Syllabus for 5-Year Integrated M.Sc. Programme in Mathematics

(Under Choice Based Credit System)

W.e.f.: Academic Session 2020 - 2021

Department of Mathematics

(Under School of Basic Sciences & Information Sciences)

Central University of Odisha
Koraput

Programme: 5-year Integrated M.Sc. in Mathematics

Duration: 5 years

Eligibility: Any candidate who has passed the 10+2 examination in Science from a recognized Board with Mathematics and Physics as subjects securing minimum 55% in aggregate and 55% in Mathematics. (5% relaxation will be given to SC/ST/PwD candidates). Those who have passed the graduation degree are not eligible for joining this programme.

Number of Seats: 26 (UR-10, EWS – 03, OBC (NCL) -07, SC-04, ST-02)

Maximum age limit: 25 years

Award: Students who successfully complete the programme are awarded the 5-Year Integrated M.Sc. degree in Mathematics. Also as per "Ordinance-52", Central University of Odisha, a student can opt for an exit after the successful completion of first six semesters and he/she shall be awarded a Bachelor of Science (Honours) degree in Mathematics.

Programme Objectives: The objectives of the 5–year Integrated M.Sc. programme in Mathematics are to develop students with the following capabilities:

- To provide with knowledge, abilities and insight in Mathematics and computational techniques so that they can work as mathematical professionals;
- To provide with advanced mathematical and computational skills that prepare them to pursue higher studies and conduct research;
- To train to deal with the problems faced by software industry through knowledge of mathematics and scientific computational techniques;
- To provide with knowledge and capability in formulating and analysis of mathematical models of real-life applications;
- To increase self - confidence in conducting research independently or within a group;
- To be able to cope up with an entirely new subject in mathematics without being taught earlier through a lifelong learning process.

Programme Outcomes: After successful completion of this program students will be able to:

- Demonstrate the ability to conduct research independently and pursue higher studies towards the Ph.D. degree in Mathematics;
- Carry out development work as well as take up challenges in the emerging areas of Industry;
- Demonstrate competence in using mathematical and computational skills to model, formulate and solve real life problems;
- Acquire deep knowledge of different mathematical and computational disciplines so that they can successfully compete at National/ International level.

Details of Courses under 5-year Integrated M.Sc. in Mathematics:

Sl. No.	Course Type	Credit
I.	Core Course (CORE)	112
II.	Ability Enhancement Compulsory Course (AECC)	08
III.	Skill Enhancement Course (SEC)	08
IV.	Discipline Specific Elective (DSE)	40
V.	Generic Elective (GE)	24
VI.	Open Elective (OE)	08
VII.	Project (PROJ)	28
	Total	228

1. Core Course: A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

2. Ability Enhancement Courses (AEC): The Ability Enhancement (AE) Courses may be of two kinds: Ability Enhancement Compulsory Courses (AECC) and Skill Enhancement Courses (SEC).

2.1 Ability Enhancement Compulsory Courses (AECC): Environmental Science, English Communication/MIL Communication etc.

2.2 Skill Enhancement Courses (SEC): These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based knowledge.

3. Elective Course: Generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.

3.1 Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

3.2 Generic Elective (GE) Course: An elective course chosen from an unrelated discipline/subject, with an intention to seek exposure beyond discipline/s of choice is called a Generic Elective.

3.3 Open Elective (OE): An elective course chosen generally from any course structure of any programme in any department subject to condition that the credit of the choosing course must be equal to the assigned credit the course structure of the parent department.

3.4 Project: An elective course designed to acquire special/advanced knowledge on his own with an advisory support by a teacher/faculty member is called project.

Evaluation: Evaluation processes are described in the "Ordinance-14", Central University of Orissa.

Course Structure (5-year Integrated M.Sc. in Mathematics):

Semester	Course Code	Course Type	Course Title	L-P-T-D[C]
1st	AECC101	AECC	English Communication	3-0-1-0[4]
	MTH101	CORE	Fundamentals of Mathematics	5-0-1-0[6]
	MTH102	CORE	Analytical Geometry	5-0-1-0[6]
		SEC	Skill Enhancement Course-I	
		GE	Generic Elective – I	
2nd	AECC102	AECC	Environmental Studies	3-0-1-0[4]
	MTH103	CORE	Linear Algebra	5-0-1-0[6]
	MTH104	CORE	Real Analysis – I	5-0-1-0[6]
		SEC	Skill Enhancement Course-II	
		GE	Generic Elective – II	
3rd	MTH201	CORE	Group Theory	5-0-1-0[6]
	MTH202	CORE	Real Analysis – II	5-0-1-0[6]
	MTH203	CORE	Probability and Statistics	5-0-1-0[6]
		GE	Generic Elective – III	
4th	MTH204	CORE	Rings and Modules	5-0-1-0[6]
	MTH205	CORE	Real Analysis – III	5-0-1-0[6]
	MTH206	CORE	Ordinary Differential Equations	5-0-1-0[6]
		GE	Generic Elective – IV	
5th	MTH301	CORE	Metric Spaces	5-0-1-0[6]
	MTH302	CORE	Partial Differential Equations	5-0-1-0[6]
		DSE	Elective – I	
		DSE	Elective – II	
6th	MTH303	CORE	Complex Analysis	5-0-1-0[6]
	MTH304	CORE	Numerical Analysis	4-2-0-0[6]
		DSE	Elective – III	
		DSE	Elective – IV	
7th	MTH401	CORE	Lebesgue Measure & Integration	3-0-1-0[4]
	MTH402	CORE	Differential Geometry	3-0-1-0[4]
	MTH403	CORE	Field Theory	3-0-1-0[4]
		DSE	Group Elective –I	
		OE	Open Elective – I	
8th	MTH404	CORE	Functional Analysis	3-0-1-0[4]
	MTH405	CORE	Topology	3-0-1-0[4]
		DSE	Group Elective –II	

		DSE	Group Elective –III	
		OE	Open Elective - II	
9^{th}	MTH501	CORE	Mathematical Methods	3-0-1-0[4]
		DSE	Group Elective – IV	
	MTH502	PROJ	Project – I	0-0-0-7[12]
10^{th}	MTH503	CORE	Integral Equations & Transformations	3-0-1-0[4]
	MTH504	PROJ	Project-II	0-0-0-7[16]

Group Electives – Department prescribes two lists of courses of Group Elective (Group – A and Group – B) from which 16 credits have to be passed, with a minimum of 4 credits from each list.
Open Electives – Any 4 credits course from any course structure of any programme in any department of the University.

List of Skill Enhancement Course:

Sl. No.	Course Code	Course Title	L-P-T-D[C]
01	SEC101	Computer Graphics	3-0-1-0[4]
02	SEC102	Operating System: Linux	3-1-0-0[4]
03	SEC103	Modeling and Simulation	3-0-1-0[4]
04	SEC104	Electronic Commerce	3-0-1-0[4]
05	SEC105	Latex and Web Designing	3-1-0-0[4]
06	SEC106	Introduction to MATLAB® Programming	3-1-0-0[4]
07	SEC107	Introduction to Python Programming	3-1-0-0[4]

List of Generic Electives for the courses Generic Elective – I & Generic Elective - II:

Sl. No.	Course Code	Course Title	L-P-T-D[C]
01	GE101	Physics – I	4-2-0-0[6]
02	GE102	Physics – II	4-2-0-0[6]
03	GE103	Information Security	5-0-1-0[6]
04	GE104	Finite Element Methods	5-0-1-0[6]

List of Generic Electives for the courses Generic Elective – III & Generic Elective - IV:

Sl. No.	Course Code	Course Title	L-P-T-D[C]
01	GE201	Computer Science – I	4-2-0-0[6]
02	GE202	Computer Science – II	4-2-0-0[6]
03	GE203	Mathematical Finance	5-0-1-0[6]
04	GE204	Econometrics	5-0-1-0[6]

List of Electives (for 5th / 6th Semester):

Sl. No.	Course Code	Course Title	L-P-T-D[C]

01	MTH305	Coding Theory	5-0-1-0[6]
02	MTH306	Digital Signal Processing	5-0-1-0[6]
03	MTH307	Data Structure using C	5-0-1-0[6]
04	MTH308	Mechanics – I	5-0-1-0[6]
05	MTH309	Mechanics – II	5-0-1-0[6]
06	MTH310	Introduction to Fourier Series	5-0-1-0[6]
07	MTH311	Combinatorics & Discrete Mathematics	5-0-1-0[6]
08	MTH312	Number Theory	5-0-1-0[6]
09	MTH313	Linear Programming and Game Theory	5-0-1-0[6]
10	MTH314	Theory of Equations	5-0-1-0[6]
11	MTH3XX	MOOCs Courses offered by SWAYAM, NPTEL, ePathshala etc.	

List of Group Electives (for 7th / 8th / 9th / 10th Semester):

Group – A

Sl. No.	Course Code	Course Title	L-P-T-D[C]
01	MTH406	Graph Theory	3-0-1-0[4]
02	MTH407	Manifold Theory	3-0-1-0[4]
03	MTH408	Algebraic Geometry	3-0-1-0[4]
04	MTH409	Algebraic Topology	3-0-1-0[4]
05	MTH410	Algebraic Number Theory	3-0-1-0[4]
06	MTH411	Number Theoretic Cryptography – I	3-0-1-0[4]
07	MTH412	Number Theoretic Cryptography – II	3-0-1-0[4]
08	MTH505	Wavelets: Theory and Applications	3-0-1-0[4]
09	MTH506	Complex Dynamics and Fractals	3-0-1-0[4]
10	MTH507	Commutative Algebra	3-0-1-0[4]
11	MTH 508	Set Theory & Logic	3-0-1-0[4]
12	MTH509	Elliptic Curves	3-0-1-0[4]
13	MTH522	Advance Linear Algebra	3-0-1-0[4]
14	MTH601	Sobolev Spaces	3-0-1-0[4]
15	MTH602	Operator Theory	3-0-1-0[4]
16	MTH603	Advance Complex Analysis	3-0-1-0[4]
17	MTH604	Lie Groups and Lie Algebras	3-0-1-0[4]
18	MTH5XX	MOOCs Courses offered by SWAYAM, NPTEL, ePathshala etc.	

Group – B

Sl. No.	Course Code	Course Title	L-P-T-D[C]
01	MTH413	Introduction to Continuum Mechanics	3-0-1-0[4]
02	MTH414	Classical Mechanics	3-0-1-0[4]
03	MTH415	Fluid Dynamics	3-0-1-0[4]
04	MTH416	Data Base Management System	3-0-1-0[4]
05	MTH417	Operations Research	3-0-1-0[4]
06	MTH418	Boolean Algebra and Automata Theory	3-0-1-0[4]

07	MTH419	Parallel Computing	3-0-1-0[4]
08	MTH420	Advanced Numerical Methods	3-0-1-0[4]
09	MTH510	Mathematical Modeling & Simulations	3-0-1-0[4]
10	MTH511	Computational Fluid Dynamics	3-0-1-0[4]
11	MTH512	Design and Analysis of Algorithms	3-0-1-0[4]
12	MTH513	Non-Linear Dynamics and Chaos	3-0-1-0[4]
13	MTH514	Discrete Dynamical Systems	3-0-1-0[4]
14	MTH515	Sampling Theory	3-0-1-0[4]
15	MTH516	Statistical Pattern Recognition	3-0-1-0[4]
16	MTH517	Statistical Simulations	3-0-1-0[4]
17	MTH518	Medical and Health Statistics	3-0-1-0[4]
18	MTH519	Reliability Modeling and Analysis	3-0-1-0[4]
19	MTH520	Design of Experiments	3-0-1-0[4]
20	MTH521	Order Statistics	3-0-1-0[4]
21	MTH605	Stochastic Processes	3-0-1-0[4]
22	MTH606	Bio-Mathematics	3-0-1-0[4]
23	MTH607	Statistical Ecology	3-0-1-0[4]
24	MTH608	Celestial Mechanics	3-0-1-0[4]
25	MTH609	Solid Mechanics	3-0-1-0[4]
26	MTH610	Statistical Genetics	3-0-1-0[4]
27	MTH5XX	MOOCs Courses offered by SWAYAM, NPTEL, ePathshala etc.	

