three-dimensional object on two-dimensional paper through methods of projections. The course explains the use of different drafting tools and the importance of conventions for uniformity and standardization of the interpretation of the drawings.
Course Outline	Fundamental of engineering drawing, line types, dimensioning, and scales. Conic sections: ellipse, parabola, hyperbola; cycloidal curves. Principle of projection, method of projection, orthographic projection, plane of projection, first angle of projection, Projection of points, lines, planes and solids. Section of solids: Sectional views of simple solids- prism, pyramid, cylinder, cone, sphere; the true shape of the section. Methods of development, development of surfaces. Isometric projections: construction of isometric view of solids and combination of solids from orthographic projections. Introduction to AutoCad and solving isometric problems.
Learning Outcome	After attending this course, the following outcomes are expected: 1. The student will understand the basic concepts of engineering drawing. 2. The student will be able to use basic drafting tools, drawing instruments, and sheets. 3. The student will be able to represent three-dimensional simple and combined solid objects on two-dimensional paper. 4. The student will be able to visualize and interpret the orientation of simple and combine solid objects.
Assessment Method	Laboratory Assignments (30%), Mid-semester examination (25%) and End-semester examination (45%).

Suggested Readings:

Textbooks:

1. N.D. Bhatt, Engineering Drawing, Charotar Publishing House.
2. Agrawal & Agrawal, Engineering Drawing, McGraw Hill.
3. Jolhe, Engineering Drawing.

References:

1. Engineering Drawing and Design by David Madsen

Course Number	EE1101/EE1201
Course Credit	3-0-3-4.5
Course Title	Electrical Sciences
Learning Mode	Lectures and Experiments
Learning Objectives	Complies with Program goals 1, 2 and 3
Course Description	The course is designed to meet the requirements of all B. Tech programmes. The course aims at giving an overview of the entire electrical engineering domain from the concepts of circuits, devices, digital systems and magnetic circuits.
Course Outline	Circuit Analysis Techniques, Circuit elements, Simple RL and RC Circuits, Kirchoff's law, Nodal Analysis, Mesh Analysis, Linearity and Superposition, Source Transformations, Thevenin's and Norton's Theorems, Time Domain Response of RC, RL and RLC circuits, Sinusoidal Forcing Function, Phasor Relationship for R, L and C, Impedance and Admittance, Instantaneous power, Real, reactive power and power factor. Semiconductor Diode, Zener Diode, Rectifier Circuits, Clipper, Clamper, UJT, Bipolar Junction Transistors, MOSFET, Transistor Biasing, Transistor Small Signal Analysis, Transistor Amplifier and their types, Operational Amplifiers, Op-amp Equivalent Circuit, Practical Op-amp Circuits, Power Opamp, DC Offset, Constant Gain Multiplier, Voltage Summing, Voltage Buffer, Controlled Sources, Instrumentation Amplifier, Active Filters and Oscillators. Number Systems, Logic Gates, Boolean Theorem, Algebraic Simplification, K-map, Combinatorial Circuits, Encoder, Decoder, Combinatorial Circuit Design, Introduction to Sequential Circuits. Magnetic Circuits, Mutually Coupled Circuits, Transformers, Equivalent Circuit and Performance, Analysis of Three-Phase Circuits, Power measurement in three phase system, Electromechanical Energy Conversion, Introduction to Rotating Machines (DC and AC Machines). Laboratory: Experiments to verify Circuit Theorems; Experiments using diodes and bipolar junction transistor (BJT): design and analysis of half -wave and full-wave rectifiers, clipping and clamping circuits and Zener diode characteristics and its regulators, BJT characteristics (CE, CB and CC) and BJT amplifiers; Experiment on MOSFET characteristics (CS, CG, and CD), parameter extraction and amplifier; Experiments using operational amplifiers (op-amps): summing amplifier, comparator, precision rectifier, Astable and Monostable Multivibrators and oscillators; Experiments using logic gates: combinational circuits such as staircase switch, majority detector, equality detector, multiplexer and demultiplexer; Experiments using flip-flops: sequential circuits such as non-overlapping pulse generator, ripple counter, synchronous counter, pulse counter and numerical display; Power Measurement by two Wattmeter method; Open and Short Circuit Tests of Transformer.
Learning Outcomes	Complies with PLO 1a, 2a and 3a
Assessment Method	Quiz, Assignments and Exams

Texts/References

1. C. K. Alexander, M. N. O. Sadiku, Fundamentals of Electric Circuits, 3rd Edition, McGraw-Hill, 2008.
2. W. H. Hayt and J. E. Kemmerly, Engineering Circuit Analysis, McGraw-Hill, 1993.
3. R. L. Boylestad and L. Nashelsky, Electronic Devices and Circuit Theory, 6th Edition, PHI, 2001.
4. M. M. Mano, M. D. Ciletti, Digital Design, 4th Edition, Pearson Education, 2008.
5. Floyd, Jain, Digital Fundamentals, 8th Edition, Pearson.
6. David V. Kerns, Jr. J. David Irwin, Essentials of Electrical and Computer Engineering, Pearson, 2004.
7. Donald A Neamen, Electronic Circuits; analysis and Design, 3rd Edition, Tata McGraw-Hill Publishing Company Limited.
8. Adel S. Sedra, Kenneth C. Smith, Microelectronic Circuits, 5th Edition, Oxford University Press, 2004.
9. A. E. Fitzgerald, C. Kingsley Jr., S. D. Umans, Electric Machinery, 6th Edition, Tata McGraw-Hill, 2003.
10. D. P. Kothari, I. J. Nagrath, Electric Machines, 3rd Edition, McGraw-Hill, 2004.
11. Del Toro, Vincent. "Principles of electrical engineering." (No Title) (1972).

Course Number	HS1101
Course Credit	L-T-P-W: 2-0-1-2.5
Course Title	English for Professionals
Learning Mode	Offline
Learning Objectives	This course aims to help the students **(a)** attain proficiency in written English through the construction of grammatically correct sentences, utilization of subject-verb agreement principles, mastery of various tenses, and effective deployment of active and passive voice to ensure coherent and impactful written expression; **(b)** enhance oral communication skills by honing public speaking abilities, acquiring strategies to deliver persuasive presentations, and cultivating a polished telephone etiquette, enabling confident and articulate verbal communication; **(c)** foster active listening capabilities by recognizing different types of listening, and applying proven methods and strategies to improve active listening skills; **(d)** strengthen reading skills, including comprehension, interpretation, and critical analysis, to grasp diverse written materials and derive meaning from various types of texts encountered in academic and professional contexts; **(e)** develop adeptness in written communication for business purposes, encompassing the understanding of essential writing elements, mastery of appropriate writing styles thereby enhancing prospects for successful job interviews and subsequent professional endeavors.
Course Description	This academic course on communication skills aims to equip students with fluency in spoken and written English for effective expression in both academic and professional settings. By focusing on essential communication principles and providing practical experiences, students develop clarity, precision, and confidence in their communication. Through interactive discussions and exercises, students enhance critical thinking and adaptability in diverse contexts. Upon completion, students will excel in formal presentations, group discussions, and persuasive writing, enhancing their overall communication proficiency.
Course Outline	**Unit I:** Introduction to professional communication – LSRW - Phonetics and phonology Sounds in English Language – production and articulation – rhythm and intonation – connected speech - Basic Grammar and Advanced Vocabulary Sounds in English Language – production and articulation – rhythm and intonation – connected speech – persuading and negotiating – brevity and clarity in language. Unit II: Characteristics of Technical Communication: Types of communication and forms of communication - Formal and informal communication Verbal and non-Verbal Communication – Communication barriers and remedies Intercultural communication – neutral language Unit III: Comprehension and Composition – summarization, precis writing Business Letter Writing CV/ Resume – E-Communication Unit IV: Statement of Purpose, Writing Project Reports, Writing research proposal, writing abstracts, developing presentations, interviews – combating nervousness Tutorial: Listening Exercises, Speaking Practice (GDs, and Presentations), and Writing Practice Learning Outcome • Attain proficiency in written English, enabling the construction of grammatically correct sentences and coherent written expression through the use of appropriate grammar, tenses, and voice. • Enhance oral communication skills, including public speaking, persuasive presentation, and polished telephone etiquette, fostering confident and articulate verbal expression. • Cultivate active listening abilities, recognizing different listening types, overcoming obstacles, and employing strategies for attentive and effective communication. • Develop proficient written communication skills for business purposes, demonstrating understanding of essential writing elements, appropriate styles, and the creation of reports, notices, agendas, and minutes that effectively convey information.
Assessment Method	Class test + Quiz = 20%; Mid-semester = 25%; Assignment = 15%; End semester = 40%

Suggested Reading

1. Balzotti, Jon. Technical Communication: A Design-Centric Approach. Routledge, 2022.
2. Kaul, Asha, Business Communication. PHI Learning Pvt. Ltd. 2009
3. Laplante, Phillip A. Technical Writing: A Practical Guide for Engineers, Scientists, and Nontechnical Professionals. CRC Press, 2018.

4. Lawson, Celeste, et al. Communication Skills for Business Professionals, Second Edition. CUP, 2019.
5. Sharon Gerson and Steven Gerson. Technical Writing: Process and Product (8th Edition), London: Longman, 2013
6. Rentz, Kathryn, Marie E. Flatley & Paula Lentz. Lesikar's Business Communication Connecting in a Digital world, McGraw-Hill, Irwin.2012
7. Allan & Barbara Pease. The Definitive Book of Body Language, New York, Bantam,2004
8. Jones, Daniel. The Pronunciation of English, New Delhi, Universal Book Stall.2010
9. Savage, Alice. Effective Academic Writing. OUP. 2014
10. Swan and Alter. Oxford English grammar course. OUP. 201

Sl. No.	Subject Code	SEMESTER II	L	T	P	C
1.	MA1201	Probability Theory and Ordinary Differential Equations	3	1	0	4
2.	CS1201	Data Structure	3	0	3	4.5
3.	CH1201/CH1101	Chemistry	3	1	3	5.5
4.	ME1201/ME1101	Mechanical Fabrication	0	0	3	1.5
5.	ME1202/ME1102	Engineering Mechanics	3	1	0	4
6.	IK1201	Indian Knowledge System (IKS)	3	0	0	3
TOTAL			**15**	**3**	**9**	**22.5**

Course Number	MA1201
Course Credit (L-T-P-C)	3-1-0-4
Course Title	Probability Theory and Ordinary Differential Equations
Learning Mode	Lectures and Tutorials
Learning Objectives	To introduce the basic concepts of probability, statistics, and Differential equations.
Course Description	This course aims to cover basic concepts of probability, statistics and ordinary differential equations. In particular, popular distributions, random sampling, various estimators and hypothesis testing will be discussed. Students will also get exposure to the linear ordinary differential equations and their solution techniques.
Course Content	**Probability (12 Lectures)**: Random variables and their probability distributions, Cumulative distribution functions, Expectation and Variance, probability inequalities, Binomial, Poisson, Geometric, negative binomial distributions, Uniform, Exponential, beta, Gamma, Normal and lognormal distributions. **Statistics (10 Lectures)**: Random sampling, sampling distributions, Parameter estimation, Point estimation, unbiased estimators, maximum likelihood estimation, Confidence intervals for normal mean, Simple and composite hypothesis, Type I and Type II errors, Hypothesis testing for normal mean. **Ordinary Differential Equations (20 Lectures)**: First order ordinary differential equations, exactness and integrating factors, Picard's iteration, Ordinary linear differential equations of n-th order, solutions of homogeneous and non-homogeneous equations (Method of variation of parameters). Systems of ordinary differential equations, Power series methods for solutions of ordinary differential equations. Legendre equation and Legendre polynomials, Bessel equation and Bessel functions.
Learning Outcome	Students will get exposure and understanding of: 1. Random variables and their probability distributions 2. Understand popular distributions and their properties 3. Sampling, estimation and hypothesis testing 4. Solution of ordinary differential equations 5. Solution of system of ordinary differential equations 6. Special functions arising as power series solutions of ordinary differential equations
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. Hogg, R. V., Mckean, J. and Craig, A. T., “Introduction to Mathematical Statistics”, 8th Ed., Pearson Education India, 2021
2. S.M. Ross “An introduction to Probability Models, Academic Press INC, 11th edition.
3. Miller, I. and Miller, M., “John E. Freund's Mathematical Statistics with Applications”, 8th Ed., Pearson Education India, 2013
4. S. L. Ross, Differential equations, 3rd Edition, Wiley, 1984
5. W. E. Boyce and R. C. Di Prima, Elementary Differential equations and Boundary Value Problems, 7th Edition, Wiley, 2001.

Course Number	CS1201
Course Credit	3-0-3-4.5
Course Title	**Data Structure**
Learning Mode	Offline
Learning Objectives	• Understand the principles and concepts of data structures and their importance in computer science. • Learn to implement various data structures and understand how different algorithms works. • Develop problem-solving skills by applying appropriate data structures to different computational problems. • Achieving proficiency in designing efficient algorithms.
Course Description	This course provides a comprehensive study of data structures and their applications in computer science. It focuses on the implementation, analysis, and use of various data structures such as arrays, linked lists, stacks, queues, trees, and graphs. Through theoretical concepts and practical programming exercises, this course aims to develop problem-solving and algorithmic thinking skills essential for advanced topics in computer science and software development.
Course Outline	• Introduction to Data Structure, • Time and space requirements, Asymptotic notations • Abstraction and Abstract data types • Linear Data Structure: stack, queue, list, and linked structure • Unfolding the recursion • Tree, Binary Tree, traversal • Search and Sorting, • Graph, traversal, MST, Shortest distance • Balanced Tree **Practical component**: Lab to be conducted on a 3-hour slot weekly. It will be conducted with the theory course so the topics for problems given in the lab are already initiated in the theory class.
Learning Outcome	• Understand Data Structure Fundamentals • Implement Basic Data Structures using a programming language • Analyse and Apply Algorithms • Design and Analyse Tree Structures • Understand the usage of graph and its related algorithms • Design and Implement Sorting and Searching Algorithms • Debug and Optimize Code
Assessment Method	Internal (Quiz/Assignment/Project), Mid-Term, End-Term

Suggested Reading

- Alfred V. Aho, John E. Hopcroft, Jeffrey D. Ullman, Data Structures and Algorithms, Published by Addison-Wesley
- Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein., Introduction to Algorithms,
- Mark Allen Weiss, Data Structures and Algorithm Analysis in Java
- Robert Sedgewick and Kevin Wayne, Algorithms
- Narasimha Karumanchi, Data Structures and Algorithms Made Easy

Course Number	**CH1101/CH1201**
Course Credit	**L-T-P-C: 3-1-3-5.5**
Course Title	**Chemistry**
Learning Mode	Offline
Learning Objectives	The course aims to lay a foundation for all three branches of chemistry, viz. Organic, Inorganic, and Physical Chemistry. The course aims to nurture knowledge to appreciate the interface of chemistry with other science and Engineering branches by combining theoretical concepts and experimental studies.
Course Description	This course introduces basic organic chemistry, inorganic chemistry and Physical chemistry to understand fundamental laws that governs various reactions, reaction rates, equilibrium, and their applications in daily life through relevant experimentation.
Course Outline	**Module 1:** Thermodynamics: The fundamental definition and concept, the zeroth and first law. Work, heat, energy and enthalpies. Second law: entropy, free energy and chemical potential. Change of Phase. Third law. Chemical equilibrium. Conductance of solutions, Kohlrausch's law-ionic mobilities, Basic Electrochemistry. **Module 2:** Coordination chemistry: Crystal field theory and consequences color, magnetism, J.T distortion. Bioinorganic chemistry: Trace elements in biology, heme and non-heme oxygen carriers, haemoglobin and myoglobin; Organometallic chemistry. **Module 3:** Stereo and regio-chemistry of organic compounds, conformational analysis and conformers, Molecules devoid of point chirality (allenes and biphenyls); Significance of chirality in living systems, organic photochemistry, Modern techniques in structural elucidation of compounds (UV–Vis, IR, NMR). **Module 4 (Lab Component):** Experiments based on redox and complexometric titrations; synthesis and characterization of inorganic complexes and nanomaterials; synthesis and characterization of organic compounds; experiments based on chromatography; experiments based on pH and conductivity measurement; experiment related to chemical kinetics and spectroscopy.
Learning Outcome	Students will be able to 1**.** identify organic and inorganic molecules and relate them to daily life applications through experiments. 2. understand important hypothesis, laws and their derivations to intercept physical phenomenon of chemical reactions and apply them in hands-on experiments. 3. understand the importance of organic and inorganic molecules in our body and environment. 4. know important analytical techniques to intercept chemical entity. 5. approach organic and inorganic synthesis as a skillset for drug manufacturing, calculate limiting reagents and yields, use various analytical tools to characterize organic compounds, interpret and ascertain data related to Physical chemistry aspects and know laboratory safety measures, risk factors and scientific report writing skills.
Assessment Method	**Theory**: 20% Quiz and assignment, 30% Mid sem and 50% End semester exams for theory part (4 credits). **Lab**: 60% lab report, lab performance and assignment, 20% End semester exam for practical part, 20% viva/quiz (1.5 credits). **Overall Weightage**: Theory (70%), Lab (30%).

Suggested Reading:

Text books:

1. Vogel's Qualitative Inorganic Analysis, G. Svehla, 7th Edition, Revised, Prentice Hall, 1996.
2. A. J. Elias, S. S. Manoharan and H. Raj, "Experiments in General Chemistry", Universities Press (India) Pvt. Ltd., 1997.
3. A. J. Elias, A Collection of Interesting General Chemistry Experiments, revised edition, Universities Press (India) Pvt. Ltd., 2007.
4. F. Albert Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, Advanced Inorganic Chemistry - 6th Edition New Delhi: Wiley India, 2008.
5. K. Mukkanti, Practical Engineering Chemistry, B.S. Publications, Hyderabad, 2009.
6. Shriver and Atkins inorganic chemistry / Peter Atkins, Tina Overton, Jonathan Rourke, Mark Weller, Fraser

Armstrong-5th Edition – Oxford: UOP. 2012.
7. Atkins' Physical Chemistry, Peter Atkins, Julio de Paula, James Keeler, Oxford University Press, 11th Edition 2017.
8. K. L. Kapoor, A Textbook of Physical Chemistry, Vol: 1, 2 (6th Edition, 2019), Vol: 3 (5th Edition, 2020) MaGraw Hill.
9. G. R. Chatwal, S. K. Anand, Instrumental Methods of Chemical Analysis, 5th Edition, Himalaya Publications, 2023.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X	X	X	X	X	X	X
CLO-2	X	X		X	X			
CLO-3	X	X	X	X		X	X	
CLO-4	X	X		X	X	X	X	X
CLO-5			X	X	X			X

Course Number	**ME1101/ME1201**
Course Credit	L-T-P-C: **0-0-3-1.5**
Course Title	**Mechanical Fabrication**
Learning Mode	Fabrication work – hands on fabrication work in Workshop
Learning Objectives	Complies with PLOs 3-4. • This course aims to develop the concepts and skills of various mechanical fabrication methods. • Fabrication of metallic and non-metallic components, fabrication using bulk and sheet metals, subtractive and additive manufacturing methods, and assemble the parts
Course Description	This course is designed to fulfil the need of hand on experience about various approaches (conventional and CNC, subtractive and additive) of mechanical fabrication approaches. Prerequisite: NIL
Course Outline	The jobs for various shops should be planned such that they are the parts of an assembled item. The student groups will fabricate different parts in various shops which will involve some amount of their creativeness/input particularly in design and/or planning. Various components as required for the assembled part can be made using the following shops: **Sheet Metal Working:** Development, sheet cutting and fabrication of designated job using sheet metal (ferrous/nonferrous); Joining of required portions by soldering, in case part is desired to be made leak proof. **Pattern Making and Foundry:** Making of suitable pattern (wood); making of sand mould, melting of non-ferrous metal/alloy (Al or Al alloys), pouring, solidification. Observation/identification of various defects appeared on the component. **Joining:** Butt/lap/corner joint job fabrication as required of low carbon steel plates; weld quality inspection by dye-penetration test (non-destructive testing approach)of the component made. Demonstration of semi-automatic Gas Metal Arc welding (GMAW). **Conventional machining:** Operations on lathe and vertical milling to fabricate the required component. The fabrication of the component should cover various lathe operations like straight turning, facing, thread cutting, parting off etc., and operations using indexing mechanism on vertical milling. **CNC centre:** Fundamentals of CNC programming using G and M code; setting and operations of job using CNC lathe or milling, tool reference, work reference, tool offset, tool radius compensation to fabricate the component with a designed profile on Al/Al-alloy plate. **3D printing (Fused Filament Fabrication): (2 weeks)** Create the model, select appropriate slicing and path for fabrication of a 3D job by layer deposition (additive manufacturing approach) using polymeric material. Demonstration on pattern fabrication using 3D printing.
Learning Outcome	• This course would enable the students to develop the concept of design, fabrication (subtractive and additive) for various engineering applications**.** Fabrication of components and assemble them. • The practical skill and hands on experience for various fabrication methods from bulk, sheet metal using conventional as well as CNC machines.
Assessment Method	Fabrication of components in each of the shops required for assembly of the given part; submission of reports for each shop, and quiz assessment.

Text and Reference books:

1. Hajra Choudhury, HazraChoudhary and Nirjhar Roy, 2007, Elements of Workshop Technology, vol. I,Mediapromoters and Publishers Pvt. Ltd.
2. W A J Chapman, Workshop Technology, 1998, Part -1, 1st South Asian Edition, Viva Book Pvt Ltd.
3. P.N. Rao, 2009, Manufacturing Technology, Vol.1, 3rd Ed., Tata McGraw Hill Publishing Company.
4. M.Adithan, B.S. Pabla, 2012, CNC machines, New Age International Publishers

Course Number	**ME1102/ME1202**
Course Number	**Engineering Mechanics**
L-T-P-C	3-1-0-4
Pre-requisites	Nil
Semester	Spring
Learning Mode	Lectures
Learning Objectives	Complies with PLOs 1, 4 • The objective of this first course in mechanics is to enable engineering students to analyze basic mechanics problems and apply vector-based approach to solve them.
Course Outline	1. **Rigid body statics**: Equivalent force system. Equations of equilibrium, Free body diagram, Reaction, Static indeterminacy. 2. **Structures**: 2D truss, Method of joints, Method of section. Beam, Frame, types of loading and supports, axial force, Bending moment, Shear force and Torque Diagrams for a member. 3. **Friction**: Dry friction (static and kinetic), wedge friction, disk friction (thrust bearing), belt friction, square threaded screw, journal bearings, Wheel friction, Rolling resistance. 4. **Centroid and Moment of Inertia** 5. **Introduction to stress and strain**: Definition of Stress, Normal and shear Stress. Relation between stress and strain, Cauchy formula. **Stress in an axially loaded member and stress due to torsion in axisymmetric section**
Learning Outcomes:	Following learning outcomes are expected after going through this course. • Learn and apply general mathematical and computer skills to solve basic mechanics problems. • Apply the vector-based approach to solve mechanics problems.
Assessment Method	Mid semester examination, End semester examination, Class test/Quiz, Tutorials

Reference Books

1. H. Shames, Engineering Mechanics: Statics and dynamics, 4th Ed, PHI, 2002.
2. F. P. Beer and E. R. Johnston, Vector Mechanics for Engineers, Vol I - Statics, 3rd Ed, Tata McGraw Hill, 2000.
3. J. L. Meriam and L. G. Kraige, Engineering Mechanics, Vol I - Statics, 5th Ed, John Wiley, 2002.
4. E.P. Popov, Engineering Mechanics of Solids, 2nd Ed, PHI, 1998.
5. F. P. Beer and E. R. Johnston, J.T. Dewolf, and D.F. Mazurek, Mechanics of Materials, 6th Ed, McGraw Hill Education (India) Pvt. Ltd., 2012.

Sl. No.	Subject Code	SEMESTER III	L	T	P	C
1.	MA2101	Design and Analysis of Algorithms	3	0	2	4
2.	MA2102	Probability and Stochastic Processes	3	1	0	4
3.	MA2103	Optimization Techniques	3	0	0	3
4.	MA2104	Algebra	3	0	0	3
5.	MA2105	Discrete Mathematics	3	0	0	3
6.	HS21XX	HSS Elective - I	3	0	0	3
TOTAL			**18**	**1**	**2**	**20**

Course Number	MA2101 (Core)
Course Credit (L-T-P-C)	3-0-2-4
Course Title	Design and Analysis of Algorithms
Learning Mode	Lectures and lab
Learning Objectives	To understand basic algorithm design techniques through solving different type of computational problems
Course Description	This course is meant to introduce the basic algorithm design techniques. It will also introduce few data structures and the notion of NP-Completeness.
Course Content	Model of Computations: RAM Model of computation, uniform cost model, logarithmic cost model. Complexity Analysis: Big O, omega, theta notations, solving recurrence relations Recurrence relations, Divide and conquer relations, Solving of recurrences by iteration method and substitution method, Master theorem, Binary search algorithm, Merger sort, Quick sort, Strassen's matrix multiplication method. Greedy strategy, Huffman coding algorithm, Graph traversal – BFS, DFS; MST - Kruskal's algorithm, Data structures of disjoint sets , Prim's algorithm; Shortest Path Algorithms - Dijkstra's and Bellman-Ford algorithms, Warshall's and Floyd's algorithms; Knapsack problem. Introduction to dynamic programming, Principle of optimality, Optimal binary search trees, Matrix-chain multiplication, Longest common subsequence. Introduction to computability, Reducibility, Polynomial-time verification, NP-completeness, NP-complete problems.
Learning Outcome	Students will be able to design efficient algorithms for different computational problems or will be able to show theoretically that the problem may not be solved in polynomial time.
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. "Introduction to Algorithms" by T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, Prentice Hall India.

Reference books:

1. "Data Structures and Algorithms in C++" by M. A. Weiss, Addison-Wesley
2. "Algorithm Design" by J. Kleinberg and Eva Tardos, Pearson Education
3. "The Design and Analysis of Computer Algorithms" by A. Aho, J. E. Hopcroft and J. D. Ullman, Addison-Wesley.

Course Number	MA2102 (Core)
Course Credit (L-T-P-C)	3-1-0-4
Course Title	Probability and Stochastic Processes
Learning Mode	Lectures and Tutorials
Learning Objectives	This particular course on probability theory and random processes aims at the undergraduate students to learn about basic properties random variables and their properties. It also covers essential theoretical concepts of random processes which are useful in many fields of practical study.
Course Description	This course is designed to cover basic concepts of probability theory. Particularly properties of random variables like mean, variance, and moment generating functions, quantiles and other important summary of information will be discussed. We also discuss joint distribution of random variables. Probability distributions of transformed random variables will also be discussed. Illustrative discussion on central limit theorems will also be presented. We further discuss basic properties of random processes and also present their classification into different types of processes. We cover both discrete and continuous time Markov chains and study various properties.
Course Content	Axiomatic construction of the theory of probability, independence, conditional probability, and basic formulae, random variables, probability distributions, functions of random variables; Standard univariate discrete and continuous distributions and their properties, mathematical expectations, moments, moment generating function, characteristic functions; Random vectors, multivariate distributions, marginal and conditional distributions, conditional expectations; Modes of convergence of sequences of random variables, laws of large numbers, central limit theorems. Definition and classification of random processes, discrete-time Markov chains, Poisson process, continuous-time Markov chains, renewal and semi-Markov processes, stationary processes, Gaussian process, Brownian motion, filtrations and martingales, stopping times and optimal stopping.
Learning Outcome	(1) Students attending this course will become familiar with different probability laws and properties. (2) This course enables students to get acquaintance with various discrete and continuous probability distributions. Also enable to compute different probabilities for such distributions. Computation of expectations, variance, quantiles and other probabilistic quantities. (3) Learn to compute joint probability distributions, conditional and marginal probability distributions and related properties. (4) Become familiar with the concepts of covariance and correlation. (5) Approximate a distribution using central limit theorem (6) Distribution of transformed random variables (7) Basic concepts of random processes. (8) Poisson processes (9) Markov Chains
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. A. Papoulis and S. Unnikrishna Pillai: Probabilities, Random Variables and Stochastic Processes, 4th Edition, Tata McGraw-Hill, 2002.
2. P. G. Hoel, S. C. Port and C. J. Stone: Introduction to Probability Theory, Universal Book Stall, 2000.