Course Description

AECC101 **L-P-T-D[C]** 3-0-1-0[4]	**English Communication** **Pre. Req.: None** Functional Grammar: Patterns & Parts of speech Subject, Predicate, Noun, Pronoun, Adjective, Adverb, Verb, Verb phrases, Conjunction, Interjection. Vocabulary: Word formation, Prefix, Suffix, Compound words, Conversion, Synonyms, Antonyms, Homophones and Homonyms, How to look up a dictionary. Sentence Structure - Tense Pattern – usage of Tenses Communication: Meaning & importance of communication, Barriers to effective communication, Channels of communication, Language as a tool of communication. Sounds of English Conversation: Extempore speech and Declamation, Reading skill, Comprehension Test, Préci Writing. **Books Recommended:** 1. Monippally , Matthukutty - Business Communication: From Principles To Practice-Tata Mc Graw Hill Education,2013. Hewings, Martin - Advanced Grammar-Cambridge University Press, 2012. 2. Raman Meenakshi & Sharma Sangeeta, Technical Communication-Principles & Practice –O.U.P. New Delhi. 2007.
AECC102 **L-P-T-D[C]** 3-0-1-0[4]	**Environmental Studies** **Pre. Req.: None** Basic Concepts of Environmental studies: Definitions: the Environment-Air, Water and Land, Ecology, Ecosystem, Environmental factors (A biotic factors-light, temperature, soil water and air and biotic factors) Limiting factors, Ecological adaptations. Ecosystem functioning, (Preliminary concept & structure) structure and its organisation, Ecological energetic, Energy flow, food chains, food web, Ecological pyramids, production-Bio-geo-chemical cycles (Hydrologic cycle (water), Gaseous cycle (Oxygen & Co2), Sedimentary cycle (Nitrogen and Sulphur) Population density Natality, mortality, carrying capacity, Age population growth corves, community structure, Ecological succession, types of succession, succession patterns, theories of climax community, Biodiversity. Environmental Pollution: Air pollution, water pollution, terrestrial pollution, Noise pollution, Radiation Pollution, Industrial pollution, Sewage and sewage treatment. Types of pollutants, sources and fate of pollutants in the environment, Depletion of Ozone layer, Green House effects, smog, Acid rain, Biological concentration and biomagnifications of pollutants.

	Conservation of natural resources: Types of renewable and non-renewable resources, soil erosion and conservation, Forest conservation, Deforestation, Afforestation, social forestry, photo geographical regions of India, Management and conservation of Wild life, Pollution control Board and their functions. Environmental awareness and Education. **Books Recommended:** 1. Ashok k Panigrahi, AlakaSahu, "Environmental Studies", SadgranthaMandir, Berhampur 2. B.P. Odum, "Fundamental of Ecology" W. B. Saunders Company Philadelphia, London. 3. M. C. Dash, "Fundamentals of Ecology", Tata Mc Graw Hill publishing Company Limited, New Delhi 4. P. C. Mishra , "Fundamentals of Air and Water Pollution" Ashis publishing House,New Delhi 5. B. N. Mishra, M. K. Mishra , "Introductory practical Biostatistics" N. P. Publishers, Calcutta 6. Dr. Ranganath Mishra, "ParibasaBigiana (odia)" 7. Dr. Basanta Ku Mahapatra , "Paribasa o Paribasa Bigiana (odia)" 8. Dr. RanganathMishra , "Concept of Env. Studies" 9. Dr. N. K. Tripathy, "Fundamental of Env. Studies" 10. Dr. M. C. Dash, "Man and Environment"
SEC101 **L-P-T-D[C]** 3-0-1-0[4]	**Computer Graphics** **Pre. Req.: None** Development of computer Graphics: Raster Scan and Random Scan graphics storages, displays processors and character generators, colour display techniques, interactive input/output devices. Points, lines and curves: Scan conversion, line-drawing algorithms, circle and ellipse generation, conic-section generation, polygon filling anti aliasing. Two-dimensional viewing: Coordinate systems, linear transformations, line and polygon clipping algorithms. **Books Recommended** 1. D. Hearn and M.P. Baker, Computer Graphics, 2nd Ed., Prentice–Hall of India, 2004. 2. J.D. Foley, A van Dam, S.K. Feiner and J.F. Hughes, Computer Graphics: Principals and Practices, 2nd Ed., Addison-Wesley, MA, 1990. 3. D.F. Rogers, Procedural Elements in Computer Graphics, 2nd Ed., McGraw Hill Book Company, 2001. 4. D.F. Rogers and A.J. Admas, Mathematical Elements in Computer Graphics, 2nd Ed., McGraw Hill Book Company, 1990.
SEC102 **L-P-T-D[C]** 3-0-1-0[4]	**Operating System: Linux** **Pre. Req.: None** Linux – The Operating System: Linux history, Linux features, Linux distributions, Linux's relationship to Unix, Overview of Linux architecture, Installation, Start up scripts, system processes (an overview), Linux Security, The Ext2 and Ext3 File systems: General Characteristics of, The Ext3 File system, file permissions. User

	Management: Types of users, the powers of Root, managing users (adding and deleting): using the command line and GUI tools. Resource Management in Linux: file and directory management, system calls for files Process Management, Signals, IPC: Pipes, FIFOs, System V IPC, Message Queues, system calls for processes, Memory Management, library and system calls for memory. **Books Recommended** 1. Arnold Robbins, Linux Programming by Examples The Fundamentals, 2nd Ed., Pearson Education, 2008. 2. Cox K, Red Hat Linux Administrator's Guide, PHI, 2009. 3. R. Stevens, UNIX Network Programming, 3rd Ed., PHI, 2008. 4. Sumitabha Das, Unix Concepts and Applications, 4th Ed., TMH, 2009. 5. Ellen Siever, Stephen Figgins, Robert Love, Arnold Robbins, Linux in a Nutshell, 6th Ed., O'Reilly Media, 2009. 6. Neil Matthew, Richard Stones, Alan Cox, Beginning Linux Programming, 3rd Ed., 2004.
SEC103 **L-P-T-D[C]** 3-0-1-0[4]	**Modelling and Simulation** **Pre. Req.: None** Systems and environment: Concept of model and model building, model classification and representation, Use of simulation as a tool, steps in simulation study. Continuous-time and Discrete-time systems: Laplace transform, transfer functions, state space models, order of systems, z-transform, feedback systems, stability, observability, controllability. Statistical Models in Simulation: Common discrete and continuous distributions, Poisson process, empirical distributions. Random Numbers: Properties of random numbers, generation of pseudo random numbers, techniques of random number generation, tests for randomness, random variate generation using inverse transformation, direct transformation, convolution method, acceptance-rejection. **Books Recommended** 1. Narsingh Deo, System Simulation with Digital Computer, Prentice Hall of India, 1999. 2. Averill Law, Simulation Modeling and Analysis, 3rd Ed., Tata McGraw-Hill, 2007. 3. G. Gordan, System Simulation, 2nd Ed., Pearson Education, 2007. 4. A.F. Seila, V. Ceric and P. Tadikamalla, Applied Simulation Modeling (International Student Edition), Thomson Learning, 2004. 5. Jerry Banks, Handbook of Simulation: Principles, Methodology, Advances, Applications and Practice, Wiley Inter Science, 1998. 6. J. Banks, J.S. Carson, B.L. Nelson, Discrete Event System Simulation, 4th Ed., Prentice Hall of India, 2004. 7. N.A. Kheir, Systems Modeling and Computer Simulation, Marcel Dekker, 1988. 8. B.P. Zeigler, T.G. Kim, and H. Praehofer, Theory of Modeling and Simulation, 2nd Ed., Academic Press, 2000.
SEC104 **L-P-T-D[C]** 3-0-1-0[4]	**Electronic Commerce** **Pre. Req.: None** Building Blocks of Electronic Commerce: Introduction, internet and networking technologies, Internet and network protocols, web server scalability, software

	technologies for building Ecommerce applications, distributed objects, object request brokers, component technology, web services, web application architectures, design of auctions, optimization algorithms for market places, multi-agent systems. Global e-Commerce and Law: Cyber law in India. Comparative evaluation of Cyber laws of certain countries. **Books Recommended** 1. E.M. Awad, Electronic Commerce from Vision to Fulfillment (3rd ed.), Prentice-Hall of India, 2006. 2. P.T. Joseph, E-Commerce: An Indian Perspective, Prentice-Hall of India, 2007. 3. Scott Bonneau, Tammy Kohl, Jeni Tennison, Jon Duckett and Kevin Williams, XML Design Handbook, Wrox Press Ltd., 2003. 4. Michael Cheshar, Ricky Kaura, and Peter Linton, Electronic Business and Commerce, Springer, 2003. 5. W.J. Pardi, XML in Action: Learn to quickly create dynamic, data-driven sites with the Web's hottest new technology, Prentice Hall of India, 1999. 6. P. Weill and M.R. Vitale, Place to Space: Migrating to eBusiness Models, Harvard Business School Press, 2001.
SEC105 **L-P-T-D[C]** 3-0-1-0[4]	**Latex and Web Designing** **Pre. Req.: None** LaTeX: Elements of LaTeX, typesetting mathematics, graphics in LaTeX, PSTricks, Beamer presentation HTML: HTML basics, creating simple web pages, images and links, design of web pages, CSS, MathJaX **Books Recommended** 1. Martin J. Erickson and Donald Bindner, A Student's Guide to the Study, Practice, and Tools of Modern Mathematics, CRC Press, Boca Raton, FL, 2011. 2. L. Lamport. LATEX: A Document Preparation System, User's Guide and Reference Manual, Addison-Wesley, New York, second edition, 1994.
SEC106 **L-P-T-D[C]** 3-0-1-0[4]	**Introduction to MATLAB Programming** **Pre. Req.: None** Variables, Scripts and Operations, Visualization and Programming, Solving Equations, Fitting Images, Animations, Advanced Methods, Symbolic Math, Simulink **Book Recommended** 1. Amos Gilat, Matlab: An Introduction with Applications, Wiley Publication
SEC107 **L-P-T-D[C]** 3-0-1-0[4]	**Introduction to Python Programming** **Pre. Req.: None** Understanding Python variables, Python basic operators, python data type, flow control, functions, strings, file operation, python objective oriented programming, python regular expression, python database interaction, contacting user through emails using pythons. **Book Recommended** 1. W. J. Chun, Core Python Programming, Pearson Pub, 2nd Ed. 2010.