Course Number	MA2103 (Core)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Optimization Techniques
Learning Mode	Lectures
Learning Objectives	The objective of the course is to train student about the modeling of linear programming problems and its dual and various algorithms to solve these problems
Course Description	Optimization technique, as a basic subject for undergraduate students, provides the initial knowledge of various models of linear programming problems and different algorithms to solve such problems with its applications in various problems arising in economics, science and engineering.
Course Content	Linear programming: Introduction and Problem formulation, Geometrical aspects of LPP, Graphical solutions, Linear programming in standard form, Simplex, Big M and Two-Phase Methods, Revised simplex method, Special cases of LPP. Duality theory: Dual simplex method, Sensitivity analysis of LP problem, Integer programming problems: Branch and bound method, Gomory cutting plane method for all integer and for mixed integer LPP. Theory of games: saddle point, linear programming formulation of matrix games, two-person zero-sum games. Computational complexity of the Simplex algorithm, Karmarkar's algorithm for LPP. Line search methods for unconstrained non linear optimization, gradient descent, Newton method, conjugate gradient method. Acquaintance to softwares to solve optimization problems.
Learning Outcome	On successful completion of the course, students should be able to: 1. Understand the terminology and basic concepts of various kinds of linear programming problems 2. model several linear programming problems and its dual 3. Develop the understanding of about different solution methods to solve linear Programing problem. 4. Apply and differentiate the need and importance of various algorithms to solve linear programing problems 5. employ programming languages to solve linear programing problems
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. Hamdy A. Taha, Operations Research: An Introduction, Eighth edition, PHI, New Delhi (2007).
2. M. S. Bazaraa, J. J. Jarvis and H. D. Sherali, Linear Programming and Network Flows, 3rd Edition, Wiley (2004).

Reference Books:

1. D. G. Luenberger, Linear and Nonlinear Programming, 2nd Edition, Kluwer, (2003).
2. S. A. Zenios (editor), Financial Optimization, Cambridge University Press (2002).
3. F. S. Hiller, G. J. Lieberman, Introduction to Operations Research, Eighth edition, McGraw Hill (2006).
4. S. Chandra, Jayadeva, Aparna Mehra, Numerical Optimization with Applications, Narosa Publishing House (2009).
5. A. Ravindran, D.T. Phillips, J.J. Solberg, Operation Research, John Wiley and Sons, New York (2005).

Course Number	MA2104 (Core)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Algebra
Learning Mode	Lectures
Learning Objectives	The aim of this course is to learn about groups, subgroups, quotient groups, homomorphisms and Sylow's theorems. Further, it also covers basic properties of rings, ideals, integral domain, ED, PID, UFD which are useful in many branches of mathematics.
Course Description	We will begin by studying the basic concepts of subgroups, homomorphisms and quotient groups with many examples. We then study group actions, and prove the Class equation and the Sylow' theorems. They are in turn used to prove the structure theorem for finite abelian groups and to discuss the classification of groups of small order. Further, we define rings and discuss ideals, quotient rings. We then discuss the important classes of commutative rings, irreducibility in general and specifically in the context of polynomial rings.
Course Content	Groups, subgroups, normal subgroups, permutation groups, cyclic groups, dihedral groups, matrix groups. Homomorphisms, quotient groups, Isomorphisms. Cayley's theorem, groups acting on sets, Sylow's theorems (without proof) and applications, direct products, finitely generated abelian groups, Structure Theorem for finite abelian groups. Rings, fields, integral domain, basic properties of rings, units, ideals, homomorphisms, quotient rings, prime and maximal ideals, fields of fractions, Euclidean domains, principal ideal domains and unique factorization domains, polynomial rings.
Learning Outcome	Students will learn basics of abstract algebra and they will be able to take advance courses in Algebra, Number Theory, Cryptography etc. This course will also build foundation for research in mathematical sciences and computer sciences.
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. D. Dummit and R. Foote, Abstract Algebra, 3rd edition, Wiley, 2004.
2. J. A. Gallian, Contemporary Abstract Algebra, 4th ed., Narosa, 1999.

Reference Books:

1. M. Artin, Algebra, Prentice Hall of India, 1994.
2. I.N. Herstein, Topics in Algebra, Wiley, 2006.
3. S. R. Nagpaul and S. K. Jain, Topics in Applied Abstract Algebra, Amer. Math. Soc., First Indian Edition, 2010.
4. J. B. Fraleigh, A First Course in Abstract Algebra Paperback, Addison-wesley 1967.
5. Paul B. Garrett, Abstract Algebra, Chapman and Hall/CRC, 1st edition, 2007.

Course Number	MA2105 (Core)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Discrete Mathematics
Learning Mode	Lectures
Learning Objectives	To learn formal mathematical way of writing through mathematical logic and different counting techniques through examples
Course Description	This course is meant to introduce different counting techniques. It also covers introductory graph theory and Boolean algebra.
Course Content	Mathematical Logic and Proofs: Propositional logic and equivalences, Predicate and Quantifiers, Introduction to Proofs, Proof methods Sets, Relations and Functions: Relations and their properties, Closure of Relations, Order Relations, Equivalence relations, POSets and Lattices Counting Techniques: Permutations and Combinations, Binomial coefficients, Pigeonhole principle, Double counting, Principle of Inclusion-Exclusion, Recurrence relations and its solution, Divide and Conquer, Generating functions. Graph Theory: Basic definitions, Trees, Connectivity, Spanning trees, Shortest Path Problems, Eulerian and Hamiltonian graphs, Planar graphs, Graph Coloring Boolean Algebra: Boolean functions, Logic gates, Simplification of Boolean Functions, Boolean Circuits
Learning Outcome	Students will be accustomed with the formal mathematical way of writing. They will also be able to apply counting techniques to different problems. Using graph theory, they will be able to model different real- life problems as well.
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. Discrete Mathematics and Its Applications by K. H. Rosen, Tata McGraw-Hill
2. Discrete Mathematics by C Liu

Reference Books:

1. Basic Techniques of Combinatorial Theory by D. I. A. Cohen, John Wiley & Sons
2. Introduction to Graph Theory by D. B. West, Pearson Prentice Hall
3. A Walk Through Combinatorics by Miklos Bona, 4th Edition, World Scientific
4. Invitation to Discrete Mathematics by J. Matousek and J. Nesetril, Oxford University Press
5. Enumerative Combinatorics Vol-I by Richard P. Stanley, Cambridge University Press

Sl. No.	Subject Code	SEMESTER IV	L	T	P	C
1.	MA2201	Introduction to Machine Learning	2	0	2	3
2.	MA2202	Real Analysis and Measure Theory	3	0	0	3
3.	MA2203	Numerical Linear Algebra	3	0	2	4
4.	MA2204	Computer Architecture and Organization	3	0	3	4.5
5.	MA2205	Database Management Systems	3	0	3	4.5
6.	XX22PQ	IDE - I	3	0	0	3
TOTAL			**17**	**0**	**10**	**22**

Course Number	MA2201 (Core)
Course Credit (L-T-P-C)	2-0-2-3
Course Title	Introduction to Machine Learning
Learning Mode	Lectures and Lab
Learning Objectives	In this subject, the students will be trained with the fundamentals of Machine Learning concepts along with the knowledge of mathematical tools that are required to grasp those skills.
Course Description	Introduction to Machine Learning, as a basic subject for undergraduate students, provides the initial knowledge of Machine Learning with its applications in various Mathematical and Statistical problems.
Course Content	Regression: Least Squares, Goodness of Fit, Bias-Variance Trade Off, Linear, Polynomial and Logistic Regression, Classification: Binary and Multinomial Classification, Naive Bayes Classifier, Neural Networks, K-Nearest Neighbors, Support Vector Machine, Decision Trees, Unsupervised Learning: PCA, K-means clustering, Hiracrhieal Clustering, Density based Clustering. **LAB:** problems based on theory lectures using R/Python.
Learning Outcome	On successful completion of the course, students should be able to: 1. Analyse the role of mathematical tools in Machine Learning. 2. Understand the terminology and basic concepts of Machine Learning 3. Differentiate and apply the Supervised and Unsupervised Learning models.
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. Tom Mitchell. Machine Learning. First Edition, McGraw- Hill, 1997
2. R. Duda, P. Hart and D. Stork, PatternClassification, Wiley

Reference Books:

1. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, An Introduction to Statistical Learning with Applications in R
2. Ethen Alpaydin, Introduction to Machine Learning, 2nd edition.
3. Machine Learning: An Applied Mathematics Introduction, Panda Ohana Publishing, 2019

Course Number	MA2202 (Core)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Real Analysis and Measure Theory
Learning Mode	Lectures
Learning Objectives	Students will understand the concept of sequences and series of real numbers as well as functions. Students also learn various concepts associated with Lebesgue measure and understand the need for Lebesgue integration. Theorems related to Lebesgue integration are discussed to highlight the applications of Lebesgue integration.
Course Description	This course discusses details of sequences and series of real numbers and real valued functions. Distinction between pointwise convergence and uniform convergence shall be covered in detail and how uniform convergence leads to some important theorems. The concept of Lebesgue integration is introduced by discussing the basics of outer measure, measurable sets and measurable functions. Various interesting theorems associated with the Lebesgue integral shall be covered in detail highlighting their applications.
Course Content	Sequence and series of real numbers and tests for convergence, Cauchy sequences, Cauchy criterion for convergence, bounded and monotonic sequences, absolute continuity and uniform continuity. Sequences and Series of real valued functions and uniform convergence, Power series. Sigma Algebra, Lebesgue outer measure, Measurable sets, Measure space, Complete measure space, Lebesgue measure on **R**, Properties of Lebesgue measure. Lebesgue Integration, the integration of non-negative functions, Measurable functions, Fatou's Lemma, Integrable functions and their properties, Lebesgue's dominated convergence theorem (without proof).
Learning Outcome	On successful completion of the course, students should be able to: 1. Differentiate between uniform convergence and point wise convergence. 2. Differentiate between continuity and uniform continuity. 3. Evaluate the Lebesgue integral of a measurable function.
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. W. Rudin, Principles of Mathematical Analysis, McGraw-Hill, 1976.
2. G de Barra, Measure Theory and Integration, New Delhi New Age International, 2003

Reference Books:

1. T.M. Apostol, Mathematical Analysis, Narosa Publishing House, 2002.
2. Frank Jones , Lebesgue Integration On Euclidean Space (Revised Ed.) (Jones And Bartlett Books In Mathematics) 2000.
3. Stein and Shakarchi, Real Analysis, Measure Theory, Integration, and Hilbert Spaces (Princeton Lectures in Analysis), Overseas (May 2005).
4. K. Ross, Elementary Analysis: The Theory of Calculus, Springer, 2004.

Course Number	MA2203 (Core)
Course Credit (L-T-P-C)	3-0-2-4
Course Title	Numerical Linear Algebra
Learning Mode	Lectures and Labs
Learning Objectives	This course answers the fundamental question of choice of suitable matrix computation method for various kind of problems required linear solvers. Hands-on experience with all the methods covered is the most crucial part of this course. All the topics discussed in this course would be accompanied with parallel practical session to reinforce the learning outcome of the course.
Course Description	Due to increasing complexity in the real world scenarios and recent advances in the area of data science, understanding of numerical linear algebra and large scale matrix computations has become essential for engineers.
Course Content	Review of basic concepts from linear Algebra; direct methods for solving linear systems; vector and matrix norms; condition numbers; least squares problems; iterative methods for solving linear systems - Jacobi, Gauss Seidel, SOR and their convergence; projection methods - general projection method, steepest descent, MR Iteration, RNSD method and their convergence; orthogonalization; singular value decomposition; numerical computation of eigenvalues and eigenvectors; Introduction to Krylov subspace methods - Arnoldi's method, GMRES method, Conjugate gradient algorithm, Lanczos Algorithm and convergence check for Krylov subspace methods, Preconditioned CG, ILU preconditioner.
Learning Outcome	On completion of the module, students will be able to • do some key matrix factorizations of a matrix, • identify suitable technique to solve linear systems of equations, least squares problems, and the eigenvalue problem.
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. Iterative Methods for Sparse Linear Systems (Textbook), Yousef Saad, SIAM 2003
2. Matrix Computations (Textbook), Gene H. Golub, Charles, F. Van Loan, John Hopkins University Press, 1996

Reference Books:

1. Matrix iterative Analysis, R. S. Varga, Prentice Hall 1962
2. Introduction to matrix computation, Gilbert W. Stewart, Academic Press 1973
3. Numerical Linear Algebra, L.N. Trefethen, D. Bau, SIAM, 1997
4. Fundamentals of Matrix Computations, Watkins, Wiley-Interscience, 2010
5. Applied numerical linear algebra, Demmel, James W., Vol. 56. SIAM, 1997

Course Number	MA2204 (Core)
Course Credit (L-T-P-C)	3-0-3-4.5
Course Title	Computer Architecture and Organization
Learning Mode	Lectures and Lab
Learning Objectives	1. Understand the CPU architecture including registers, instruction execution cycle, addressing modes, and instruction set. 2. Explore CPU control unit design, memory organization, peripheral devices, and their characteristics, while also becoming familiar with assembly language programming.
Course Description	This course covers the fundamentals of CPU architecture, including registers, instruction execution cycle, and addressing modes. It delves into CPU control unit design, memory organization, cache memory, and peripheral devices. Practical aspects include assembly language programming and case studies on instruction sets of common CPUs.
Course Content	CPU - registers, instruction execution cycle, RTL interpretation of instructions, addressing modes, instruction set. Case study - instruction sets of some common CPUs; Assembly language programming for some processor; Data representation: signed number representation, fixed and floating-point representations, character representation. Computer arithmetic - integer addition and subtraction, ripple carry adder, carry look-ahead adder, etc. multiplication – shift-and-add, Booth multiplier, carry save multiplier, etc. Division - non-restoring and restoring techniques, floating point arithmetic; CPU control unit design: hardwired and micro-programmed design approaches, Case study - design of a simple hypothetical CPU; Pipelining: Basic concepts of pipelining, throughput and speedup, pipeline hazards; Memory organization: Memory interleaving, concept of hierarchical memory organization, cache memory, cache size vs block size, mapping functions, replacement algorithms, write policy; Peripheral devices and their characteristics: Input-output subsystems, I/O transfers - program controlled, interrupt driven and DMA, privileged and non-privileged instructions, software interrupts and exceptions. Programs and processes - role of interrupts in process state transitions. Familiarization with assembly language programming; Synthesis/design of simple data paths and controllers, processor design using HDL like verilog/vhdl; Interfacing - DAC, ADC, keyboard-display modules, etc. Development kits as well as Microprocessors/PCs may be used for the laboratory, along with design/simulation tools as and when necessary.
Learning Outcome	1. Develop a comprehensive understanding of CPU architecture, memory organization, and peripheral devices, along with proficiency in assembly language programming. 2. Apply theoretical concepts to design and analyze simple hypothetical CPUs
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. Stalling W, “Computer Organization and Architecture ”, Pearson Eduction India. 2008
2. Tanenbaum, A.S, “Structured Computer Organization”, Prentice-Hall. 1994

Reference Books:

1. D V Hall, Microprocessors and Interfacing, TMH, 1995
2. Brey. Barry B, The Intel Microprocessors 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium, and Pentium Pro Processor Architecture, Programming, and Interfacing, Prentice Hall India, 2005
3. Patterson, D.A., and Hennessy, J.L. , “Computer Organization and Design: The Hardware/Software Interface”, Morgan Kaufmann Publishers, 4th Edition, Inc.2005
4. Patterson, D.A., and Hennessy, J.L. , “Computer Architecture : A Quantitative Approach ”, Morgan Kaufmann Publishers, 4th Edition, Inc.2005
5. Hamacher, V.C., Vranesic, Z.G., and Zaky, S.G., “Computer Organization”, 5/e. McGraw-Hill. 2008

Course Number	MA2205 (Core)
Course Credit (L-T-P-C)	3-0-3-4.5
Course Title	Database Management Systems
Learning Mode	Lectures and Lab
Learning Objectives	Develop a comprehensive understanding of database system architecture, data models, etc.
Course Description	This course covers database system architecture, data models, relational query languages, relational database design, query processing and optimization, storage strategies, transaction processing, and recent trends in database systems.
Course Content	Database system architecture: Data Abstraction, Data Independence, Data Definition and Data Manipulation Languages; Data models: Entity-relationship, network, relational and object oriented data models, integrity constraints and data manipulation operations; Relational query languages: Relational algebra, tuple and domain relational calculus, SQL and QBE; Relational database design: Domain and data dependency, Armstrongs axioms, normal forms, dependency preservation, lossless design; Schema refinement; Query processing and optimization: Evaluation of relational algebra expressions, query equivalence, join strategies, query optimization algorithms; Storage strategies: Indices, B-trees, hashing; Transaction processing: Recovery and concurrency control, locking and timestamp based schedulers, multiversion and optimistic Concurrency Control schemes; Recent Trends: XML Data, XML Schema, JSON etc. Database schema design, database creation, SQL programming and report generation using a commercial RDBMS like ORACLE/SYBASE/DB2/SQL-Server/INFORMIX. Students are to be exposed to front end development tools, ODBC and CORBA calls from application Programs, internet based access to databases and database administration.
Learning Outcome	Students will develop a comprehensive understanding of database systems, including their architecture, design principles, query processing techniques, transaction management, and emerging trends in data management technologies
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. A Silberschatz, H Korth and S Sudarshan, Database System Concepts, 6th Ed., McGraw-Hill, 2010.
2. H Garcia-Molina, JD Ullman and Widom, Database Systems: The Complete Book, 2nd Ed., Prentice-Hall, 2008.

Reference Books:

1. R Elmasri, S Navathe, Fundamentals of Database Systems, 6th edition, Addison-Wesley, 2010.
2. R Ramakrishnan, J Gehrke, Database Management Systems, 3rd Ed., McGraw-Hill, 2002.

Sl. No.	Subject Code	SEMESTER V	L	T	P	C
1.	MA3101	Ordinary and Partial Differential Equations	3	0	0	3
2.	MA3102	Complex Analysis	3	0	0	3
3.	MA3103	Theory of Computation	3	0	0	3
4.	MA3104	Computer Networks	3	0	3	4.5
5.	MA3105	Operating Systems	3	0	3	4.5
6.	XX31PQ	IDE - II	3	0	0	3
TOTAL			**18**	**0**	**6**	**21**

Course Number	MA3101 (Core)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Ordinary and Partial Differential Equations
Learning Mode	Lectures
Learning Objectives	To get expose to the ordinary differential equations. To understand the theory and qualitative properties of solutions of differential equations. The course will also introduce students to partial differential equations and methods of solutions of some basic partial differential equations.
Course Description	This course is meant to introduce the basic properties and solutions of both the ordinary and partial differential equations.
Course Content	**ODE:** Review of ODEs, IVPs and existence and uniqueness theorems, System of ODEs: Phase plane, critical point, stability, Oscillation and Comparison theorems for second order linear equations and applications, Self-adjoint Eigenvalue problems on a finite interval, BVPs and Sturm Liouville Problems, Green's function. **PDE:** Introduction to PDE and the classification of PDEs (Linear, Nonlinear, Quasi Linear), Lagrange's and Charpit's Method, Second order PDEs and Their Classification, Method of Separation of Variables, Method of Characteristics, D'Alembert Solution, Duhamel's principle. Maximum Principle and existence theorems, Fourier series, Fourier Transform, Laplace Transform and their application to solve ODEs and PDEs.
Learning Outcome	Students will be able to identify properties of solutions of the ODEs even when explicit solutions are not possible or feasible. The solutions methods for the PDEs will be explicitly introduced.
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:
1. Earl A. Coddington, Norman Levinson, Theory of Ordinary Differential Equations, Tata McGraw Hill Education Private Limited, New Delhi, 1972.
2. Ian Sneddon, Elements of Partial Differential Equations, McGraw-Hill International Editions, 1957.

Reference Books:
1. Mark A. Pinsky, Partial Differential Equations and Boundary-Value Problems with Applications, American Mathematical Society, 2013.
2. Myint U. Tyn, Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers, Birkhauser, 4th Edition.
3. T. Amarnath, An Elementary Course in Partial Differential Equations, Narosa, 2nd Edition.

Course Number	MA3102 (Core)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Complex Analysis
Learning Mode	Lectures
Learning Objectives	The objective of the course is to train student about the fundamental properties of complex valued functions
Course Description	Complex Analysis is a basic course for undergraduate student and is intended to discuss about important Mathematical properties of complex valued functions and enables students to solve some real-life problem.
Course Content	Limit, Continuity, Differentiability, Analytic functions, Cauchy-Riemann Equations, Harmonic Functions, Reflection Principle, Elementary Functions, Branch point and Branch Cut, Contour Integration, Cauchy-Goursat Theorem- Simply and Multiply Connected Domains, Cauchy Integral Formula, Liouville's Theorem and the Fundamental Theorem of Algebra, Morera’s Theorem, Maximum Modulus Principle, Taylor Series, Laurent Series, Classification of Singularities, Cauchy's Residue Theorem, Residues at Poles, Zeros of Analytic Functions, Zeros and Poles, Behavior Near Isolated Singular Points, Evaluation of Improper Integrals, Jordan's Lemma, Definite integrals involving Sines and Cosines, Argument Principle, Rouche's Theorem, Bilinear Transformations, Conformal Mapping.
Learning Outcome	On successful completion of the course, students should be able to: 1. Analyse the geometric behaviours of different kind of complex valued functions and use them to solve some real life problems. 2. Behaviour of complex valued function near singular points. 3. Use of Branch cut to solve difficult definite integrals.
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. Complex Variables and Applications: James Ward Brown and Ruel V. Churchill, 8th Edition, McGraw Hills.
2. Lars Ahlfors, Complex Analysis, McGraw Hill Education; Third edition (1 July 2017).

Reference Books:

1. Fischer, Wolfgang, Lieb, IngoA Course in Complex Analysis, Springer-Verlag, (2012).
2. Joseph L. Taylor, Complex Variables - American Mathematical Society, 2011.
3. Edward C. Titchmarsh, The Theory of Functions, Oxford University Press; 2 edition, 1976.
4. Stein and Shakarchi, Complex Analysis, Overseas (1 January 2006).

Course Number	MA3103 (Core)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Theory of Computation
Learning Mode	Lectures
Learning Objectives	To understand how efficiently a computational problem can be solved on a model of computation using algorithm.
Course Description	This course is meant to introduce the fundamental but abstract areas of theoretical computer science.
Course Content	Basic definitions, deterministic and non-deterministic finite automata. Regular Languages, regular operations, Regular Expressions, Equivalence of DFA, NFA, Nonregular Languages and pumping lemma. Context-Free Languages: Context-Free Grammars, Chomsky Normal Form, Pushdown Automata. Noncontext-Free Languages and pumping lemma, Deterministic Context-Free Languages Turing Machines: Definition of TM and its variants, Decidability, Reducibility. Complexity Theory: Time complexity and Space Complexity.
Learning Outcome	Students will have strong theoretical foundation to identify which computational problems are solvable which helps them to learn other areas of computer science like compiler, artificial intelligence, natural language processing and many more.
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. Introduction to the Theory of Computation, by Michael Sipser,
2. Computational Complexity, by Christos H. Papadimitriou, Addison-Wesley publishers.

Reference Books:

1. Computational Complexity: A Modern Approach, by Sanjeev Arora and Boaz Barak.

Course Number	MA3104 (Core)
Course Credit (L-T-P-C)	3-0-3-4.5
Course Title	Computer Networks
Learning Mode	Lectures and Labs
Learning Objectives	Comprehend the historical development of computer networks and grasp both the theoretical and practical foundations of data communication.
Course Description	This course provides an in-depth exploration of computer networks, covering the evolution, physical layer, medium access control, data link layer, network layer, transport layer, quality of service, and application layer protocols.
Course Content	Evolution of computer networks; Physical Layer; transmission media and impairments, switching systems Medium Access Control Sublayer: Channel allocation Problem, multiple access protocols, Ethernet Data link layer: Framing, HDLC, PPP, sliding window protocols, error detection and correction Network Layer: Internet addressing, IP, ARP, ICMP, CIDR, routing algorithms (RIP, OSPF, BGP); Transport Layer: UDP, TCP, flow control, congestion control; Introduction to quality of service; Application Layer: DNS, Web, email, authentication, encryption. Simulation experiments for protocol performance, configuring, testing and measuring network devices and parameters/policies; network management experiments; Exercises in network programming.
Learning Outcome	Students will develop a comprehensive understanding of computer networks.
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. Peterson & Davie, Computer Networks, A Systems Approach: 5th Edition
2. William Stallings, Data and Computer Communication, Prentice-Hall.
3. AS Tanenbaum, DJ Wetherall, Computer Networks, 5th Ed., Prentice-Hall, 2010.

Reference Books:

1. LL Peterson, BS Davie, Computer Networks: A Systems Approach, 5th Ed., Morgan-Kauffman, 2011.
2. JF Kurose, KW Ross, Computer Networking: A Top-Down Approach, 5th Ed., Addison-Wesley, 2009.

Course Number	MA3105 (Core)
Course Credit (L-T-P-C)	3-0-3-4.5
Course Title	Operating Systems
Learning Mode	Lectures and Labs
Learning Objectives	Gain a comprehensive understanding of operating system fundamentals.
Course Description	This course covers essential concepts in operating systems, including process management, concurrency, memory management, file systems, secondary storage, and advanced topics like distributed systems, security, and real-time systems, with practical examples drawn from Linux, Windows NT/7/8.
Course Content	Process Management: process; thread; scheduling. Concurrency: mutual exclusion; synchronization; semaphores; monitors; Deadlocks: characterization; prevention; avoidance; detection. Memory Management: allocation; hardware support; paging; segmentation. Virtual Memory: demand paging; replacement; allocation; thrashing. File Systems and Implementation. Secondary Storage: disk structure; I/O management; device drivers; disk scheduling; disk management. (Linux will be used as a running example, while examples will draw also from Windows NT/7/8.); Advanced Topics: Distributed Systems. Security. Real-Time Systems. Programming assignments to build different parts of an OS kernel.
Learning Outcome	Students will develop a comprehensive understanding of operating system principles and mechanisms, enabling them to design, implement, and manage efficient and reliable computer systems.
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. Silberschatz, P. B. Galvin and G. Gagne, Operating System Concepts, 8th Ed, John Wiley & Sons, 2010.
2. A. S. Tenenbaum, Modern Operating Systems, 2nd Ed, Prentice Hall of India, 2001.

Reference Books:

1. H. M. Deitel, P. J. Deitel and D. R. Choffness, Operating Systems, 3rd Ed, Prentice Hall, 2004.
2. W. Stallings, Operating Systems: Internal and Design Principles, 5th Ed, Prentice Hall, 2005.
3. M. J. Bach, The Design of the UNIX Operating System, Prentice Hall of India, 1994.

Sl. No.	Subject Code	SEMESTER VI	L	T	P	C
1.	MA3201	Number Theory and Cryptography	3	0	0	3
2.	MA3202	Numerical Methods	3	0	2	4
3.	MA3203	Mathematical Statistics	3	0	0	3
4.	MA3204	Convex Optimization	3	0	2	4
5.	MA3205	Functional Analysis	3	0	0	3
6.	MA3206	Artificial Intelligence	3	0	2	4
TOTAL			**18**	**0**	**6**	**21**

Course Number	MA3201 (Core)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Number Theory and Cryptography
Learning Mode	Lectures
Learning Objectives	Readers of this course will be well-equipped with basic concepts of numbers, their properties, and some of the standard results which are fundamental to any branch of mathematics. The course will study further properties and some advanced concept which has a lot of application in Cryptography.
Course Description	This course introduces divisibility in integers and some knowledge of the arithmetic of congruences. The prime numbers are the building blocks of all natural numbers. The interplay between the multiplicative and additive properties of numbers and their uses in quadratic residues is particularly interesting. A few applications of these topics of number theory to modern cryptography are also introduced.
Course Content	Integers, mathematical induction, divisibility in integers, basic algebra of infinitude of primes, Prime number theorem, Fundamental theorem of arithmetic, Dirichlet's theorem (without proof). Arithmetic functions, Mobius inversion formula, Structure of units modulo n, Euler's phi function. Primitive roots and indices, group of units. Congruences, Fermat's theorem and Euler's theorem, Wilson's theorem, linear congruences, Simultaneous linear congruences, Chinese Remainder Theorem, Simultaneous non-linear congruences. Quadratic residues, law of quadratic reciprocity, binary quadratics forms, Fermat's two square theorem (without proof). Algorithm to solve quadratic equations in Zm. Finite fields: construction and examples, factorizations of polynomials over finite fields, algorithm to determine irreducible polynomials of degree n over Zm. Introduction to classical cryptosystems, DES-security and generalizations, Prime number generation. Public key cryptosystem (RSA).
Learning Outcome	On successful completion of the course, students should be able to: 1. Understand the importance of integers; 2. Understand other basic courses of mathematics, like Algebra, Topology, Calculus, Analysis, Geometry and Combinatorics; 3. Help to understand the basic techniques of Cryptography (the techniques for protecting information from unauthorized access) & Coding Theory and Information Theory (the study of the transfer of information securely) and make able to develop some new techniques too.
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. David M. Burton, Elementary Number Theory, 6th Edition, McGrow Hill Higher Education, 2007.
2. Koblitz…

Reference Books:

1. Kenneth H. Rosen: Elementary Number Theory, 6th edition, Pearson, 2010.
2. W. W. Adams and L.J. Goldstein, Introduction to the Theory of Numbers, 3rd ed., Wiley Eastern, 1972.
3. A. Baker, A Concise Introduction to the Theory of Numbers, Cambridge University Press, Cambridge, 1984.
4. I. Niven and H.S. Zuckerman, An Introduction to the Theory of Numbers, 5th Ed., Wiley, New York, 2008.
5. Thomas Koshy, Elementary Number Theory with Applications, 2nd Edition, Academic Press, 2007.