GE101 **L-P-T-D[C]** 4-2-0-0[6]	**Physics – I** **Pre. Req.: None** Kinematics: Displacement, Time and Average Velocity (x-t graph illustrations to be included), Instantaneous Velocity (Finding of velocity on an x-t graph), Average and Instantaneous Acceleration (Illustration with v – t and a – t graph), Motion with Constant Acceleration (Illustration with a – t and v – t graph), Freely Falling Bodies (Up and Down motion in fall with y-t and vy-t graph), Velocity and Position by Integration. Position and Velocity Vectors, Acceleration Vector Problems, Newton's laws of motion: Newton's First and Second Law and their explanation, Working with Newton's First and Second Law. Newton's Third Law of motion and its explanation with problems. Various types of forces in nature (explanation), Pseudo Forces (e.g. Centrifugal Force), Problems, Work and Energy: Kinetic Energy, Work and Work-Energy Theorem, Calculation of Work done with i) Constant Force ii) Spring Force Illustration, Work-Energy Theorem, Potential Energy, Conservative and Non-conservative Forces. Definition of potential energy and conservation of Mechanical energy. Change in the potential energy in a rigid body motion. Mass-energy equivalence, Problems. Basic Concepts of Thermodynamics: Thermodynamic state of a system, Thermal Equilibrium, Zeroth law of Thermodynamics, Internal Energy of System-Concept of heat, Equation of State : The Ideal Gas Equation, Indicator Diagram, First law of Thermodynamics, Thermodynamic Process-Isothermal, Adiabatic, Isobaric, Isochoric. Adiabatic relations of system for perfect gas.Work done during Isothermal and Adiabatic changes. Reversible and Irreversible changes. Problems, Second Law of Thermodynamics: Entropy: Conversion of Heat into Work and its converse, Reversible and Irreversible Processes. Examples of Irreversible Processes. Carnot's Cycle and Carnot's Heat Engine and its efficiency. Second law of Thermodynamics: Statements. Carnot Theorem.Entropy.Principle of Increase in Entropy. Generalised form of the First and Second laws: Entropy changes for an Ideal Gas. Entropy of van der Waals' gas. Problems Sound: Definition of sound intensity, loudness, pitch, quality and timber. Acoustic intensity level measurement. Acoustic pressure and it's measurement. Reverberation time and Reverberation of a hall.Sabine's formula (without derivation). Stroboscope Doppler Effect: Explanation of Doppler effect in sound. Expression for apparent frequency in different cases. Asymmetric nature of Doppler effect in sound. Doppler effect in light, symmetric nature of Doppler effect in light. Applications: Red shift, Violet shift, Radar, Speed trap, Width of a spectral line. Problems. **Books Recommended:** 1. University Physics, Sears and Zeemansky, XIth edition, Pearson education. 2. Concepts of Physics (Vol -1), H.C. Varma, BharatiBhavan Publishers 3. Problems in Physics, P.K. Srivastava, Wiley Eastern Ltd. 4. Physics, 4th Edition, Volume I, Resnick/Halliday/Krane, JOHN WILEY & SONS (SEA) PTE LTD. 5. Heat and Thermodynamics, Mark. W. Zemansky, Richard H. Dittman, Seventh Edition, McGraw-Hill International Editions. 6. Heat and Thermodynamics, Brijlal, N. Subrahmanyam, S. Chand & Company Ltd, New Delhi.

	7. Concept of Physics (Vol -2), H.C. Verma, BharatiBhavan Publishers. 8. A text book of sound, Subramanyam and Brijlal, VikasPrakashan. 9. Sound, Mee, Heinmann, Edition – London. **Practical:** 1. Mechanics (1) Range and Least Count of Instruments, Measurements using various instruments and error analysis (Vernier caliper, screw gauge, travelling microscope, spectrometer etc.) (2) Interpretation of kinematics graphs – part I From data plotting of x vs. t graph, From this graph plotting of v vs. t and a vs. t graph (3) Interpretation of kinematics graphs – part II From data plotting of a vs. t graph, From this graph plotting of v vs. t and x vs. t graph. (4) Determination MI of disc using ring (5) MI of Flywheel (5) Determination of coefficient of viscosity by Poiseulli's method (6) Determination of Y and n by flat spiral spring (7) Determination of Y by bending (8) Surface Tension by Jeager's method. (9) Determine the Height of a Building using a Sextant. (10) Determine the Young's Modulus of a Wire by Optical Lever Method. (11) Determine the Modulus of Rigidity of a Wire by Maxwell's needle. (12) Determine the Elastic Constants of a Wire by Searle's method. (13) Determine g by Bar Pendulum. (14) Determine g by Kater's Pendulum. (15) Determine g and velocity for a freely falling body using Digital Timing Technique 2. Heat and Thermodynamics (1) Interpretation of isothermal and adiabatic curves on PV diagram (Theoretical). Theoretical study of Carnot's cycle by drawing graphs of isothermal and adiabatic curves. (2) Temperature coefficient of resistance. (3) Study of thermocouple and determination of inversion temperature (4) Thermal conductivity by Lee's method (5) Specific heat of graphite 3. Sounds (1)Velocity of sound by Ruben's flame method (2) Measurement of coefficient of absorption of sound for different materials (cork, thermocol, mica, paper etc.) (3) Velocity of sound by phase shift method. (4) Audibility of human ear. (5) Directional characteristics of Microphone. **Books Recommended:** 1. Advanced Practical Physics for students, B.L.Flint and H.T.Worsnop, 1971, Asia Publishing House. 2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition,

	reprinted 1985, Heinemann Educational Publishers. 3. Engineering Practical Physics, S.Panigrahi& B.Mallick,2015, Cengage Learning India Pvt. Ltd. 4. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
GE102 **L-P-T-D[C]** 4-2-0-0[6]	**Physics – II** **Pre. Req.: GE101** Geometrical Optics: Introduction to development of Optics, Lenses: thin and thick lenses, Lens equation, Lens maker's formula, Cardinal points of an optical system, Combination of two thin lenses (equivalent lenses) (including derivation for focal length and cardinal points). Problems.Lens Aberrations: Introduction, Types of aberrations: monochromatic and chromatic aberration, Types of monochromatic aberration and their reduction, Spherical aberration, Coma, Astigmatism, Curvature of field, Distortion, Types of chromatic aberration: Achromatism (lenses in contact and separated by finite, distance), Problems. Optical Instruments: Simple microscope and Compound microscope, Telescopes, Reflection and transmission type of telescope, Eyepieces: Huygen's eyepiece, Ramsden's eyepiece, Gauss's eyepiece, Constant deviation spectrometer, Problems. Interference and Diffraction: Classification of interference of thin films, Interference by division of amplitude, Interference by wedge shaped film: Interference due to reflected light and transmitted light. Fringes of equal inclination, equal thickness, equal chromatic order (FECO fringes), colors of thin films, Interferometry: Michelson's interferometer and Fabry-Perot interferometer, Types of diffraction: Fresenel's diffraction and Fraunhoffer's diffraction, Fraunhoffer's diffraction at double slit and its analytical treatment, Fraunhoffer's diffraction at N slits, Plane diffraction grating, Rayleigh's criterian for resolution, Resolving power of a grating, Problems. Electrostatics: Coulomb's law, Statement, Vector form of Coulomb's law for like and unlike charges, Variation force with distance (F.vs.r graph), Superposition principle, Statement and explanation with illustration, Illustrations with specific configuration of three charges (triangular form) and four charges (square form), Problems on superposition principle, Energy of the system of charges, Illustration with three charges, Electric potential energy Concept of electric field, Electric field due to point charge, Electric field due to group of charges, Lines of force, Relation between electric intensity and electric potential Concept of electric flux, Gauss's theorem in electrostatics (statement only and explanation), Illustrations of Gauss law with examples DIELECTRICS: Electric Dipole, Electric dipole and dipole moment, Electric potential due to dipole, Electric intensity due to dipole, Torque on electric dipole in external electric field, Polar and non – polar molecules with examples. Effect of external electric field on polar and non – polar molecules ,Dielectric materials, Electric polarization of dielectric material, Electric polarization vector, Strength of dielectric material and Dielectric breakdown, Electric displacement and Gauss law in dielectric, Relation between three electric vectors (E, D and P)(Without derivation, qualitative discussion only), Effect of dielectric on capacitance of problems (parallel plate capacitor only), Problems. (Ref. 2, 21.7, 24.4, 24. 6). Magnetostatics: Concept of magnetic field, Definition and properties of magnetic field, Revision of Biot – Savart's law, Examples : 1. Long straight conductor, 2. Current

	carrying circular loop on the axis, Ampere's circuital law, Field of solenoid, Field of toroidal solenoid, Magnetic Field lines and Magnetic flux, Gauss's law for magnetism, Problems. Magnetic Properties Of Material: Magnetic Materials, Bohr magneton, Magnetisation (M), Magnetic Intensity (H) and magnetic induction (B), Magnetisation and Susceptibility and magnetic permeability, Relation between B, M and H (without derivation, qualitative discussion only), Diamagnetic, paramagnetic and ferromagnetic. Explanation with the help of susceptibility and permeability, Problems. Hysteresis (Ref. 2, 28.8) **Books Recommended:** 1. Optics, fourth edition, Pearson education, E. Hetch, A. R. Genesan 2. A Text book of Optics, N.Subhramanyam, Brijlal, M. N. Avadhanulu, S. Chand publication. 3. Introduction to Optics, Third Edition, F.L. Pedrotti, Pearson Education 4. Physical Optics by A.K.Ghatak, McMillan, New Delhi 5. Fundamental of Optics, F.A.Jenkins, H.E.White, McGraw-Hill international Edition. 6. Principles of optics, D.S. Mathur, Gopal Press, Kanpur 7. Optics and Atomic physics, D.P.Khandhelwal, Himalaya Publication Bombay. 8. Fundamentals of optics- Francies A Jenking, Harvey E.White, Tata McGraw Hill 9. Berkeley Physics Course – Vol – II Electricity and Magnetism. Edward M Purcell. 10. University Physics – H.D. Young R. A. Freedman Pearson – Freedman 11. Resnick and Halliday, Physics Vol – II 12. Electromagnetics by B.B.Laud **Practical:** Optics 1. Newton's Ring: Determination of wavelength of monochromatic light source 2. Dispersive power of glass prism 3. Total internal reflection (using spectrometer, Na/Hg Source, glass prism) and determination of refractive index of a liquid. 4. Diffraction at straight edge/cylindrical obstacle 5. Optical activity of sugar solution (polarimeter) 6. Goniometer to determine cardinal points and focal length 7. To determine temperature of sodium flame. 8. Double refracting prism. Electricity: 1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses. 2. Ballistic Galvanometer: (i) Measurement of charge and current sensitivity (ii) Measurement of CDR (iii) Determine a high resistance by Leakage Method (iv) To determine Self Inductance of a Coil by Rayleigh's Method. 3. To compare capacitances using De'Sauty's bridge. 4. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx). 5. To study the Characteristics of a Series RC Circuit. 6. To study the a series LCR circuit and determine its (a) Resonant Frequency, (b) Quality Factor