Course Number	MA3202 (Core)
Course Credit (L-T-P-C)	3-0-2-4
Course Title	Numerical Methods
Learning Mode	Lectures and Labs
Learning Objectives	In this subject, the students will be trained with the basic available numerical methods which are required to solve applied models. This objective is required for anyone who wanted to work on computational areas.
Course Description	This course will highlight the root finding approximation methods which are required for solving system of differential equations. In addition, the basic convergence criteria for solving ODE and PDEs will be also explained in addition to the numerical algorithms.
Course Content	Bisection Method, Fixed Point Iteration, Secant Method, Solution of Nonlinear System based on Newton Raphson Method, Sufficient condition for convergence of Nonlinear systems, Interpolation (Lagrange's formula, Newton's forward and backward method, central difference, divided difference, sterling's formula), Integration (Trapezoidal, Simpson's $1/3^{rd}$ rule, Simpson's $3/8^{th}$ rule, Quadrature Methods) and Differentiation. Single step methods (Euler method and Runge Kutta Method), Multi-step methods for IVPs (Adam-Bashforth, Adam-Moulton methods), Finite difference methods for BVPs (2^{nd} order scalar case only), Finite difference methods for parabolic, hyperbolic and elliptic PDEs
Learning Outcome	Students will be able to know the Mathematics behind the basic numerical algorithms
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. M. K. Jain, S.R.K. Iyenger, RK Jain, Numerical Methods, For Scientific and Engineering Computation, New Age Publisher.
2. K. E. Atkinson, An Introduction to Numerical Analysis, John Wiley & Sons.

Reference Books:

1. Michael T. Heath, Scientific Computing, An Introductory Survey, Tata McGraw Hill.
2. Endre Suli and David F. Mayers, An Introduction to Numerical Analysis, Cambridge Univ Press.
3. A Theoretical Introduction to Numerical Analysis, 1st Edition, By Victor S. Ryaben'kii, Semyon V. Tsynkov, Chapman and Hall/CRC.
4. Sastry…

Course Number	MA3203 (Core)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Mathematical Statistics
Learning Mode	Lectures
Learning Objectives	This course on mathematical statistics is aimed at the undergraduate students who are interested to learn basic concepts of statistics via mathematical approach. It gives essential background to students who further wish to learn statistics at advanced level.
Course Description	This course is designed to cover various important methods of statistical inference. Order statistics and their join distributions are considered. Various properties of order statistics will be discussed. Then sampling from normal distribution will be discussed. Further different types of estimation problems will be described and illustrated. In this regard point and interval estimation problems will be demonstrated. Both classical and Bayesian methods of estimation will be discussed. Towards the end problem of testing will be covered.
Course Content	Ordered Statistics, probability distributions of Sample Range, Minimum and Maximum order Statistics. Random Sampling, Sampling distributions: Chi-square, T, F distributions. Point Estimation: Sufficiency, Factorization theorem, Consistency, Moment method of estimation, Unbiased Estimation, Minimum Variance Unbiased Estimator and their properties, Rao-Cramer lower bound, Rao-Blackwellization, Fisher Information, Maximum Likelihood Estimator and properties, Criteria for evaluating estimators: Mean squared error. Interval Estimation: Coverage Probabilities, Confidence level, Sample size determination, Shortest Length interval, Pivotal quantities, interval estimators for various distributions. Testing of Hypotheses: Null and Alternative Hypotheses, Simple hypothesis, Composite hypothesis, Test Statistic, Critical region, Error Probabilities, Power Function, Level of Significance, Neyman-Pearson Lemma, One and Two Sided Tests for Mean, Variance and Proportions, One and Two Sample T-Test, Pooled T-Test, Paired T-Test, Chi-Square Test, Contingency Table Test, Maximum Likelihood Test, Duality between Confidence Intervals. Bayesian Estimation: Prior and Posterior Distributions, Quadratic Loss Function, Posterior Mean, Bayes Estimates for well Known Distributions (Normal, Gamma, Exponential, Binomial, Poisson, Beta etc.)
Learning Outcome	Students will become familiar with following topics: (1) Distribution properties of order statistics (2) Desirable properties point estimators like unbiasedness, efficiency, consistency etc. (3) Mean squared error computations (4) Coverage probabilities (5) Posterior distributions (6) Error probabilities and most powerful tests (7) Chi-square test
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. Mathematical Statistics with applications, Kandethody M. Ramachandran, Chris P. Tsokos, Academic Press, 2009
2. Probability and Statistics in Engineering, William W. Hines, Douglas C. Montgomery, David M. Goldsman, Connie M. Borror, John Wiley & Sons; 4th Edition Edition, 2003.

Course Number	MA3204 (Core)
Course Credit (L-T-P-C)	3-0-2-4
Course Title	Convex Optimization
Learning Mode	Lectures and Labs
Learning Objectives	The objective of the course is to train student about the modeling of convex programming problems and various classical and numerical optimization techniques and algorithms to solve these problems
Course Description	Convex Optimization, as a basic subject for undergraduate students, provides the knowledge of various models of nonlinear convex optimization problems and different algorithms to solve such problems with its applications in various problems arising in economics, science and engineering.
Course Content	Introduction to nonlinear programming, Convex Sets, Convex Functions and their properties. Unconstrained optimization of functions of several variables: Necessary and Sufficient conditions. Numerical methods for unconstrained optimization: Newton, LM method, and Quasi Newton methods (DFP and BFGS methods) Constrained optimization of functions of several variables, Lagrange Multiplier method, Karush-Kuhn-Tucker theory, Constraint Qualifications, Convex optimization, Interior point methods for inequality constrained optimization, Merit functions for constrained minimization, logarithmic barrier function for inequality constraints, A basic barrier-function algorithm, Perturbed optimality conditions. Quadratic optimization: Wolfe method, Beale's Method, applications of quadratic programs in some domains like portfolio optimization and support vector machines, etc. Practice of optimization algorithms using Software.
Learning Outcome	On successful completion of the course, students should be able to: 1. Understand the terminology and basic concepts of various kinds of convex optimization problems 3. Develop the understanding about different solution methods to solve convex Programing problem. 4. Apply and differentiate the need and importance of various algorithms to solve convex programing problems 5. Employ programming languages to solve convex programing problems 6. Model and solve several problems arising in science and engineering as a convex optimization problem
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. Edwin K. P. Chong and Stanislaw H. Zak: An Introduction to optimization, 4th Edition, John Wiley & Sons, New York, (2013).
2. S. Boyd and L. Vandenberghe: Convex Optimization, Cambridge University Press, New York, (2004).

Reference Books:

1. O.L. Mangsarian: Nonlinear Programming, SIAM, (1994).
2. D. G. Luenberger, Linear and Nonlinear Programming, 2nd Edition, Kluwer, (2003).
3. M.S. Bazaraa, H.D. Sherali and C.M. Shetty: Nonlinear Programming: Theory and Algorithms, John Wiley and Sons, New Jersey, (2006).
4. Singiresu. S. Rao: Engineering Optimization: Theory and Practice, John Wiley & Sons, (2009).
5. J. Nocedal and S. J. Wright, Numerical Optimization, Springer Verlag, (1999).
6. D.P. Bertsekas, Dynamic programming and Optimal Control, Athena Scientific, Belmont, 4th Edition, (2012).

Course Number	MA3205 (Core)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Functional Analysis
Learning Mode	Lectures
Learning Objectives	The objective of the course is to train student about the advanced concepts of metric space, normed linear spaces, Banach Space, inner product spaces, Hilbert Spaces, orthogonal sets and Lp spaces.
Course Description	This is an advanced course for undergraduate student and is intended to discuss about important Mathematical properties of functional analysis.
Course Content	Metric spaces, Open sets, Closed sets, Continuous functions, Completeness, Cantor intersection theorem, Baire category theorem, totally boundedness, Finite intersection property. Normed spaces, Banach spaces, Properties of Banach spaces, Lp-spaces, Holder's inequality, Minkowski's inequality. Linear operators, Bounded linear operators, fixed point theorems, functionals on Banach spaces, Dual space. Inner product space, Hilbert spaces, Properties of inner product spaces, Orthogonal complements and direct sums, Orthonormal sets and sequences, Total orthonormal sets.
Learning Outcome	On successful completion of the course, students should be able to: 1. Validate the properties of a metric space. 2. Find the norm of a bounded linear operator. 3. Construct orthogonal basis for Hilbert space.
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. Erwin Kreyszig, Introductory Functional Analysis With Applications, John Wiley & Sons 1978.
2. W. Rudin, Principles of Mathematical Analysis, McGraw-Hill, 1976.

Reference Books:

1. Stein and Shakarchi, Functional Analysis: Introduction to Further Topics in Analysis: 04 (Princeton Lectures in Analysis), Overseas (1 January 2011).
2. M. T. Nair, Functional Analysis: A First Course, PHI Pvt. Ltd, 2004.
3. B. V. Limaye, Functional Analysis, 2nd ed., New Age International, New Delhi, 1996.
4. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Inc. 1983.

Course Number	MA3206 (Core)
Course Credit (L-T-P-C)	3 – 0 – 2 – 4
Course Title	Artificial Intelligence
Learning Mode	Lectures and Labs
Learning Objectives	This course aims to impart a deep understanding of theoretical AI concepts while equipping students for research and industry applications in artificial intelligence.
Course Description	This course offers a comprehensive overview of artificial intelligence, covering its foundation, history, and modern advancements, with a focus on uncertainty theory, learning algorithms, decision trees, neural networks, reinforcement learning, and practical machine learning applications for images and language.
Course Content	Introduction to Artificial Intelligence: Foundation, History, State-of-the-Art, Definition of AI: Thinking Vs Active and Humanly Vs Rationally, Example Tasks, Phases of AI; Uncertainty Theory and Learning: Acting under Uncertainty, Uncertain Knowledge, Bayesian Networks, Hidden Markov Models, Bayesian Learning, Bayesian Parameter Learning, Hidden Variables, The EM Algorithm for Unsupervised Learning; Learning Theory for Decision Tree: Types of Learning, Classification using Learning, Decision Tree for Discrete Input/Output Variable, Entropy, Information Gain, Overfitting, Decision Tree Pruning, Significance Test for Pruning, Extending Decision Tree for Continuous Input/Output Variable, Generalizability in Evaluation of the Learning Models, Cross-validation, Regularization, Scaling. Computational Learning Theory: PAC, Regression Using Linear Model, Artificial Neural Network: Structure, Perceptron, Non-Linearity, Multi-layer Architecture, Forward Propagation, Backward Propagation; Reinforcement Learning: Active Learning, Passive Learning, Adaptive Dynamic Programming, Generalization, Application of Reinforcement Learning to Game Playing; Study of Practical Machine Learning for Images and Languages.
Learning Outcome	Students will gain a solid understanding of AI principles and techniques, enabling them to apply theoretical knowledge to real-world problems in research and industry settings.
Assessment Method	Quiz /Assignment/ MSE / ESE

Text Books:

1. Russell, Stuart, and Peter Norvig. "Artificial intelligence: a modern approach.", Prentice Hall Pearson.
2. E. Rich, K Knight, SB Nair. “Artificial intelligence” third edition, Tata McGraw-Hill.
3. Dick, Stephanie. "Artificial intelligence" MIT Press.

Reference books:

1. Nilsson, Nils J. “Principles of artificial intelligence.” Springer Science & Business Media2.
2. Witten Ian H., Eibe Frank, Mark A. Hall, and Christopher J. Pal. “Data Mining: Practical machine learning tools and techniques”. Morgan Kaufmann.
3. Cohen, Paul R., and Edward A. Feigenbaum, eds. The Handbook of Artificial Intelligence: Volume 3. Vol. 3. Butterworth-Heinemann.
4. Trevor Hastie, R. Tibshirani, J . Friedman. “The Elements of Statistical Learning” Second Edition, Springer.

Sl. No.	Subject Code	SEMESTER VII	L	T	P	C
1.	HS41XX	HSS Elective - II	3	0	0	3
2.	XX41PQ	IDE - III	3	0	0	3
3.	MA41XX	Departmental Elective – I	3	0	0	3
4.	MA41XX	Departmental Elective – II	3	0	0	3
5.	MA4198	Summer Internship*	0	0	12	3
6.	MA4199	Project – I	0	0	12	6
TOTAL						**21**

Sl. No.	Course Code	Department Elective I	L	T	P	C
1.	MA4101	Advanced Algorithms	3	0	0	3
2.	MA4102	Cryptography and Network Security	3	0	0	3
3.	MA4103	Rings and Modules	3	0	0	3

Course Number	MA4101 (DE)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Advanced Algorithms
Learning Mode	Lectures
Learning Objectives	To learn few advanced algorithms and also to learn how to deal with the computational problems which are NP-Complete
Course Description	This course introduces some advanced algorithms along with algorithm designing techniques in randomized and approximation algorithms.
Course Outline	Graph algorithms: Maximum bipartite matching, Maximum weighted bipartite matching, Matching in general graphs. Fast Fourier transformation and its applications. String Matching: Rabin-Karp algorithm, Knuth-Morris-Pratt algorithm. Randomized algorithm: Randomized Min-Cut algorithm, Coupon collector's problem, Median finding, Randomized quick sort, Markov-Chebyshev, Chernoff bound, Load balancing, Hashing revisited, Probabilistic methods: Basic counting, Expectation arguments, Sample and Modify, Application of Lovasz Local Lemma Introduction to approximation algorithms.
Learning Outcome	Students will learn few advanced algorithms and also learn how to design randomized algorithms, approximation algorithms for different computational problems.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. Algorithm Design By Jon Kleinberg, Éva Tardos, Pearson Education
2. The Design of Approximation Algorithms By David P. Williamson, David B. Shmoys, Cambridge University Press
3. Probability and Computing: Randomization and Probabilistic Techniques in Algorithms and Data Analysis By Michael Mitzenmacher, Eli Upfal , Cambridge University Press

Reference Books:

1. Design and Analysis of Algorithms: A Contemporary Perspective By Sandeep Sen and Amit Kumar, Cambridge University Press
2. Algorithms By Sanjoy Dasgupta, Christos H. Papadimitriou, Umesh Virkumar Vazirani, McGraw-Hill Higher Education, Pearson Education

Course Number	MA4102 (DE)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Cryptography and Network Security
Learning Mode	Lectures
Learning Objectives	The objective of the course is to present an introduction to Cryptography, with an emphasis on how to protect information security from unauthorized users and is to understand the basics of Network vulnerability and Security Protection.
Course Description	The aim of this course is to introduce the student to the areas of cryptography and cryptanalysis. This course develops a basic understanding of the algorithms used to protect users online and to understand some of the design choices behind these algorithms.
Course Outline	Security goals and attacks, Cryptography and cryptanalysis basics, Mathematics behind cryptography, Traditional and modern symmetric-key ciphers, DES, AES, Asymmetric-key ciphers, One-way function, Trapdoor one-way function, RSA cryptosystem, Elgamal Cryptosystem, Diffie-Hellman key exchange algorithm, Cryptographic hash function, Message authentication, Digital signature, RSA digital signature, IPSec, SSL/TLS, PGP and Email security
Learning Outcome	Students will be familiar with the significance of information security in the digital era. Also, they can identify various threats and vulnerabilities in networking.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. Cryptography and Network Security by Behrouz A. Forouzan and Debdeep Mukhopadhyay, Second edition, Tata McGraw Hill, 2011.
2. Cryptography and Network Security Principles and practice by W. Stallings, 5/e, Pearson Education Asia, 2012.

Reference Books:

1. Cryptography: Theory and Practice by Stinson. D., third edition, Chapman &Hall/CRC, 2010.
2. Elementary Number Theory with applications by Thomas Koshy, Elsevier India, 2005.
3. Research papers

Course Number	MA4103 (DE)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Rings and Modules
Learning Mode	Lectures/ Tutorials
Learning Objectives	Readers of this course will be well-equipped with basic concepts of Rings & Modules which are prerequisites to the courses on Fields and Galois Theory, Coding Theory, Cryptography, Homological Algebra, Noncommutative Algebra, Algebraic Geometry, and advanced courses on Analysis.
Course Description	It gives a foundation for further studies in algebra by discussing several classes of rings and modules. This course includes structure theorems for modules over PID, Artinian, and Noetherian rings and modules, and their radicals.
Course Outline	Rings, Ring of Endomorphisms, Ideal, Prime Ideals, Maximal Ideal, Principal Ideal Domain, Nilpotent Ideal, Nil Ideal, UFD, Field of Fractions. Modules, submodules, quotient modules and module homomorphisms, Generation of modules, direct sums and free modules, simple modules Finitely generated modules over principal ideal domains. Ascending Chain Condition and Descending Chain Condition, Artinian and Noetherian rings and modules, Hilbert basis theorem, Primary decomposition of ideals in Noetherian rings. Radicals: Nil radical, Jacobson radical and prime radical, the relation of radicals in the case of Artinian and Noetherian rings.
Learning Outcome	On successful completion of the course, students should be able to: 1. Understand, apply and analyze the notion of rings, ideals, and modules in related concepts required for advanced courses and research in Algebra. 2. Familiar with the key properties and examples of Artinian and Noetherian rings and modules and their generalization; 3. Decide whether a given ring or module, or a class of rings or modules, is Noetherian/Artinian, by applying the characterizations discussed in the course; 4. Able to use this concept for research in Information Circuits (Coding Theory, Cryptography, Image Processing, etc.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. C. Musili, Introduction to Rings and Modules, Narosa Pub. House, New Delhi, Sec. Edition, 2001.
2. J. A. Beachy, Introduction to Rings and Modules, London Math. Soc., Cam. Univ. Press, 2004.

Reference Books:

1. M. F. Atiyah and I. G. Macdonald, Introduction to Commutative Algebra, Addison Wesley, 1969.
2. K. R. Goodearl and Jr. R. B. Warfield, An Introduction to Noncommutative Noetherian Rings. 2nd ed. Cambridge University Press; 2004.
3. D. S. Dummit and R. M. Foote, Abstract Algebra, 2nd Ed., John Wiley, 2002.
4. N. Jacobson, Basic Algebra I and II, 2nd Ed., W. H. Freeman, 1985 and 1989.
5. S. Lang, Algebra, 3rd Ed., Springer (India), 2004.

Sl. No.	Course Code	Department Elective II	L	T	P	C
1.	MA4104	Deep Learning	2	0	2	3
2.	MA4105	Fields and Galois theory	3	0	0	3
3.	MA4106	Mathematical Finance	3	0	0	3

Course Number	MA4104 (DE)
Course Credit (L-T-P-C)	2 – 0 – 2 – 3
Course Title	Deep Learning
Learning Mode	Lectures and Labs
Learning Objectives	Gain expertise in artificial neural networks, covering fundamentals, feedforward and deep neural networks, convolutional networks, recurrent neural networks, and popular deep learning architectures, to proficiently tackle pattern recognition tasks and real-world challenges.
Course Description	Explore the foundations and applications of deep learning, covering artificial neural networks, convolutional networks, recurrent neural networks, and popular architectures like VAE, and GANs for solving real-world tasks.
Course Outline	Basics of artificial neural networks (ANN); Feedforward neural networks: Pattern classification using perceprton, Multilayer feedforward neural networks, Backpropagation learning, Normalization; Deep neural networks (DNNs): Difficulty of training DNNs, Optimization for training DNNs, Optimization methods for neural networks (AdaGrad, RMSProp, Adam etc.), Regularization methods. Convolutional Networks (CNNs): Introduction to CNNs – convolution, pooling, Deep CNNs, Deep CNN architectures (AlexNet, VGG, GoogLeNet, ResNet), Other Recent CNN architectures. Recurrent neural networks (RNNs), Long Short Term Memory (LSTM), Other Recent Sequential Networks; Some popular Architectures/concepts in Deep Learning: Object Detection and Localization, Siamese Networks, Autoencoders & VAE, Generative Adversarial Networks (GANs), Other Recent Topics.
Learning Outcome	Students will acquire a thorough grasp of both foundational and advanced concepts in deep learning, along with practical proficiency in utilizing these methods to address real-world challenges.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. Deep learning, Ian Goodfellow, Yoshua Bengio and Aaron Courville, MIT Press, 2016.

Reference Books:

1. S. Haykin, Neural Networks and Learning Machines , Prentice Hall of India, 2010
2. Satish Kumar, Neural Networks - A Class Room Approach, Second Edition, Tata McGraw-Hill, 2013
3. C.M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006

Course Number	MA4105 (DE)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Fields and Galois Theory
Learning Mode	Lectures
Learning Objectives	To get exposed to the classical journey of solving polynomial equations, the theoretical ways to look at it, particularly when numerical methods have its limitations.
Course Description	This course will cover the basics of field theory and its extensions from the perspective of the existence of solutions of polynomial equations.
Course Content	Review of Rings, Ring homomorphisms, Ideals, prime and maximal ideals Fields, basic theory of field extensions: field automorphisms, Algebraic extension, splitting fields, algebraic closure, separable and inseparable extensions, finite fields, cyclotomic polynomials, normal extensions. Galois extension, Galois group of a field extension, The fundamental theorem of Galois theory, Galois closure, theory of symmetric polynomials, the fundamental theorem of Algebra, solvable extensions, radical extensions, solution of polynomial equations by radicals, insolvability of the quintic, transcendence of e and pi
Learning Outcome	The students will know algebraically closed field, splitting fields, Fundamental theorems of Algebra and of Galois theory. Students will understand why it is not possible to have a formula for solving a polynomial equation of degree five.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. D. S. Dummit and R. M. Foote, Abstract Algebra, John Wiley & sons, Inc., 2nd Edition, 1999.
2. I. Stewart: Galois Theory, Academic Press, edition 1989.

Reference Books:

1. Emil Artin: Galois Theory, University of Notre Dame Press, 1971.
2. S. Lang: Algebra, III Edition, Springer, 2004.

Course Number	MA4106 (DE)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Mathematical Finance
Learning Mode	Lectures
Learning Objectives	The main objective of the course is to introduce the students to the broader area of mathematical finance from a theoretical and computational perspective.
Course Description	Mathematical Finance, as an interdisciplinary subject, focuses on relations between fundamentals of Mathematics and concepts of financial markets along with the other economic activities.
Course Outline	Financial markets and instruments, risk-free and risky assets; Interest rates, present and future values of cash flows, term structure of interest rates, spot rate, forward rate; Bonds, bond pricing, yields, duration, term structure of interest rates; Asset pricing models, no-arbitrage principle; Cox-Ross-Rubinstein binomial model, geometric Brownian motion model; Financial derivatives, Forward and futures contracts and their pricing, hedging strategies using futures, interest rate and index futures; Swaps and its valuation, interest rate swaps, currency swaps; Options, general properties of options, trading strategies involving options; Discrete time pricing of European and American derivative securities by replication; Continuous time pricing of European and American derivate securities by risk-neutral valuation.
Learning Outcome	On successful completion of the course, students should be able to: 1. Understand the fundamentals of quantitative finance. 2. Grasp the concept of time value of money and interest rates. 3. Comprehend ideas of pricing through the application of basic mathematical concepts.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. M. Capinski and T. Zastawniak, Mathematics for Finance: An Introduction to Financial Engineering, 2nd Edition, Springer, 2010.
2. D. Higham, Introduction to Financial Option Valuation: Mathematics, Stochastic and Computation, Cambridge University Press, 2004.

Reference Books:

1. J.C. Hull, Options, Futures and Other Derivatives, 10th Edition, Pearson, 2018.

J. Cvitanic and F. Zapatero, Introduction to the Economics and Mathematics of Financial Markets, Prentice-Hall of India, 2007.

Sl. No.	Subject Code	SEMESTER VII	L	T	P	C
1.	HS41XX	HSS Elective - II	3	0	0	3
2.	XX41PQ	IDE - III	3	0	0	3
3.	MA41XX	Departmental Elective – I	3	0	0	3
4.	MA41XX	Departmental Elective – II	3	0	0	3
5.	MA4198	Summer Internship*	0	0	12	3
6.	MA4199	Project – I	0	0	12	6
TOTAL						**21**

Sl. No.	Course Code	Department Elective III	L	T	P	C
1.	MA4201	Topology	3	0	0	3
2.	MA4206	Control Theory	3	0	0	3
3.	MA4207	Finite Element Analysis	3	0	0	3
4.	MA4208	Introduction to Coding Theory	3	0	0	3
5.	MA4209	Portfolio Theory and Risk Management	3	0	0	3

Course Number	MA4201 (DE)
Course Credit (L-T-P-C)	3 – 0 – 0 – 3
Course Title	Topology
Learning Mode	Lectures and Tutorials
Learning Objectives	The main objectives of this course is to lay a foundation for general topology. Students will learn how to generalize concepts from the realm of real numbers to arbitrary sets with some structure. The course will help students for future study in geometry or analysis.
Course Description	This course serves to lay the foundations for general topology. It begins with defining topological spaces, its basis, subspace topology, order topology, product and box topology. The core of the subject includes limit points, properties of functions on topological spaces, metric spaces, connectedness, compactness, countability and separation axioms.
Course Content	Definition and examples of topological spaces (including metric spaces), Open and closed sets, Subspaces and relative topology, Closure and interior, Accumulation points, Dense sets, Neighborhoods, Boundary, Bases and sub-bases. Construction of Topological spaces from known spaces. Product spaces, Cone and Suspension construction. Identification spaces. Neighborhood systems. Nets and Filters. Continuous functions and homeomorphism, Quotient topology, First and second countability and separability, Lindelöf spaces. The separation axioms T0, T1, T2, T3,T3_1/2 , and T4; their characterizations and basic properties. Urysohn's lemma, Urysohn's metrization theorem, Tietze's extension theorem. Compactness. Basic properties of compactness. Compactness and the finite intersection property, Local compactness, One-point compactification. Connected spaces and their basic properties. Connectedness of the real line. Components, Locally connected spaces. Tychonoff 's theorem
Learning Outcome	(1) Students will learn the concepts of general topology. (2) Students will appreciate the art of abstraction by relating the course with real analysis. (3) They will learn to extend the notions of open and closed sets, limit points, closure, connected and compact sets from the set of real numbers to general topological spaces. (4) They will learn the separation and countability axioms which will help them differentiate between the structural properties of spaces. (5) This course will enhance the research appetite of students through some deep ideas through Tychonoff theorem and the Titze extension theorem.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. M. A. Armstrong, Basic Topology, Springer, 2014.
2. J. R. Munkres, Topology, 2nd Edition, Pearson International, 2000.
3. K. D. Joshi, Introduction to General Topology, New Age International, 2000.

Reference Books:

1. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 1963.

J. L. Kelley, General Topology, Van Nostrand, 1995.

Course Number	MA4206 (DE)
Course Credit	3-0-0-3
Course Title	Control Theory
Learning Mode	Lectures
Learning Objectives	The objective of the course is to train student about the fundamental principles of control theory to analyze and design control systems.
Course Description	Control theory is a basic course for undergraduate student and is intended to discuss about important mathematical properties of control systems and enables students to solve some optimal control problems.
Course Outline	Mathematical models of control systems, State space representation, Autonomous and non-autonomous systems, State transition matrix, Solution of linear dynamical system. Transfer function, Realization, Controllability, Kalman theorem, Controllability Grammian, Control computation using Grammian matrix, Observability, Duality theorems, Discrete control systems, Controllability and Observability results for discrete systems. Companion form, Feedback control, State observer, Liapunov stability, Stability analysis for linear systems, Liapunov theorems for stability and instability for nonlinear systems, Stability analysis through Linearization, Routh criterion, Nyquist criterion, Stabilizability and detachability. State feedback of multivariable system, Riccatti equation, Introduction to Calculus of variation, Euler- Hamiltonian equations, Computation of optimal control for linear systems.
Learning Outcome	By the end of the course, students will be able to describe the fundamental components of control systems, including controllability, observability and stability. They should be able to explain how these components interact to achieve desired system behavior.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. S. Barnett, Introduction to Mathematical Control Theory, Clarendon press Oxford 1975
2. R. V. Dukkipati, Control Systems, Narosa 2005
3. I. J. Nagrath and M. Gopal, Control System Engineering, New Age international 2001.
4. B. Datta, Numerical Methods for Linear Control Systems, Academic press Elsevier, 2004.

Course Number	MA4207 (DE)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Finite Element Analysis
Learning Mode	Lectures
Learning Objectives	In this course, the students will be trained with the knowledge of finite element methods and its mathematical analysis for solving ODE/PDEs.
Course Description	This course will be providing computational algorithms for solving non dimensionalized mathematical models and their mathematical analysis.
Course Outline	Polynomial approximations and interpolation errors. Piecewise linear basis functions, Poincare inequality. Construction of finite element spaces. Distributions. Triangular finite elements. Computation of finite element solutions and their convergence analysis. Variational formulation for elliptic boundary value problems in one and two dimensions. Galerkin orthogonality. Parabolic initial and boundary value problems: Semi-discrete and fully discrete (forward and backward Euler in time) schemes, Convergence analysis. Stiffness matrix and computational algorithms.
Learning Outcome	On successful completion of the course, students should be able to: 1. know the methodology of finite element approach 2. write algorithms for solving one and two dimensional ODE/PDEs by using finite element approach 3. understand on how to solve engineering problems by using finite element
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. E. Suli and D. F. Mayers, An Introduction to Numerical Analysis, Cambridge Univ. Press, 2003.
2. S. C. Brenner and R. Scott, The Mathematical Theory of Finite Element Methods, Springer, 2008.
3. E. Suli, Lecture Notes on Finite Element Methods for Partial Differential Equations, University of Oxford, 2020.