	7. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q 8. To determine a Low Resistance by Carey Foster's Bridge. 9. To verify the Thevenin and Norton theorem 10. To verify the Superposition, and Maximum Power Transfer Theorem **Books Recommended:** 1. Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House. 2. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi. 3. Engineering Practical Physics, S. Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd. 4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
GE103 **L-P-T-D[C]** 5-0-1-0[6]	**Information Security** **Pre. Req.: None** Overview of Security: Protection versus security; aspects of security–data integrity, data availability, privacy; security problems, user authentication, Orange Book. Security Threats: Program threats, worms, viruses, Trojan horse, trap door, stack and buffer over flow; system threats- intruders; communication threats- tapping and piracy. Cryptography: Substitution, transposition ciphers, symmetric-key algorithms-Data Encryption Standard, advanced encryption standards, public key encryption - RSA; DiffieHellman key exchange, ECC cryptography, Message Authentication- MAC, hash functions. Digital signatures: Symmetric key signatures, public key signatures, message digests, public key infrastructures. Security Mechanisms: Intrusion detection, auditing and logging, tripwire, system-call monitoring. **Books Recommended** 1. W. Stallings, Cryptography and Network Security Principles and Practices, 4th Ed., PrenticeHall of India, 2006. 2. C. Pfleeger and S.L. Pfleeger, Security in Computing , 3rd Ed., Prentice-Hall of India, 2007. 3. D. Gollmann, Computer Security, John Wiley and Sons, NY, 2002. 4. J. Piwprzyk, T. Hardjono and J. Seberry, Fundamentals of Computer Security, SpringerVerlag Berlin, 2003. 5. J.M. Kizza, Computer Network Security, Springer, 2007. 6. M. Merkow and J. Breithaupt, Information Security: Principles and Practices, Pearson Education, 2006.
GE104 **L-P-T-D[C]** 5-0-1-0[6]	**Finite Element Methods** **Pre. Req.: None** Introduction to finite element methods, comparison with finite difference methods, Methods of weighted residuals, collocations, least squares and Galerkin's method. Variational formulation of boundary value problems equivalence of Galerkin and Ritz methods. Applications to solving simple problems of ordinary differential equations. Linear, quadratic and higher order elements in one dimensional and assembly, solution

	of assembled system. Simplex elements in two and three dimensions, quadratic triangular elements, rectangular elements, serendipity elements and isoperimetric elements and their assembly, discretization with curved boundaries Interpolation functions, numerical integration, and modeling considerations. Solution of two dimensional partial differential equations under different Geometric conditions. **Books Recommended** 1. J.N. Reddy, Introduction to the Finite Element Methods, Tata McGraw-Hill, 2003. 2. K.J. Bathe, Finite Element Procedures, Prentice-Hall, 2001. 3. R.D. Cook, D.S. Malkus and M.E. Plesha, Concepts and Applications of Finite Element Analysis, John Wiley and Sons, 2002. 4. Thomas J.R. Hughes, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Dover Publication, 2000. 5. George R. Buchanan, Finite Element Analysis, McGraw Hill, 1994.
GE201 **L-P-T-D[C]** 4-2-0-0[6]	**Computer Science – I** **Pre. Req.: None** Fundamentals of Computer: Model of a digital computer, Functioning of a digital computer, Historical evolution of computers, classification of computers, Human being vs computer, Input / Output devices, Storage devices, Memory and mass storage devices, characteristics of memory systems, types of memory, RAM, ROM, concepts of Virtual and Cache memory, Types of software, Application and system software and its functions, time sharing, multiprocessing, Applications of Computer. Operating Systems and Utility programs, Application Software, Computer Networks, The Internet and World Wide Wave, Network and Internet Security. Programming languages: Machine language, Assembly language, High level languages, Compilers and Interpreters. Problem Solving using Computers : Algorithms, Flowcharts Introduction to Windows: Types of windows, windows as an operating system, windows explorer, using clipboard, using paintbrush, control panel, installing a printer. MS Power Point: Introduction, Power point slide creation, Slide-show, Adding graphics, Formatting Customizing and Printing. MS-Word: Introduction to MS-Word, Standard Toolbar, Word Wrap, Text formatting, Indents, Tabs, Formatting paragraphs, Applying Effects to text, Applying animation to text. MS Excel: Introduction to MS Excel, Working with Toolbars, Formatting, Formulas, Data management, Graphs and Charts, Macros and other additional functions. **Books Recommended:** 1. Donald Sanders, Computers Today, McGraw-Hill Publishers. 2. Davis, Introduction to Computers, McGraw-Hill Publishers. 3. V. Rajaraman, Fundamental of Computers, Prentice-Hall India Ltd., New Delhi.

	Practical: Basic DOS commands: Comparison of DOS and Windows, Switching Between DOS and Windows. Elements of Word Processing: 1. Word Processing Basic 2. Opening Documents and Closing documents 3 Moving Around in a Document: 4 Using a Document/Help Wizard 5 Text Creation and Manipulation 6 Formatting the Text 7 Handling Multiple Documents 8 Table Manipulation 9 Printing Spread Sheet: 1 Elements of Electronics Spread Sheet 2 Manipulation of cells 3 Providing Formulas 4 Spread sheets for Small accountings Computer Communication and Internet: 1 Basic of Computer networks 2 Internet 3 Service on Inter Net WWW and Web Browsers: 1 Web Browsing software 2 Surfing the Internet Making Small Presentations 1 Creation of Presentation 2. Preparation of Slides 3. Providing aesthetics 4. Slide Manipulation and Slide Show 5.Presentation of the Slides **Books Recommended:** 1. C.S. French "Data Processing and Information Technology", BPB Publications 1998 2. P.K Sinha `Computer Fundamentals`, BPB Publications, 1992 3. Guy Hart-Davis "The ABCs of Microsoft Office 97 Professional edition", BPB Publications, 1998 4. Karl Schwartz, "Microsoft Windows 98 Training Guide", 1998
GE202 **L-P-T-D[C]** 4-2-0-0[6]	**Computer Science – II** **Pre. Req.: GE201** Introduction to C: History, Structure of a C program, Functions as building blocks, Application Areas, C Program development life cycle.

	C Tokens : Keywords, Identifiers, Variables, Constants – character, integer, float, string, escape, sequences, Data types – built-in and user defined, Operators and Expressions, Operator types (arithmetic, relational, logical, assignment, bitwise, conditional , other operators) , precedence and associativity rules. Input and Output : Character input and output, String input and output, Formatted input and output Control Structures : Decision making structures- If, if-else, switch, Loop Control structures - While, do-while, for, Nested structures, break and continue Functions in C : What is a function, Advantages of Functions, Standard library, functions, User defined functions, Declaration, definition, function call, parameter passing (by value), return keyword, Scope of variables, storage classes, Recursion Arrays : Array declaration, initialization, Types – one, two and multidimensional, Passing arrays to functions Pointers : Pointer declaration, initialization, Dereferencing pointers, Pointer arithmetic, Pointer to pointer, Arrays and pointers, Functions and pointers – passing pointers to functions, function returning pointers, pointer to function, Dynamic memory allocation Strings: Declaration and initialization, Standard library functions, Strings and pointers, Array of strings. Structures and Unions : Creating structures, Accessing structure members (dot Operator), Array of structures, Passing structures to functions, Nested structures, Pointers and structures, Unions, Difference between structures and unions. C Preprocessor: Format of Preprocessor directive, File Inclusion directive, Macro substitution, nested macro, argumented macro, Conditional compilation. Command Line Arguments: Accessing command line arguments. File Handling: Streams, Types of Files, Operations on files, Random access to files **Books Recommended:** 1. Balagurusamy : “C Programming” Tata McGraw-Hill 2. P. Dey & M. Ghosh, “Computer Fundamental & Programming in C”- Oxford University Press 3. Deitel - “C How to programme” PHI publication/ Pearson Publication 4. Structured Programming approach using C – Forouzan and Gilberg, Thomson learning publications 5. The C Programming language – Kernighan and Ritchie 6. Complete C Reference – Herbert Schildt 7. Y. Kanitkar – “Let us C” BPB Publisher 8. Schaum Series- “C Programming” – Gotterfried **Practical:** 1. Practical to demonstrate use of data types, simple operators (expressions) 2. Practical to demonstrate decision making statements (if and if-else, nested structures) 3. Practical to demonstrate decision making statements (switch case) 4. Practical to demonstrate use of simple loops

	5. Practical to demonstrate use of nested loops 6. Practical to demonstrate menu driven programs. 7. Practical to demonstrate writing C programs in modular way (use of user defined functions) 8. Practical to demonstrate recursive functions. 9. Practical to demonstrate use of arrays (1-d arrays) and functions 10. Practical to demonstrate use of multidimensional array(2-d arrays) and functions 11. Practical to demonstrate use of pointers 12. Practical to demonstrate concept of strings (string & pointers) 13. Practical l to demonstrate array of strings. 14. Practical to demonstrate use of bitwise operators. 15. Practical to demonstrate structures (using array and functions) 16. Practical to demonstrate structures and unions 17. Practical to demonstrate command line arguments and pre-processor directives. 18. Practical to demonstrate file handling (text files) 19. Practical to demonstrate file handling (binary files and random access to files) 20. Practical to demonstrate graphics using C **Books Recommended:** 1. Balagurusamy : "C Programming" Tata McGraw-Hill 2. Y. Kanitkar – "Let us C" BPB Publisher
GE203 **L-P-T-D[C]** 5-0-1-0[6]	**Mathematical Finance** **Pre. Req.: None** Basic principles: Comparison, arbitrage and risk aversion, Interest (simple and compound, discrete and continuous), time value of money, inflation, net present value, internal rate of return (calculation by bisection and Newton-Raphson methods), comparison of NPV and IRR Bonds, bond prices and yields, Macaulay and modified duration, term structure of interest rates: spot and forward rates, explanations of term structure, running present value, floating-rate bonds, immunization, convexity, putable and callable bonds. Asset return, short selling, portfolio return, (brief introduction to expectation, variance, covariance and correlation), random returns, portfolio mean return and variance, diversification, portfolio diagram, feasible set, Markowitz model (review of Lagrange multipliers for 1 and 2 constraints), Two fund theorem, risk free assets, One fund theorem, capital market line, Sharpe index. Capital Asset Pricing Model (CAPM), betas of stocks and portfolios, security market line, use of CAPM in investment analysis and as a pricing formula, Jensen's index. **Books Recommended** 1. David G. Luenberger, Investment Science, Oxford University Press, Delhi, 1998. 2. John C. Hull, Options, Futures and Other Derivatives, 6th Ed., Prentice-Hall India, Indian reprint, 2006. 3. Sheldon Ross, An Elementary Introduction to Mathematical Finance, 2nd Ed., Cambridge University Press, USA, 2003.
GE204 **L-P-T-D[C]** 5-0-1-0[6]	**Econometrics** **Pre. Req.: None** Statistical Concepts Normal distribution; chi-square, t- and F-distributions; estimation