Reference Books:

1. C. Johnson, Numerical solutions of Partial Differential Equations by Finite Element Methods, Cambridge Univ. Press, 2009.
2. Philippe G. Ciarlet, The Finite Element Method for Elliptic Problems, SIAM, 2002

Course Number	MA4208 (DE)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Introduction to Coding Theory
Learning Mode	Lectures/ Tutorials
Learning Objectives	Readers of this course will be well-equipped with the application of the basics of mathematics, specially, Algebra, Number Theory and Probability Theory in Information Theory.
Course Description	It gives a foundation for further studies in information communications. This course includes different codes such as binary codes, Hamming codes, linear codes (cyclic codes in detail), and nonlinear codes, with different bounds by using mathematical tools, which are essential to understand an information communication system.
Course Content	Polynomial rings over fields, Extension of fields, Computation in GF(q), n-th roots of unity, Vector space over finite fields. Error Detection, correction and decoding. Linear block codes: Hamming weight, Generator and Parity-check matrix Encoding and Decoding of linear codes, Bounds: Sphere-covering bound, Gilbert-Varshamov bound, Hamming bound, Singleton bound. Hamming codes, Simplex codes, Golay codes, First and Second order Reed-Muller codes. Nonlinear codes: Hadamard codes, Preparata codes, Kerdock codes, Nordstorm-Robinson code, Weight distribution of codes. The structure of cyclic codes, roots of cyclic codes, Decoding of cyclic codes, Burst-error-correcting codes, Quadratic residue codes, BCH codes, Reed-Solomon (RS) codes, GRS codes, Convolutional codes, LDPC codes, Turbo codes.
Learning Outcome	On successful completion of the course, students should be able to: 1. Understand the primary information communication circuits; 2. Able to understand the importance of better codes in communication channels; 3. Help to develop some MDS, and better new codes using the concept of number theory and algebra; 4. Capable of analyzing the capacity of a code based on studied bounds and results.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. Raymond Hill, A First Course in Coding Theory (Oxford Applied Mathematics and Computing Science Series), Clarendon Press, 1986.
2. Ron Roth, Introduction to Coding Theory, Cambridge University Press, 2006.

Reference Books:

1. J. H. van Lint, Introduction to Coding Theory, Springer, 1999.
2. San Ling and Chaoping Xing, Coding Theory: A First Course. Cambridge University Press, 2004.

Course Number	MA4209 (DE)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Portfolio Theory and Risk Management
Learning Mode	Lectures
Learning Objectives	The goal of this course are two-folds, namely design of portfolios and the identification as well as risk management of such portfolios.
Course Description	Portfolio theory involves the usage of techniques of probability theory and statistics in the design and analysis of a financial portfolios (such as mutual funds). On the other hand, risk management involves tools from Mathematics and Statistics in the identification of financial risks to portfolios.
Course Outline	Return and risk of a portfolio, mean-variance portfolio theory, efficient frontier, Capital Asset Pricing Model, Arbitrage Pricing Theory; Utility theory, risk attitude of investors; Non-mean-variance portfolio theory, safety first models, semi-deviation, stochastic dominance; Bond portfolios, duration and convexity of a bond. Fundamentals of financial risk management, credit risk, market risk, operational risk, Basel and Solvency regulations; Market risk, Value-at-Risk (VaR), computation of VaR, coherent measures of risk.
Learning Outcome	On successful completion of the course, students should be able to: 1. Understand the fundamentals of portfolio theory from asset picking to asset allocation and performance analysis of the portfolio. 2. Identification and quantification of risk of financial portfolios using mathematical and statistical tools. 3. Determination of robust techniques to mitigate the identified financial risks.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. S.P. Chakrabarty and A. Kanaujiya, Mathematical Portfolio Theory and Analysis, 1st Edition Birkshauser, 2023.
2. T. Roncalli, Handbook of Financial Risk Management, CRC Press, 2020

Reference Books:

1. J. C. Francis and D. Kim, Modern Portfolio Theory: Foundations, Analysis, and New Developments, 1st Edition, Wiley, 2013.

J. C. Hull, Risk Management and Financial Institutions, 4th Edition, Wiley, 2016.

Sl. No.	Course Code	Department Elective IV	L	T	P	C
1.	MA4210	Differential Geometry	3	0	0	3
2.	MA4211	Introduction to Mathematical Biology	3	0	0	3
3.	MA4212	Statistical Decision Theory	3	0	0	3
4.	MA4213	Applied Computational Techniques	3	0	0	3

Course Number	MA4210 (DE)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Differential Geometry
Learning Mode	Lectures
Learning Objectives	Same as Learning Outcome
Course Description	It is a basic course in classical differential geometry of curves and surfaces.
Course Content	Curve theory: Regular curves, arc-length parametrization, curvature, torsion, Frenet formula, isoperimetric inequality Surface theory: Regular surfaces, Curvatures: Gauss and Mean, Surfaces of revolution, Constant mean curvature surfaces: minimal surfaces, Weierstrass-Enneper representation, Geodesics: The geodesic equations, Isometries and conformal maps. The Gauss-Bonnet theorem.
Learning Outcome	At the end of this course, students will learn: - to compute curvature and torsion of curves - to compute Gauss and mean curvature of surfaces - to compute the complex representation formula for a minimal surface given in isothermal parametrization. - the relation between Euler characteristic of a surface and the Gaussian curvature of a surface through Gauss-Bonnet theorem.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. Oprea, John., Differential Geometry and its Applications, The Mathematical Association of America, second edition (2007)

Reference Books:

1. do Carmo, Manfred P., Differential Geometry of Curves and Surfaces, Prentice Hall (1976)
2. Bar, Christian, Elementary Differential Geometry, Cambridge University Press. (2010)
3. Millman, Richard S. and Parker, George D., Elements of Differential Geometry, Prentice Hall-Inc. (1977

Course Number	MA4211 (DE)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Introduction to Mathematical Biology
Learning Mode	Lectures
Learning Objectives	To learn application of Mathematics in Biology. To comprehend mathematical analysis and to correlate the outcome of mathematical system into biological system. To learn and understand the bridge between mathematical and biological worlds.
Course Description	This course is meant to expose the candidate to mathematical modeling biological systems and then apply it to various systems and analyse these models and obtain biological inferences from models.
Course Outline	Motivation. Introduction to biological systems and their mathematical representation. Basic mathematical tools such as Linearization, qualitative solution of difference and differential equations, stability, nonlinear dynamics. Mathematical modeling in ecology: Single species models (continuous and discrete), multispecies models: Prey-predator models, Competition models, cooperation models, harvesting in population, fisheries models, optimal harvest. Mathematical modeling of infectious diseases: Introduction to disease modeling, compartmental models, Basic models- SI, SIS, SIR, SIRS etc. Models with demography, Vaccination models, Ross Malaria Model. Mathematical models in cellular biology such as HIV in vivo dynamics, Models in immunology. Stochastic models. Parameter estimation.
Learning Outcome	Students will be able to apply the mathematical knowledge on a biological system, analyse it and interpret it in terms of the biological systems.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. M. Kot, Elements of Mathematical Ecology, Cambridge University Press, 2012.
2. M.Y. Li, An introduction to mathematical modeling of infectious diseases, Springer, 2018.

Reference Books:

1. 1. J.D. Murray, Mathematical Biology Vol I & II, Springer, 2001

Course Number	MA4212 (DE)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Statistical Decision Theory
Learning Mode	Lectures
Learning Objectives	This course provides an in-depth content for understanding useful fundamentals concepts of statistical decision theory. Several inference problems under this framework will be discussed.
Course Description	Most of inference problems are described under faily general setup of statistical decision theory. Efficient estimation procedures will be discussed under different parametric restrictions.
Course Outline	Decision theoretic estimation problems, Classical risk functions, Bayes risk, Bayes and minimax estimators, Admissible Bayes estimators, essentially complete class rules, minimal complete class, illustrations, Ancillarity, UMVUE, truncated parameter space estimation problems, equivariance of decision rules, location-scale groups of transformations, minimum risk equivariant estimators, highest posterior density intervals.
Learning Outcome	Students will learn basic concepts of statistical decision problems with a focus on deriving efficient estimators for various parametric functions.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. A. M. Mood, F. A. Graybill, D. C. Boes. Introduction to the Theory of Statistics, Tata McGraw-Hill, Third Edition, 2017.

Reference Books:

1. E. L. Lehmann, Theory of Point Estimation, Springer, Second Edition, 1998.
2. G. Casella and R.L. Berger. Statistical Inference, Duxbury Advanced Series, 2007.

Course Number	MA4213 (DE)
Course Credit (L-T-P-C)	3 – 0 – 0 – 3
Course Title	Applied Computational Techniques
Learning Mode	Lectures
Learning Objectives	In this subject, the students will be informed about numerical analysis and computational schemes for solving ordinary and partial differential equations.
Course Description	This course involves basic parts of computing approaches involving numerical analysis and how to solve differential equations
Course Outline	Introduction to floating point arithmetic, Machine precision, Approximation errors, Truncation and roundoff errors, Condition number of function Generation of finite differences schemes by interpolating data, Finite-difference schemes for various derivatives, Smoothness, Rate of accuracy Introduction of system of linear IVP's and BVP's, Euler's Explicit and Implicit Method, Runge-Kutta Methods, Linear Multistep Methods, Nonlinear Two-Point BVPs and its discretization. PDEs, Initial and Boundary Conditions, Finite difference method for elliptic PDE. Approximations of parabolic and hyperbolic PDEs by FTCS and BTCS, Crank-Nicolson schemes, ADI methods, Lax Friedrich method, Upwind scheme; CFL conditions. Consistency, Stability analysis by matrix method and/or von Neumann analysis, Convergence by Lax's equivalence theorem.
Learning Outcome	Through this course, students will learn the basic ideas of computations and their convergence analysis. They will also learn solving differential equations numerically.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. M. Heath, Scientific Computing, McGraw-Hill Education; 2nd edition, 2001.
2. W. Morton and D. F. Mayers, Numerical Solution of Partial Differential Equations, Cambridge University Press, 2nd Edn., 2005.
3. J. Li, Y. Chen, Computational Partial Differential Equations Using MATLAB, 2020

Reference Books:

1. J. C. Strikwerda, Finite Difference Schemes and Partial Differential Equations, SIAM, 2004

M. K. Jain, S. R. K. Iyengar, R. K. Jain, Numerical Methods For Scientific And Engineering Computation, New Age International, 2019

Sl. No.	Course Code	Department Elective V	L	T	P	C
1.	MA4214	Deep Learning for Computer Vision	2	0	2	3
2.	~~MA4212~~ MA4215	Discrete Differential Geometry	3	0	0	3
3.	MA4216	Integral Equations and Calculus of Variations	3	0	0	3

Course Number	MA4214 (DE)
Course Credit (L-T-P-C)	2 – 0 – 2 – 3
Course Title	Deep Learning for Computer Vision
Learning Mode	Lectures and Labs
Learning Objectives	This is an advanced course on Computer Vision. This will enable the students to learn concepts of image processing, computer vision and utilize these techniques to implement vision algorithms efficiently for use in research or industry.
Course Description	This course provides a comprehensive exploration of computer vision fundamentals, covering image formation, deep learning techniques, and advanced topics such as object detection, segmentation, and 3D computer vision.
Course Outline	Introduction and Overview: Course Overview and Motivation; Introduction to Image Formation, Capture and Representation; Linear Filtering, Correlation, Convolution; Visual Features and Representations: Edge, Blobs, Corner Detection; SIFT, SURF; HoG, LBP; Review of Deep Learning (DL): Multi-layer Perceptrons, Backpropagation, CNN, RNN, Transfomer, AE, VAE, GANs, Diffusion Models etc. Deep Learning for Computer Vision; Image Classification and Action/Activity Recognition; Object Detection; Segmentation: FCN, SegNet, U-Net, Other Recent Models; Visualizing CNN features, DeepDream, Style Transfer. DL for Pose Estimation, Optical Flow, Object Tracking, Depth Estimation, Image Matching, Image Editing, Image Inpainting, and Image Super-resolution; 3D computer vision: 3D scene understanding and segmentation, 3D shape synthesis; Other Recent Topics.
Learning Outcome	At the end of the course, the students will be able to: 1. Implement fundamental image processing techniques required for computer vision 2. Understand Image formation process 3. Develop computer vision applications
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. David A. Forsyth and Jean Ponce, Computer Vision: A Modern Approach, 2nd edition, Pearson, 2012.
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, 2016
3. Michael Nielsen, Neural Networks and Deep Learning, 2016

Reference Books:

1. Yoshua Bengio, Learning Deep Architectures for AI, 2009
2. Richard Szeliski, Computer Vision: Algorithms and Applications, 2010.
3. Simon Prince, Computer Vision: Models, Learning, and Inference, 2012.