	of parameters; properties of estimators; testing of hypotheses: defining statistical hypotheses; distributions of test statistics; testing hypotheses related to population parameters; Type I and Type II errors; power of a test; tests for comparing parameters from two samples. Simple Linear Regression Model: Two Variable Case Estimation of model by method of ordinary least squares; properties of estimators; goodness of fit; tests of hypotheses; scaling and units of measurement; confidence intervals; Gauss-Markov theorem; forecasting. Multiple Linear Regression Model Estimation of parameters; properties of OLS estimators; goodness of fit - R2 and adjusted R2; partial regression coefficients; testing hypotheses – individual and joint; functional forms of regression models; qualitative (dummy) independent variables. Violations of Classical Assumptions: Consequences, Detection and Remedies Multicollinearity; heteroscedasticity; serial correlation. Specification Analysis Omission of a relevant variable; inclusion of irrelevant variable; tests of specification errors. **Books Recommended** 1. Jay L. Devore, Probability and Statistics for Engineers, Cengage Learning, 2010. 2. John E. Freund, Mathematical Statistics, Prentice Hall, 1992. 3. Richard J. Larsen and Morris L. Marx, An Introduction to Mathematical Statistics and its Applications, Prentice Hall, 2011. 4. D.N. Gujarati and D.C. Porter, Essentials of Econometrics, 4th Ed., McGraw Hill, International Edition, 2009. 5. Christopher Dougherty, Introduction to Econometrics, 3rd Ed., Oxford University Press, Indian edition, 2007.
MTH101 **L-P-T-D[C]** 5-0-1-0[6]	**Fundamentals of Mathematics** **Pre Req.: None** Method of Mathematical Proofs: Induction, Construction, Contradiction, Contrapositive; Logic: Introduction, propositions, truth table, negation, conjunction and disjunction, Implications, biconditional propositions, converse, contrapositive and inverse propositions and precedence of logical operators. Set Theory: Introduction, subsets, algebraic operations on sets, family of sets, Cartesian product of sets, relation on sets, equivalence relation, equivalence classes, order relation on a set, function, injection, surjection, bijection, composition of functions, inverse function, graph of a function. Countable and uncountable sets, Natural numbers, Well ordering property, Integers, Rational numbers, Real Numbers, Completeness property of $\mathbb{R}$, Archimedean property of $\mathbb{R}$, density property of $\mathbb{R}$, extended set of real numbers. Inequalities : Cauchy's and Schwartz inequality, Theorem on means, Theorem on weighted means, Weierstrass's Inequality, Holder's Inequality, Jensen's Inequality, Jensen's Theorem, Minkowski's Inequality Integers, Divisibility of integers, the division algorithm, the greatest common divisor of two integers, Existence and uniqueness of $g.c.d.$, Relatively prime integers, Prime integers, Congruences, Linear Congruences, Euler Phi function **Books Recommended:** 1. G. Polya, \How to Solve It", Princeton University Press, 2004. 2. K. B. Sinha et. al., \Understanding Mathematics", Universities Press (India), 2003.

	3. M. Artin, \Algebra", Prentice-Hall of India, 2007 (Chapters 1, 4, 5). 4. J. R. Munkres, \Topology", Prentice-Hall of India, 2013 (Chapter 1). 5. R. G. Bartle, D. R. Sherbert, \Introduction to Real Analysis", John Wiley & Sons,1992. 6. S.K. Mapa,\Introduction to Real Analysis", Sarat Book Distributors
MTH102 **L-P-T-D[C]** 5-0-1-0[6]	**Analytical Geometry** **Pre Req.: None** Two Dimensional Geometry: Transformation of Rectangular axes, General Equation of second degree in two variables, Reduction into canonical form, Classification of conics, Lengths and position of the axes. Polar equation of a conic referred to a focus as pole. Equations of tangent, normal, chord of contact. Circle, Parabola, Ellipse and Hyperbola : Equations of pair of tangents from an external point, chord of contact, poles and polars, conjugate points and conjugate lines. Three Dimensional Geometry: Rectangular Cartesian co-ordinates in space. Equation of Plane, Straight lines in space, Sphere: General Equation. Circle, Sphere through the intersection of two spheres. Radical Plane, Tangent, Normal. Cone: Right circular cone. General homogeneous second degree equation. Section of cone by a plane as a conic and as a pair of lines. Condition for three perpendicular generators. Reciprocal cone. Cylinder: Generators parallel to either of the axes, general form of equation. Right-circular cylinder. Ellipsoid, Hyperboloid, Paraboloid: Canonical equations only. Tangent planes, Normals, Enveloping cone. Surface of Revolution (about axes of reference only). Ruled surface. Generating lines of hyperboloid of one sheet and hyperbolic paraboloid. Transformation of rectangular axes by translation, rotation and their combinations. Knowledge of Cylindrical, Polar and Spherical polar co-ordinates, their relations (No deduction required). **Books Recommended:** 1. S.L. Loney, \The Elements of Coordinate Geometry", Macmillan 2. R. M. Khan, \Analytical Geometry and Vector algebra", New Central book agency, Kolkata. 3. J.G. Chakraborty, \Analytical Geometry & Vector Analysis", UBS Publishers' Distributors (p) Ltd.
MTH103 **L-P-T-D[C]** 5-0-1-0[6]	**Linear Algebra** **Pre Req.: None** System of Linear Equations, Matrices, Matrix Operation (Addition, Scalar Multiplication, Multiplication, Block Multiplication, Transpose, Adjoint and their properties), Special type of matrix (Null, Identity, Diagonal, Triangular, Idempotent, Nilpotent, Involuntary, Symmetric, Skew Symmetric, Hermitian, Skew Hermitian, Orthogonal), elementary row operations, Row reduced echelon form of matrices, Elementary Matrices, Normal form of matrices. Vector spaces, subspaces, quotient spaces, bases and dimension, direct sums. Linear transformations and their matrix representations, dual spaces, dual basis, double dual, transpose of a linear transformation and its matrix in the dual basis, determinant function. Eigen spaces of a linear operator, diagonalizability, invariant subspaces and

	Cayley-Hamilton theorem, the minimal polynomial for a linear operator, Simultaneous diagonalization/ Triangulazation. **Books Recommended:** 1. K. Hoffman, R. Kunze, \Linear Algebra", Prentice-Hall of India, 2012. 2. W.S. Burnside and A.W. Panton, \The Theory of Equations", Dublin University Press, 1954. 3. S. H. Friedberg, A. J. Insel, L. E. Spence, \Linear Algebra", Prentice Hall, 1997. 4. C. C. MacDuffee, Theory of Equations, John Wiley & Sons Inc., 1954.
MTH104 **L-P-T-D[C]** 5-0-1-0[6]	**Real Analysis – I** **Pre Req.: None** Intervals, Neighbourhood, Interior point, Open set, Limit Point, Isolated Point, Derived Set, Closed Set, Adherent Point, Dense Set, Nested Intervals, Cantor's Intersection Theorem, Cover, Open Cover, Compact Set, Heine-Borel Theorem. Sequences of Real Numbers: Definition and examples, Bounded sequences, Convergence of sequences, Uniqueness of limit, Algebra of limits, Monotone sequences and their convergence, Sandwich rule, Subsequence, subsequential limit, characterisation of a compact set, upper limit and lower limit, Cauchy criterion, Cauchy's theorem on limits. Series: Definition and convergence, Telescopic series, Series with non-negative terms. Tests for convergence [without proof](Cauchy condensation test, Comparison test, Ratio test, Root test, Raabe's test, Logarithmic test, Kummer's test, Gauss test, De Morgan and Bertrand's test), Abel's and Dirichlet's tests for series, Absolute and conditional convergence, Alternating series and Leibnitz test, Riemann rearrangement theorem. Limit of a function at a point, Sequential criterion for the limit of a function at a point. Algebra of limits, Sandwich theorem, Continuity at a point and on intervals, Algebra of continuous functions. discontinuous functions, Types of discontinuity. Continuous functions on compact set, Intermediate value theorem, Monotone functions and continuity, Uniform continuity. Differentiability: Definition and examples, Geometric and physical interpretations, Algebra of differentiation, Chain rule, Darboux Theorem, Rolle's Theorem, Mean Value Theorems of Lagrange and Cauchy. Application of derivatives: Increasing and decreasing functions, Maxima and minima of functions. Higher order derivatives, Taylor's Theorem and expansion of functions, Leibnitz rule, L'Hopital rule. **Books Recommended:** 1. R. G. Bartle, D. R. Sherbert, \Introduction to Real Analysis", John Wiley & Sons,1992. 2. W. Rudin, \Principles of Mathematical Analysis", McGraw Hill International 3. K. A. Ross, \Elementary Analysis", Undergraduate Texts in Mathematics, Springer, 2013. 4. S. K. Berberian, \A First Course in Real Analysis", Undergraduate Texts in Mathematics, Springer-Verlag, 1994.
MTH201 **L-P-T-D[C]** 5-0-1-0[6]	**Group Theory** **Pre Req.: None** Symmetries of a square, Dihedral groups, definition and examples of groups including

	permutation groups and quaternion groups (illustration through matrices), elementary properties of groups. Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups. Properties of cyclic groups, classification of subgroups of cyclic groups. Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem. External direct product of a finite number of groups, normal subgroups, factor groups, Cauchy's theorem for finite abelian groups.Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms, First, Second and Third isomorphism theorems. Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups, Characteristic subgroups, Commutator subgroup and its properties. Properties of external direct products, the group of units modulo n as an external direct product, internal direct products, Fundamental Theorem of finite abelian groups. Group actions, stabilizers and kernels, permutation representation associated with a given group action, Applications of group actions: Generalized Cayley's theorem, Index theorem. Groups acting on themselves by conjugation, class equation and consequences, conjugacy in S_n, p-groups, Sylow's theorems and consequences, Cauchy's theorem, Simplicity of A_n for $n \geq 5$, non-simplicity tests. **Books Recommended:** 1. Joseph Gallian, \Contemporary Abstract Algebra (Fourth Edition)" Narosa Publishing House 2. D. S. Dummit, R. M. Foote, \Abstract Algebra", Wiley-India edition, 2013. 3. I. N. Herstein, \Topics in Algebra", Wiley-India edition, 2013. 4. M. Artin, \Algebra", Prentice-Hall of India, 2007.
MTH202 **L-P-T-D[C]** 5-0-1-0[6]	**Real Analysis – II** **Pre Req.: MTH104** Riemann Integration: Darboux's integral, Riemann sums and their properties, Algebra of Riemann integrable functions, Class of Riemann integrable functions, Mean value theorem, Fundamental theorems of calculus, Change of variable formula (statement only), Riemann-Stieltjes integration. Taylor's theorem and Taylor's series, Elementary functions. Improper integral, Beta and Gamma functions. Sequence & Series of function: Sequence of functions, pointwise convergence, uniform convergence, series of functions, uniform convergence, Abel's and Dirichlet's test. Power Series: Introduction, determination of radius of convergence, properties of power series. Fourier series: Periodic function, Fourier series expansion, convergence of Fourier series, Fourier Cosine and Sine series, Parseval Identity. Multiple integrals, Line integral, surface integral, volume integral. Curve tracing, Tangent and Normal, Curvature, Rectilinear Asymptotes, Envelopes, concavity, convexity. **Books Recommended:** 1. R. G. Bartle, D. R. Sherbert, \Introduction to Real Analysis", John Wiley & Sons, 1992. 2. K. A. Ross, \Elementary Analysis", Undergraduate Texts in Mathematics, Springer,

	2013. 3. Erwin Kreyszig, \ Advanced Engineering Mathematics", Wiley India 4. T. M. Apostol, \Calculus Vol. I", Wiley-India edition, 2009. 5. S. K. Berberian, \A First Course in Real Analysis", Undergraduate Texts in Mathematics, Springer-Verlag, 1994. 6. W. Rudin, \Principles of Mathematical Analysis", McGraw Hill International
MTH203 **L-P-T-D[C]** 5-0-1-0[6]	**Probability and Statistics** **Pre Req.: None** Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function, discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential. Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, conditional expectations, independent random variables, bivariate normal distribution, correlation coefficient, joint moment generating function (jmgf) and calculation of covariance (from jmgf), linear regression for two variables. Chebyshev's inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers, Central Limit theorem for independent and identically distributed random variables with finite variance, Markov Chains, Chapman-Kolmogorov equations, classification of states. **Books Recommended:** 1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007. 2. Irwin Miller and Marylees Miller, John E. Freund, Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia, 2006. 3. Sheldon Ross, Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007. 4. Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw- Hill, Reprint 2007
MTH204 **L-P-T-D[C]** 5-0-1-0[6]	**Rings and Modules** **Pre Req.: MTH201** Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring. Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals. Ring homomorphisms, properties of ring homomorphisms, Isomorphism theorems I, II and III, field of quotients. Polynomial rings over commutative rings, division algorithm and consequences, principal ideal domains, factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion, unique factorization in Z[x]. Divisibility in integral domains, irreducibles, primes, unique factorization domains, Euclidean domains. Modules, submodules, quotients modules, isomorphism theorems, generators, direct product and direct sum of modules, Finitely generated modules, Free modules. **Book Recommended:**

	1. D. S. Dummit, R. M. Foote, \Abstract Algebra", Wiley-India edition, 2013. 2. Joseph Gallian, \Contemporary Abstract Algebra (Fourth Edition)" Narosa Publishing House 3. I. N. Herstein, \Topics in Algebra", Wiley-India edition, 2013. 4. M. Artin, \Algebra", Prentice-Hall of India, 2007.
MTH205 **L-P-T-D[C]** 5-0-1-0[6]	**Real Analysis – III** **Pre Req.: MTH104** Function of several variables, continuity of functions from $\mathbb{R}^n$ to $\mathbb{R}$ and from $\mathbb{R}^m$to $\mathbb{R}^n$. Partial derivatives, directional derivatives, Differentiability and derivative as a linear transformation, chain rule, sufficient conditions for differentiability, higher derivatives, Mean value theorem for functions of several variables, theorem of interchange of order of partial derivatives, Taylor expansion in several variables, Inverse function theorem and Implicit function theorem (without proofs). (some justification for Lagrange's method of undetermined multipliers), curve in $\mathbb{R}^2$ and $\mathbb{R}^3$, Stationary points and local maxima and minima, Lagrange's method of multipliers (without formal proof). Scalar and vector fields, surfaces and curves in space, examples using analytical geometry, parametric equations for curves and surfaces, intrinsic dimension of subsets of background space using analytical geometry. Continuity and differentiability of vector and scalar fields. Partial derivatives of vectors and scalar fields, the vector operator ∇. Gradient of a scalar field, level surfaces, directional derivative and interpretation of gradient, tangent plane and normal to level surfaces. Divergence and curl expressions. Important vector and scalar calculus identities. Flux of a vector field through a surface portion with an example calculation. Gauss Divergence theorem and outline of proof. Interpretation of divergence in terms of flux.Vector line differential and integral with example calculations.Deriving Green's theorem in a plane. Definition of vector line integral (for 2D vectors on a plane) and relation to Green's theorem. Stokes' theorem and outline of proof (e.g., using Green's theorem).Interpretation of curl in terms of vector line integrals. Conservative vector fields, line integrals and gradients: basic results with proofs, irrotational and solenoidal vector fields. **Books Recommended:** 1. W. Fleming, \Functions of Several Variables", Undergraduate Texts in Mathematics. Springer-Verlag, 1977. 2. T. M. Apostol, \Calculus Vol. II", Wiley-India edition, 2009. 3. M. R. Spiegel, \Vector Analysis", McGraw Hill. 4. Erwin Kreyszig, Advanced Engineering Mathematics.Wiley India, 2014. 5. W. Kaplan, \Advanced Calculus", Addison-Wesley Publishing Company, 1984. 6. T. M. Apostol, \Mathematical Analysis", Narosa Publishing House, 2013.
MTH206 **L-P-T-D[C]** 5-0-1-0[6]	**Ordinary Differential Equations** **Pre Req.: None** Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations, existence of solutions by Picard's method, uniqueness of solutions, power series method for solving ordinary differential equation with application. Introduction to

	compartmental model, exponential decay model, drug assimilation into the blood (case of a single cold pill, case of a course of cold pills), exponential growth of population. General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters. Boundary value problems, Eigen value and Eigen function. Equilibrium points, Interpretation of the phase plane, predatory-prey model and its analysis, Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions. **Books Recommended:** 1. Martin Braun, \Differential Equation and their Application", Springer 2. S. L. Ross, \Differential Equations", Wiley-India Edition, 2009. 3. E. A. Coddington, \An Introduction to Ordinary Differential Equations", Prentice-Hall of India, 2012. 4. G. F. Simmons, S. G. Krantz, \Differential Equations", Tata Mcgraw-Hill Edition, 2007. 5. B. Rai, D. P. Choudhury, \A Course in Ordinary Differential Equation", NarosaPublishing House, New Delhi, 2002. 6. G. Birkhoff and G.C. Rota,\Ordinary Differential Equations", Blaisdell, Masachusetts
MTH301 **L-P-T-D[C]** 5-0-1-0[6]	**Metric Spaces** **Pre Req.: MTH104** Definition and examples of metric spaces, Open spheres and closed spheres, Neighbourhoods, Open sets, Interior, exterior and boundary points, Closed sets, Limit points and isolated points, Interior and closure of a set, Boundary of a set, Bounded sets, Distance between two sets, Diameter of a set, Subspace of a metric space. Cauchy and Convergent sequences, Completeness of metric spaces, Cantor's intersection theorem, Dense sets and separable spaces, Nowhere dense sets and Baire's category theorem, Continuous and uniformly continuous functions, Homeomorphism, Banach contraction principle. Compact spaces, Sequential compactness, Bolzano-Weierstrass property, Compactness and finite intersection property, Heine-Borel theorem, Totally bounded sets, Equivalence of compactness and sequential compactness, Continuous functions on compact spaces. Separated sets, Disconnected and connected sets, Components, Connected subsets of $\mathbb{R}$, Continuous functions on connected sets. **Books Recommended:** 1. E. T. Copson (1988). Metric Spaces. Cambridge University Press. 2. P. K. Jain & Khalil Ahmad (2019). Metric Spaces. Narosa. 3. S. Kumaresan (2011). Topology of Metric Spaces (2nd edition). Narosa. 4. Satish Shirali & Harikishan L. Vasudeva (2006). Metric Spaces. Springer-Verlag. 5. Micheál O'Searcoid (2009). Metric Spaces. Springer-Verlag. 6. G. F. Simmons (2004). Introduction to Topology and Modern Analysis. McGraw-

	Hill.
MTH302 **L-P-T-D[C]** 5-0-1-0[6]	**Partial Differential Equations** **Pre Req.: None** Partial Differential Equations – Basic concepts and Definitions, Mathematical Problems. FirstOrder Equations: Classification, Construction and Geometrical Interpretation. Method of Characteristics for obtaining General Solution of Quasi Linear Equations. Canonical Forms of First-order Linear Equations. Method of Separation of Variables for solving first order partial differential equations. Derivation of Heat equation, Wave equation and Laplace equation. Classification of second order linear equations as hyperbolic, parabolic or elliptic. Reduction of second order Linear Equations to canonical forms. The Cauchy problem, the Cauchy-Kowaleewskaya theorem, Cauchy problem of an infinite string. Initial Boundary Value Problems, Semi-Infinite String with a fixed end, Semi-Infinite String with a Free end, Equations with non-homogeneous boundary conditions, Non Homogeneous Wave Equation. Method of separation of variables, Solving the Vibrating String Problem, Solving the Heat Conduction problem. **Books Recommended:** 1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007. 2. Irwin Miller and Marylees Miller, John E. Freund, Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia, 2006. 3. Sheldon Ross, Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007. 4. Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw- Hill, Reprint 2007 Wiley)
MTH303 **L-P-T-D[C]** 5-0-1-0[6]	**Complex Analysis** **Pre. Req.: MTH104** Algebraic and geometric representation of complex numbers; concept of holomorphic (analytic) functions, complex derivative and the Cauchy-Riemann equations; harmonic functions; power series, elementary functions - the exponential functions and its relatives (log, cos, sin, cosh, sinh, etc.); Conformal Mapping, Linear Fractional Transformations, Complex line integrals, Cauchy's Theorem, Cauchy Integral formula, Representation of holomorpic functions in terms of power series, Morera's theorem, Cauchy estimates and Liouville's theorem, zeros of holomorphic functions, Uniform limits of holomorphic functions. Behaviour of holomorphic function near an isolated singularity, Laurent expansions, Counting zeros and poles, Argument principle, Rouche's theorem, Calculus of residues and evaluation of integrals using contour integration. The Open Mapping theorem, Maximum Modulus Principle, Schwarz Lemma. **Books Recommended:** 1. J. B. Conway, \Functions of One Complex Variable", Narosa Publishing House,2002.

	2. R. E. Greene, S. G. Krantz, \Function Theory of One Complex Variable", American Mathematical Society, 2011. 3. E. M. Stein, R. Shakarchi, \Complex Analysis", Princeton University Press, 2003. 4. W. Rudin, \Real and Complex Analysis", Tata McGraw-Hill, 2013. 5. L. V. Ahlfors, \Complex Analysis", Tata McGraw-Hill, 2013. 6. T. W. Gamelin, \Complex Analysis", Undergraduate Texts in Mathematics, Springer, 2006.
MTH304 **L-P-T-D[C]** 5-0-1-0[6]	**Numerical Analysis** **Pre Req.: None** Errors in computation: Representation and arithmetic of numbers, source of errors, error propagation, error estimation. Numerical solution of non-linear equations: Bisection method, Secant method, Newton-Raphson method, Fixed point methods, Muller's method. Interpolations: Lagrange interpolation, Newton divided differences, Hermite interpolation, Piecewise polynomial interpolation. Approximation of functions: Weierstrass and Taylor expansion, Least square approximation. Numerical Integration: Trapezoidal rule, Simpson's rule, Newton-Cotes rule, Guassian quadrature. Numerical solution of ODE: Euler's method, multi-step methods, Runge-Kutta methods, Predictor-Corrector methods. Solutions of systems of linear equations: Gauss elimination, pivoting, matrix factorization, Iterative methods - Jacobi and Gauss-Siedel methods. Matrix eigenvalue problems: power method. **Practical (Using C/C++ Language):** 1. Gauss elimination method 2. Gauss-seidal method 3. Jacobi's method 4. Power method 5. Lagrange's interpolation 6. Trapezoidal rule 7. Simpsons I/3rd and 3/8th rule. 8. Bisection method 9. Newton-Raphson's method 10. Runge-Kutta method (first and fourth order) **Books Recommended:** 1. K. E. Atkinson, \An Introduction to Numerical Analysis" Wiley-India Edition, 2013. 2. M.K. Jain, S.R.K Iyengar, R.K. Jain: Numerical Methods, New age International 3. C. Balachandra Rao and Shantha, C.K: Numerical Methods, University Press 4. Samuel D. Conte, Carl de Boor, \Elementary Numerical Analysis", Tata McGraw-Hill Edition
MTH305 **L-P-T-D[C]** 5-0-1-0[6]	**Coding Theory** **Pre. Req.: None** The communication channel, The coding problem, Block codes, Hamming metric, Nearest neighbour decoding, Linear codes, Generator and Parity-check matrices, Dual code, Standard array decoding, Syndrome decoding. Hamming codes, Golay codes, Reed-Muller codes, Codes derived from Hadamard matrices. Bounds on codes: Sphere packing bound, Perfect codes, Gilbert-Varshamov bound, Singleton bound, MDS codes, Plotkin bound. Weight distributions of codes, Mac Williams identities. Algebra of polynomials, Residue class rings, Finite fields, Cyclic codes, Generator polynomial and check polynomial, Defining set of a cyclic code. BCH bound, Encoding and decoding of cyclic codes, Hamming and Golay codes as cyclic codes, BCH codes, Reed-Solomon codes, Quadratic residue codes, Graphical codes, Convolutional codes.