Course Number	MA4215 (DE)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Discrete Differential Geometry
Learning Mode	Lectures
Learning Objectives	Same as Learning Outcome
Course Description	The aim of this course is to discretize. The classical differential geometric object. This course also finds its application in design, graphics and architectural engineering.
Course Content	Brief introduction to Differential geometry of curves and surfaces (smooth). Exterior calculus: Vectors and 1-forms, differential forms and the wedge product, differential operators and Stoke's theorem. Curvature of discrete surfaces: Vector area, Area gradient, Volume gradient, Gauss-Bonnet theorem. The Laplacian: Discretization via finite element method and via discrete exterior calculus.
Learning Outcome	At the end of this course, students should be able to: -discretize classical geometric objects such as curves, surfaces. -discretize the Laplacian operator
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. Discrete Differential Geometry: An applied introduction, Notes by Keenan Crane, available at https://www.cs.cmu.edu/~kmcrane/Projects/DDG/paper.pdf (2023)

Reference Books:

1. Bobenko, Alexander I., Schroder, P., Sullivan, John M., and Ziegler, Gu¨nter M. (2008), Discrete differential geometry. Birkhauser Verlag AG.
2. Discrete Integrable Geometry and Physics, Oxford lecture series in mathematics and its applications 16, edited by A. I. Bobenko and R. Seiler, Clarendon Press (1999).
3. Bobenko, Alexander I. and Yuri B. Suris (2008), "Discrete Differential Geometry (integrable structure)", American Mathematical Society

Course Number	MA4216 (DE)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Integral Equations and Calculus of Variations
Learning Mode	Lectures
Learning Objectives	In this subject, the students will learn the mathematical methods for solving integral equations and integro differential equations and their convergence analysis.
Course Description	This course is on the existing approaches for solving integral equations and integro differential equations with their convergence analysis.
Course Content	Introduction of Integral Equation, Correlation between integral and differential Equations, Classification of integral equations - Volterra and Fredholm equations, Green's function. Iterative methods for solving equations of the second kind, Neumann series and Fredholm theory, Singular integral equations. Calculus of Variation: Variational problem with functionals containing first order derivatives and Euler equations. Variational problem with moving boundaries. Boundaries with constraints. Higher order necessary conditions, Existence of solutions of variational problem
Learning Outcome	Main focus will be on how to solve integral equations and integro differential equations and their convergence analysis
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. A. S. Gupta, Calculus of variations with applications, PHI Learning Pvt Ltd, 2017.
2. B. N. Mandal, A Chakrabarti, Applied singular integral equations, CRC Press, 2011.
3. Lokenath Debnath and D. Bhatta, Integral Transform and their Applications, Taylor & Francis Group, 2002.

Reference Books:

1. Ram P Kanwal, Linear Integral Equations, Birkhauser Boston, 2013
2. Peter Linz, Analytical and numerical methods for Volterra equations, SIAM, 1985.

IDE - I (Available to students other than Dept. of M&C)

Sl. No.	Code	Course Name	L	T	P	C
1.	MA2206	Introduction to Numerical Methods	3	0	0	3
2.	MA2207	Complex Analysis	3	0	0	3

Course Number	MA2206 (IDE)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Introduction To Numerical Methods
Learning Mode	Lectures
Learning Objectives	To learn basics of computation, errors, and how to manage error during computation.
Course Description	Course starts with definition of number representation and errors. It focuses on solutions of nonlinear equations, system of nonlinear equations, quadrature, finite differences, their applications to solve ODEs and PDEs.
Course Content	Number Representation and Errors: Numerical Errors; Floating Point Representation; Finite Single and Double Precision Differences; Machine Epsilon; Significant Digits. Numerical Methods for Solving Nonlinear Equations: Method of Bisection, Secant Method, False Position, Newton-Raphson's Method, Multidimensional Newton's Method, Fixed Point Method and their convergence. Numerical Methods for Solving System of Linear Equations: Norms; Condition Numbers, Forward Gaussian Elimination and Backward Substitution; Gauss-Jordan Elimination; FGE with Partial Pivoting and Row Scaling; LU Decomposition; Iterative Methods: Jacobi, Gauss Siedal; Power method and QR method for Eigen Value and Eigen vector. Interpolation and Curve Fitting: Introduction to Interpolation; Calculus of Finite Differences; Finite Difference and Divided Difference Tables; Newton-Gregory Polynomial Form; Lagrange Polynomial Interpolation; Theoretical Errors in Interpolation; Spline Interpolation; Approximation by Least Square Method. Numerical Differentiation and Integration: Discrete Approximation of Derivatives: Forward, Backward and Central Finite Difference Forms, Numerical Integration, Simple Newton-Cotes Rules: Trapezoidal and Simpson's (1/3) Rules; Gaussian Quadrature Rules: Gauss-Legendre, Gauss-Laguerre, Gauss-Hermite, Gauss-Chebychev. Numerical Solution of ODE & PDE: Euler's Method for Numerical Solution of ODE; Modified Euler's Method; Runge-Kutta Method (RK2, RK4), Error estimate; Multistep Methods: Predictor-Corrector method, Adams-Moulton Method; Boundary Value Problems and Shooting Method; finite difference methods, numerical solutions of elliptic, parabolic, and hyperbolic partial differential equations. Exposure to software package MATLAB.
Learning Outcome	Students should be able to write Program in MATLAB and solve some real life problems based the techniques learned during the course.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. S. D. Conte and C. de Boor, Elementary Numerical Analysis - An Algorithmic Approach, McGraw-Hill, 2005.

Reference Books:

1. J. Stoer and R. Bulirsch, Introduction to Numerical Analysis, 2nd Edition, Texts in Applied Mathematics, Vol. 12, Springer Verlag, 2002.
2. J. D. Hoffman, Numerical Methods for Engineers and Scientists, McGraw-Hill, 2001.
3. K. E. Atkinson, Numerical Analysis, John Wiley, Low Price Edition (2004).

Course Number	MA2207 (IDE)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Complex Analysis
Learning Mode	Lectures
Learning Objectives	This course involves necessity of complex analysis over basic real analysis and its use to approximate indefinite integrals and for other purposes.
Course Description	This course mainly involves theory and applications of complex analysis with several mathematical examples.
Course Outline	Complex Analysis: Complex numbers, Geometric representation, Applications of complex numbers in geometry, Powers and roots of complex numbers. Functions of a complex variable: Limit, Continuity, Differentiability, Analytic functions, Cauchy-Riemann equations, Laplace equation, Harmonic functions, Harmonic conjugates. Elementary Analytic functions (polynomials, exponential function, trigonometric functions), Complex logarithm function, Branches and Branch cuts of multiple valued functions. Complex integration, Cauchy's integral theorem, Cauchy's integral formula. Liouville's Theorem and Maximum-Modulus theorem, Power series and convergence, Taylor series and Laurent series. Zeros, Singularities and its classifications, Residues, Rouches theorem (without proof), Argument principle (without proof), Residue theorem and its applications to evaluating real integrals and improper integrals. Conformal mappings, Mobius transformation, Schwarz-Christoffel transformation.
Learning Outcome	Upon the finishing of this course, students will be able to incline on higher mathematics and to obtain analytical understanding. It will also help them to move towards research.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. R. V. Churchill and J. W. Brown, Complex Variables and Applications, 5th Edition, McGraw-Hill, 2013.
2. S. Ponnusamy, Foundations of Complex Analysis. Narosa, 2011.

Reference Books:

1. J. H. Mathews and R. W. Howell, Complex Analysis for Mathematics and Engineering, 3rd Edition, Narosa, 2011.
2. A. R. Shastri, Basic Complex Analysis of One Variable, Laxmi, 2011

B. Simon, Basic Complex Analysis, A Comprehensive Course in Analysis. Part 2A, AMS

IDE - II (Available to students other than Dept. of M&C)

Sl. No.	Code	Course Name	L	T	P	C
1.	MA3106	An Introduction to Computational Commutative Algebra	3	0	0	3
2.	MA3107	Partial Differential Equations	3	0	0	3

Course Number	MA3106 (IDE)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	An Introduction to Computational Commutative Algebra
Learning Mode	Lectures
Learning Objectives	To expose students with the basic computational techniques in Commutative Algebra and its applications in engineering problems
Course Description	This course covers the classical theory of Grobner basis and some of its first applications.
Course Content	Ring, Ideals, Ring homorphisms, polynomial rings, Unique factorization, polynomials and affine space, affine varieties, parametrization of affine varieties, monomial ordering: Lexicographic order, graded lex order, graded rev lex order, inverse lexicographic order etc, division algorithm for polynomials in n variables, monomial ideals, Dickson's Lemma, Hilbert basis theorem, Grobner bases and its properties, Buchberger's algorithm, reduced Grobner basis, Applications of Grobner basis: Ideal description problem, Ideal membership problem, Solving polynomial equations, Implicitization problem, integer programming problem.
Learning Outcome	Students will learn the basic theory of Grobner basis, Hilbert basis theorem, a division algorithm for polynomials in n variables etc. students will be exposed to various applications of Grobner basis in engineering and math problems.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. David A Cox, John Little and Donal O'Shea, , Ideals, Varieties and Algorithms, An introduction to computational Algebraic Geometry and Commutative Algebra, Fourth Addition, Springer Undergraduate texts in Mathematics
2. Martin Kreuzer and Lorenzo Robbiano, Computational Commutative Algebra 1, first edition, Springer Berlin, Heidelberg

Reference Books:

1. David Eisenbud, Commutative Algebra with a view towards Algebraic Geometry, Springer-Verlag New York (1995).
2. David S. Dummit and Richard M. Foote, Abstract Algebra, third edition, Wiley Publication, 2011.

Course Number	MA3107 (IDE)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Partial Differential Equations
Learning Mode	Lectures
Learning Objectives	To understand the basic concepts of the Partial Differential Equations, how they arise and what are the main methods to solve them. In addition to build conceptual understanding of properties of the solutions.
Course Description	The course will introduce the students about Fourier Series and Fourier Transform and further introduce them to the first and second order partial differential equations and their solutions.
Course Outline	**Fourier series**: Fourier Integral, Fourier series of 2π periodic functions, Fourier series of odd and even functions, Half-range series, Convergence of Fourier series, Gibb's phenomenon, Differentiation and Integration of Fourier series, Complex form of Fourier series. **Fourier Transformation:** Fourier Integral Theorem, Fourier Transforms, Properties of Fourier Transform, Convolution and its physical interpretation, Statement of Fubini's theorem, Convolution theorems, Inversion theorem. **Partial Differential Equations:** Introduction and motivation, basic concepts, Linear and quasi-linear first order PDE, Lagrange's Method of solution and its geometrical interpretation, compatibility condition, Charpits method, special types of first order equations. Derivations of Heat and Wave equations in one-dimension and interpretation of different types of conditions. Second order PDE and classification of second order semi-linear PDE, Canonical form. Cauchy problems. D' Alemberts formula and Duhamel's principle for one dimensional wave equation, Fourier series method for IBV problem for wave and heat equation in 1-D, rectangular region. Uniqueness of solutions for IBVPs for heat and wave equations. Laplace and Poisson equations, Maximum principle with application, Fourier series method for Laplace equation in two and three dimensions. Fourier transform method to solve PDEs.
Learning Outcome	The students will be able to understand what are PDEs and how to find their solutions, when they exist. They will also understand tools to find these solutions for standard cases.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. K. Sankara Rao, Introduction to Partial Differential Equations, 2nd Edition, 2005.
2. I. N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1957.

Reference Books:

1. E. Kreyszig, Advanced Engineering Mathematics, 5th / 8th Edition, Wiley Eastern / John Wiley, 1983/1999

IDE - III (Available to students other than Dept. of M&C)

Sl. No.	Code	Course Name	L	T	P	C
1.	MA4112	Number Theory and Algebra	3	0	0	3
2.	MA4113	Theory of Relativity	3	0	0	3

Course Number	MA4112 (IDE)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Number Theory and Algebra
Learning Mode	Lectures
Learning Objectives	This course aims to help the students: (1) well-equipped with basic concepts of numbers, their properties, and some of the standard results that are fundamental to any branch of mathematics; (2) gain a comprehensive understanding of algebraic structures as groups and rings; (3) help to understand the advanced algebraic structures and their applications; (4) properties of these topics and some advanced concept have a lot of applications in Cryptography, Coding Theory, Networking etc
Course Description	It covers basic topics of number theory, groups and rings. Besides the many examples of groups, rings, this course includes applications of Sylow's theorems, Isomorphism theorems for groups and rings, Euclidean domain, UFD, quotient fields, and finite field extensions with several examples. On the other hand, this course also presents quadratic residue and Gauss quadratic reciprocity law and its applications.
Course Content	Number Theory: Divisibility, primes, fundamental theorem of arithmetic. Congruences, solution of congruences, Euler's Theorem, Fermat's Little Theorem, Wilson's Theorem, Chinese remainder theorem, primitive roots and power residues. Arithmetical functions ($\Phi(n)$, $\mu(n)$, $d(n)$, $\sigma(n)$). Quadratic residues, quadratic reciprocity. Diophantine equations. Semigroups, groups, subgroups, normal subgroups, homomorphisms, quotient groups, isomorphisms. Examples: group of integers modulo m, permutation groups, cyclic groups, dihedral groups, matrix groups. Sylow's theorems (without proof) and applications. Basic properties of rings, units, ideals, homomorphisms, Isomorphism theorems, quotient rings, prime and maximal ideals, fields of fractions, Euclidean domains, principal ideal domains and unique factorization domains, polynomial rings.
Learning Outcome	On successful completion of the course, students should be able to: 1. Understand the importance of integers and their properties; 2. Understand, apply, and analyze the notion of groups, rings, and ideals in related concepts required for advanced courses; 3. Familiar with the basic properties and examples of different notions of algebra and their generalization; 4. Help to understand the basic techniques of Cryptography (the techniques for protecting information from unauthorized access) & Coding Theory and Information Theory (the study of the transfer of information securely) and make able to develop some new techniques too.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. I. N. Herstein: Topics in Algebra, Wiley, 2006.
2. David M. Burton: Elementary Number Theory, 6th Edition, McGrow Hill Higher Education, 2007.

Reference Books:

1. D.S. Dummit and R.M. Foote: Abstract Algebra, Wiley, 1999.
2. I. Niven, H.S. Zuckerman, H.L. Montgomery: An introduction to the theory of numbers, Wiley, 2000
3. G.H. Hardy, E.M. Wright: An introduction to the theory of numbers, OUP, 2008.
4. T.M. Apostol: Introduction to Analytic Number Theory, Springer, UTM, 1998.

Course Number	MA4113 (IDE)
Course Credit (L-T-P-C)	3-0-0-3
Course Title	~~Mathematical Relativity~~ Theory of Relativity
Learning Mode	Lectures
Learning Objectives	The students would learn the singularity theorems of Hawking and Penrose, the positive mass theorem, and the theorems on black hole uniqueness and black hole thermodynamics.
Course Description	To introduce the students to some of the most important mathematical results of general relativity.
Course Content	Minkowski spacetime, Penrose diagrams, The Schwarzschild solution, Causality, Singularity theorems: Geodesic congruences, Hawking's Singukarity theorem, Penrose's singularity theorem, Cauchy Problem: Klein-Gordon equation, Maxwell's equation, Einstein's equations, Mass in General relativity: Komar mass, Field theory, Einstein-Hilbert action, Gravitational waves, Positive mass theorem, Penrose inequality, Black holes: The Kerr solution, Black hole thermodynamics and Hawking radiation.
Learning Outcome	The students would learn the singularity theorems of Hawking and Penrose, the positive mass theorem, and the theorems on black hole uniqueness and black hole thermodynamics.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Text Books:

1. Jose Natario, An introduction to Mathematical Relativity, Latin American Mathematics Series, Springer (2021)

Reference Books:

1. Robert M. Wald, General Relativity, The University of Chicago Press (1984)