	Books Recommended 1. F.J. Mac Williams and N.J.A. Sloane, The Theory of Error Correcting Codes, North Holland, 1977. 2. S. Ling and C. Xing, Coding Theory: A First Course, Cambridge University Press, 2004. 3. R.M. Roth, Introduction to Coding Theory, Cambridge University Press, 2006.
MTH306 **L-P-T-D[C]** 5-0-1-0[6]	**Digital Signal Processing** **Pre. Req.: None** Discrete time signals and systems, Z-transforms, structures for digital filters, design procedures for FIR and IIR filters. Frequency transformations: linear phase design; DFT. Methods for computing FFT. Noise analysis of digital filters, power spectrum estimation. Signals and Signal Processing: characterization and classification of signals, typical Signal Processing operations, example of typical Signals, typical Signals Processing applications. Time Domain Representation of Signals and Systems: Discrete Time Signals, Operations on Sequences, the sampling process, Discrete-Time systems, Time-Domain characterization of LTI Discrete-Time systems. Transform-Domain Representation of Signals: the Discrete-Time Fourier Transform, Discrete Fourier Transform, DFT properties, computation of the DFT of real sequences, Linear Convolution using the DFT. Z-transforms, Inverse z-transform, properties of z transform, transform domain representations of random signals, FFT. Transform-Domain Representation of LTI Systems: the frequency response, the transfer function, types of transfer function, minimumphase and maximum-phase transfer functions. Digital Processing of continuous-time signals: sampling of continuous signals, analog filter design, anti-aliasing, filter design, sample-and-hold circuits, A/D and D/A converter, reconstruction filter design. Digital Filter Structure: Block Diagram representation, Signal Flow Graph Representation, Equivalent Structures, FIR Digital Filter Structures, IIR Filter Structures. transfer, modes of data transfer, priority interrupt, direct memory access, input-output processor. Digital Filter Design: Impulse invariance method of IIR filter design, Bilinear Transform method Of IIR Filter Design, Design of Digital IIR notch filters, FIR filter Design based on truncated Fonnerfonnersens, FIR filter design based on Frequency Sampling approach. Applications of DSP. **Books Recommended** 1. Sanjit K. Mitra, Digital Signal Processing a Computer based approach, TMH, 2009. 2. Allan Y. Oppenhein and Ronald W. Schater , Digital Signal Processing, PHI, 1975. 3. ProakisManodans, Digital Signal Processing: Principles, Algorithms and Applications, PHI, 2003. 4. Vijay K. Madisetti, The Digital Signal Processing Hand Book, Butterworth-Heinemann, USA, 1999. 5. Vinay K. Ingle, John G. Proaksis, Digital Signal Processing - A MATLAB Based Approach, Cengage Learning, 2009.
MTH307 **L-P-T-D[C]** 5-0-1-0[6]	**Data Structure using C** **Pre. Req.: None** Introduction to data structures: Concept, Data type, Data object, ADT, Need of Data Structure, Types of Data Structure. Algorithm analysis: Algorithm – definition,

	characteristics, Space complexity, time complexity, Asymptotic notation (Big O, Omega)Linear data structures : Introduction to Arrays - array representation , sorting, algorithms with efficiency - bubble sort, Insertion sort, Merge sort, Quick Sort. Linked List : Introduction to List, Implementation of List – static & dynamic representation, Types of Linked List, Operations on List, Applications of Linked List – polynomial manipulation, Generalized linked list – concept & representation. Stacks : Introduction, Representation-static & dynamic, Operations, Application - infix to postfix & prefix, postfix evaluation, Recursion using implicit stack, Concept of Multiple stacks Queues : Introduction, Representation -static & dynamic, Operations, Circular queue, De Que, priority queues, Concept of Multiple Queues. Trees : Concept & Terminologies, Binary tree, binary search tree, Representation – static & dynamic, Operations on BST – create. Insert, delete, traversals (preorder, inorder, postorder), counting leaf, non-leaf & total nodes, Application - Heap sort, Height balance tree-AVL trees- Rotations. Graph : Concept & terminologies, Graph Representation, Traversals – BFS & DFS, Applications – AOV network – topological sort, AOE network – critical path, Shortest path with implementation **Books Recommended:** 1. Fundamentals of Data Structures ---- By Horowitz Sahani (Galgotia) 2. Data Structures using C --- By ISRD Group (Tata McGraw Hill) 3. Introduction to Data Structures using C---By Ashok Kamthane 4. Data Structures using C --- Bandopadhyay & Dey (Pearson)
MTH308 **L-P-T-D[C]** 5-0-1-0[6]	**Mechanics – I** **Pre. Req.: None** Fundamental notions and principles, laws of motion. Motion of a particle in a straight line with uniform and variable acceleration, simple harmonic motion, Collision of elastic bodies. Work, power and energy, impulse and Impulsive forces, Motion in a resisting medium, projectile in a resisting medium. Motion in a plane, velocity and acceleration in Cartesian and polar coordinate, angular velocity and angular acceleration. Central forces and Central Orbit, planetary motion, stability of orbit. Constrained motion in a plane, motion with varying mass. **Books Recommended:** 1. Chorltan, F., \Textbook of Dynamics” 2. Loney, S. L., \Dynamics” 3. Synge, John. L; Griffith, Byron. A, “ Principles Of Mechanics”, McGraw Hill publisher
MTH309 **L-P-T-D[C]** 5-0-1-0[6]	**Mechanics – II** **Pre. Req.: MTH308** Coplanar forces, condition of equilibrium of a system of coplanar forces, force of friction, angle of friction, cone of friction, Principle of virtual work, stable and unstable equilibrium. Centre of gravity, forces in three dimension. Perfect fluid, pressure at a point, compressibility, density and specific gravity, pressure of heavy fluid. Thrust on plane surfaces, centre of pressure, pressure of gasses. **Books Recommended:**

	1. Loney, S. L., \Statics". 2. Verma, R. S., \A Textbook on Statics". 3. Besant, W. H., Ramsey, A. S., \A Treatise on Hydromechanics (Part I)" 4. Synge, John. L; Griffith, Byron. A, " Principles Of Mechanics", McGraw Hill publisher
MTH310 **L-P-T-D[C]** 5-0-1-0[6]	**Introduction to Fourier Series** **Pre Req.: MTH202** Basic properties of Fourier Series, Convolution, Good Kernels, Cesaro & Abel summability, Abel summability, poission kernel and Dirichlet's problem in the unit Disk. Mean square convergence , pointwise convergence of Fourier series, construction of continuous function with divergent Fourier series. The isoperimetric inequality, Weyl's equidistribution, construction of continuous but nowhere differentiable function. Fourier analysis on Z(N) ,Fourier inversion theorem & plancheral identity, FFT, Fourier analysis on finite abelian groups. Basic reviews of number theory: divisibility, the fundamental theorem of arithmetic, the infinitude of primes congruence, Proof of Dirichlet's theorem. **Books Recommended:** 1. Fourier Analysis: An introduction by E.M Stein and Rami Shakarchi, Princeton University Press. 2. Exercise for Fourier Analysis by T.W Korner, Cambridge University Press 3. Fourier Analysis and It's Applications, by G.B. Folland, American Mathematical Society 4. Early Fourier Analysis, by H.L Montgomery, American Mathematical Society 5. Fourier Series, by Rajendra Bhatia, American Mathematical Society
MTH311 **L-P-T-D[C]** 5-0-1-0[6]	**Combinatorics & Discrete Mathematics** **Pre Req.: None** Pigeonhole principle, Counting principles, Binomial coefficients, Principles of inclusion and exclusion, Recurrence relations, generating functions, Catalan numbers, Stirling numbers, Partition numbers, SchrÖder numbers. Block designs, Latin squares, Partially ordered sets. Lattices, Boolean algebra, chromatic numbers and chromatic index, planarity, covering numbers, Orthogonal Latin squares, Hadamard Matrices. Graphs: Definitions and examples, Graphs as models. Subgraphs, walks, paths and cycles, Connectedness, Matrix representation of graphs, Operations on graphs, connectedness algorithm. Trees and connectivity: Definition and simple properties, Bridge, spanning trees, Cayley's theorem. Connector problems, Cut vertices, Connectivity. **Books Recommended:** 1. R. A. Brualdi, "Introductory Combinatorics", Pearson Prentice Hall, 2010. 2. J. P. Tremblay, R. Manohar, "Discrete Mathematical Structures with Application to Computer Science", Tata McGraw-Hill Edition, 2008. 3. Alan Tucker, Applied Combinatorics (third edition), John Wiley &sons , New York (1995). 4. John Clerk and Derek Allan Holton, "A first look at Graph Theory", Allied Publishers Ltd./World Scientific. 5. J. H. van Lint, R. M. Wilson, \A Course in Combinatorics", Cambridge University

	Press, 2001. 6. I. Anderson, \A First Course in Discrete Mathematics", Springer Undergraduate Mathematics Series, 2001. 7. R. P. Stanley, \Enumerative Combinatorics Vol. 1", Cambridge Studies in Advanced Mathematics, 49, Cambridge University Press, 2012. 8. M. J. Erickson, \Introduction to Combinatorics", John Wiley (1996). 9. Narsingh Deo,\Introduction to Graph Theory with applications to Engineering and Computer Science".
MTH312 **L-P-T-D[C]** 5-0-1-0[6]	**Number Theory** **Pre Req.: None** Divisibility, Primes, Fundamental theorem of arithmetic, Congruences, Chinese remainder theorem, Linear congruences, Congruences with prime-power modulus, Fermat's little theorem, Wilson's theorem, Euler function and its applications, Group of units, primitive roots, Quadratic residues, Jacobi symbol, Binary quadratic form, Arithmetic functions, Möbius Inversion formula, Dirichlet product, Sum of squares, Continued fractions and rational approximations. **Books Recommended:** 1. I. Niven, H. S. Zuckerman, H. L. Montgomery, \An Introduction to the Theory of Numbers", Wiley-India Edition, 2008. 2. David M. Burton,\Elementary Number Theory", Mcgraw-Hill Education (India) Pvt. Ltd. 3. T. M. Apostol, \Introduction to Analytic Number Theory", Springer International Student Edition, 2000. 4. G. A. Jones, J. M. Jones, \Elementary Number Theory", Springer Undergraduate Mathematics Series.Springer-Verlag, 1998.
MTH313 **L-P-T-D[C]** 5-0-1-0[6]	**Linear Programming and Game Theory** **Pre Req.: None** Linear Programming: Convex sets, Supporting and Separating Hyper-planes, Standard linear Programming Problem, basic feasible solution, Simplex algorithm and simplex method, graphical solution, two phase method. Duality in linear programming, duality theorems, dual simplex method with justification, sensitivity. Transportation and assignment algorithms, Hungarian method of assignment, transhipment problems, duality theory of testing optimality of solution in transportation problem and transhipment problems, transportation problem and transhipment problems as network problems Balance and degeneracy in transportation problem. Maximization, prohibitions and other variations of assignment problems. Traveling Salesman problem. Concept of Game problem. Concept of Dominance. Fundamental Theorem of Rectangular games. Algebraic method. Graphical method and Dominance method of solving Rectangular games. **Books Recommended:** 1. Kambo, N.S. (1991) \Mathematical Programming Techniques" (Affiliated Eas-west press Pvt. Ltd.). 2. Hadley, G. (1987),\Linear Programming". 3. Taha, H.A. (1992),\Operations Research" 5th ed. (Macmillan)

	4. Panneerselvam, R. \Operations Research" (Prentic hall of India) 5. S. Vajda,\An Introduction to Linear Programming & Theory of Games"
MTH314 **L-P-T-D[C]** 5-0-1-0[6]	**Theory of Equations** **Pre Req.: None** General properties of polynomials, Graphical representation of a polynomial, maximum and minimum values of a polynomials, General properties of equations, Descarte's rule of signs positive and negative rule, Relation between the roots and the coefficients of equations. Symmetric functions, Applications of symmetric function of the roots, Transformation of equations. Solutions of reciprocal and binomial equations. Algebraic solutions of the cubic and biquadratic. Properties of the derived functions. Symmetric functions of the roots, Newton's theorem on the sums of powers of roots, homogeneous products, limits of the roots of equations. Separation of the roots of equations, Strums theorem, Applications of Strum's theorem, Conditions for reality of the roots of an equation and biquadratic. Solution of numerical equations. **Books Recommended:** 1. W.S. Burnside and A.W. Panton, The Theory of Equations, Dublin University Press, 1954. 2. C. C. MacDuffee, Theory of Equations, John Wiley & Sons Inc., 1954.
MTH401 **L-P-T-D[C]** 3-0-1-0[4]	**Lebesgue Measure and Integration** **Pre Req.: None** Lebesgue measure: σ -algebras of sets, Borel sets, outer measure and its properties, σ -algebra of measurable sets, Lebesgue measure and its properties, a non-measurable set, measurable functions, Littlewood's three principles, Egoroff's theorem, Lusin's theorem. Lebesgue integral: Simple functions, Lebesgue integral of a bounded function over a set of finite measure, bounded convergence theorem, Lebesgue integral of nonnegative functions, Fatou's Lemma, monotone convergence theorem, the general Lebesgue integral, Lebesgue convergence theorem, Differentiation and integration: Differentiation of monotone functions, functions of bounded variation, differentiation of an integral, absolute continuity. L_p-spaces: Definition and properties, Minkowski's inequality and Hölder's inequality, convergence and completeness of L_p, approximation in L_p, bounded linear functionals on L_p spaces. General measure and integration theory: Measure spaces, measurable functions, integration, general convergence theorems, signed measures, The Radon-Nikodym theorem, product measures - Fubini's theorem and Tonelli's theorem. **Books Recommended:** 1. H. L. Royden, Real Analysis, 3rd Edition, Phi Learning, 2009. 2. E. M. Stein and R. Shakarchi, Real Analysis: Measure Theory, Integration, and Hilbert Spaces, Princeton University Press, 2005. 3. G. B. Folland, Real Analysis: Modern Techniques and Their Applications, 2nd Edition, John Wiley & Sons, 1999. 4. Paul R. Halmos, Measure theory, Springer, 2009. 5. G. Debarra, Measure Theory and Integration, New Age International, 1981. 6. Michael Taylor, Measure Theory and Integration, American Mathematical Society,

	2006. 7. K. B. Athreya and S. N. Lahiri, Measure Theory, Hindustan Book Agency, 2006. 8. T. Tao, An Introduction to Measure Theory, GSM, Vol. 126, AMS, 2011.
MTH402 **L-P-T-D[C]** 3-0-1-0[4]	**Differential Geometry** **Pre Req.: None** Local curve theory: Serret-Frenet formulation, Fundamental existence theorem of space curves; Plane curves and their global theory: Rotation index, convex curves, isoperimetric inequality, Four vertex theorem; Local surface theory: First fundamental form and arc length, normal curvature, geodesic curvature and Gauss formulae, Geodesics, parallel vector fields along a curve and paralelism; the second fundamental form and the Weingarten map; principal, Gaussian, mean and normal curvatures; Riemannian curvature and Gauss's theorem Egregium; isometries and fundamental theorem of surfaces; Global theory of surfaces: Geodesic coordinate patches, Gauss-Bonnet formula & Euler characteristic, index of a vector field, surfaces of constant curvature.; Elements of Riemannian geometry: Concept of manifold, tensors (algebraic and analytic), covariant differentiation, symmetric properties of curvature tensor, notion of affine connection, Christofel symbols; Riemannian metric and its associated affine connection, geodesic and normal coordinates (if time permits). **Books Recommended:** 1. S. Kumaresan, A Course in Differential Geometry and Lie Groups, Hindustan Book Agency, 2002. 2. W. Klingenberg, A Course in Differential Geometry, Springer-Verlag, 1978. 3. Christian Bar, Elementary Differential Geometry, Cambridge University Press, 2010. 4. R.S. Millman and G.D. Parker, Elements of Differential Geometry, Prentice Hall Inc., 1977.
MTH403 **L-P-T-D[C]** 3-0-1-0[4]	**Field Theory** **Pre Req.: MTH201** Field extensions, algebraic extensions, Ruler and compass constructions, splitting fields, algebraic closures, separable and inseparable extensions, cyclotomic polynomials and extensions, automorphism groups and fixed fields, Galois extensions, Fundamental theorem of Galois theory, Fundamental theorem of algebra, Finite fields, Galois group of polynomials, Computations of Galois groups over rationals, Solvable groups, Solvability by radicals. **Books Recommended:** 1. D. S. Dummit, R. M. Foote, \Abstract Algebra", Wiley-India edition, 2013. 2. I. N. Herstein, \Topics in Algebra", Wiley-India edition, 2013. 3. M. Artin, \Algebra", Prentice-Hall of India, 2007. 4. J. Rotman, \Galois Theory", Universitext, Springer-Verlag, 1998.
MTH404 **L-P-T-D[C]** 3-0-1-0[4]	**Functional Analysis** **Pre Req.: MTH201** Normed linear spaces, Riesz lemma, characterization of finite dimensional spaces, Banach spaces. Operator norm, continuity and boundedness of linear maps on a normed linear space. Fundamental theorems: Hahn-Banach theorems, uniform

	boundedness principle, divergence of Fourier series, closed graph theorem, open mapping theorem and some applications. Dual spaces and adjoint of an operator: Duals of classical spaces, weak and weak* convergence, adjoint of an operator. Hilbert spaces: Inner product spaces, orthonormal set, Gram-Schmidt ortho-normalization, Bessel's inequality, orthonormal basis, separable Hilbert spaces.Projection and Riesz representation theorems: Orthonormal complements, orthogonal projections, projection theorem, Riesz representation theorem. Bounded operators on Hilbert spaces: Adjoint, normal, unitary, self-adjoint operators, compact operators. Unbounded operators. Spectral theorem: Spectral theorem for compact self adjoint operators, statement of spectral theorem for bounded self adjoint operators. **Books Recommended:** 1. J. B. Conway, \A Course in Functional Analysis", Graduates Texts in Mathematics 96, Springer, 2006. 2. B. Bollobás, \Linear Analysis", Cambridge University Press, 1999. 3. G. F. Simmons, \Introduction to Topology and Modern Analysis", Tata McGraw-Hill, 2013.
MTH405 **L-P-T-D[C]** 3-0-1-0[4]	**Topology** **Pre Req.: MTH104** Definition of Topologies in terms of open sets, neighbourhood system, closed sets and closure operations and their equivalence, points of accumulation, interior, exterior and boundary points. Base and subbase of a topology, subspace, product space, quotient space, continuous, open and closed maps, homeomorphism, convergence of sequence and filters, connectedness and local connectedness, compactness, local compactness, sequential and countable compactness, separation axioms, separability, Lindeloff space, Urysohn's metrization theorem, Tietze Extension Theorem, Tychonoff theorem, one point compactification. **Books Recommended:** 1. J.R. Munkres, Topology, 2nd Edition, Prentice Hall, 2000. 2. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw- Hill, 1963. 3. J. Dugundji, Topology, Prentice Hall, 1965. 4. I.M. Singer and J.A. Thorpe, Lecture Notes on Elementary Topology and Geometry, Springer, 1976.
MTH406 **L-P-T-D[C]** 3-0-1-0[4]	**Graph Theory** **Pre Req.: None** Graphs : Definitions and examples, Graphs as models. Subgraphs, walks, paths and cycles, Connectedness, Matrix representation of graphs, Operations on graphs, connectedness algorithm. Trees and connectivity : Definition and simple properties, Bridge, spanning trees, Caley's theorem. Connector problems. Kruskal's Algorithm, Prim Algorithm. Shortest path problems. The Breadth First Search Algorithm. The Back-tracking Algorithm. Dijkstra's Algorithm. Cut vertices, Connectivity. Euler Tours and Hamiltonian Cycles : Euler Tours, Konigsberg Seven bridges problem Eulerian graphs. Fleury's Algorithm, Hierholzer's Algorithm. The Chinese postman Problem. Hamiltonian graphs. Dirac theorem. Closure of a graph. Bondy and Chavatal Theorem. The travelling salesman problem. The two optimal algorithm. The closest

	Insertion Algorithm. Matchings : Matching and Augmenting paths, Berge theorem. The Marriage problem. The Personnel Assignment problem. The matching algorithm for bipartite graps. The Hungerian Algorithm. The optimal assignment problem. The Kuhn-Munkrej Algorithm. Networks :Max-Min Theorem, Separating sets, Menger's Theorem. Ramsey Theory : Party Problem, relations among Ramsey numbers. **Books Recommended:** 1.John Clerk and Derek Allan Holton : A first look at Graph Theory (Allied Publishers Ltd./World Scientific). 2. F. Haray : Graph Theory. 3. Narsingh Deo : Introduction to Graph Theory with applications to Engineering and Computer Science. 4. Bhave and T. T. Raghunathan : Elements of Graph Theory.
MTH407 **L-P-T-D[C]** 3-0-1-0[4]	**Manifold Theory** **Pre Req.: None** Idea of differential forms. Calculus of forms. Exterior derivatives. Examples of exterior differentiation. Stoke's theorem. Gauss's theorem. Hodge star operator and its properties.Differential Manifolds: definition and examples. The example of a circle. Orientation of a Manifold. Maps between Manifolds. Pull back maps. Lie brackets. Coordinate basis. Introduction to Lie derivatives. Properties of the Lie derivative. Poincare lemma. A brief discussion on de-Rham cohomology. Idea of Killing vectors. Integration on Manifolds. Partition of unity. Applications. **Books Recommended:** 1. B.Schutz, Geometrical Methods in Mathematical Physics, Cambridge University Press. 2. D.Martin Manifold Theory: An introduction for mathematical Physicists, Albion/Horwood. 3. Siddhartha Sen, A short course on Differentiable Manifolds, Calcutta University Press (2011).
MTH408 **L-P-T-D[C]** 3-0-1-0[4]	**Algebraic Geometry** **Pre Req.: None** Prime ideals and primary decompositions, Ideals in polynomial rings, Hilbert Basis theorem. Noether normalisation lemma, Hilbert's Nullstellensatz, Affine and Projective varieties, Zariski Topology, Rational functions and morphisms, Elementary dimension theory, Smoothness, Curves, Divisors on curves, Bezout's theorem, Riemann-Roch for curves, Line bundles on Projective spaces. **Books Recommended:** 1. K. Hulek, "Elementary Algebraic Geometry", Student Mathematical Library 20, American Mathematical Society, 2003. 2. I. R. Shafarevich, "Basic Algebraic Geometry 1: Varieties in Projective Space", Springer, 2013. 3. J. Harris, "Algebraic geometry", Graduate Texts in Mathematics 133, Springer Verlag, 1995.

	4. M.Reid,"UndergraduateAlgebraicGeometry",LondonMathematicalSocietyStudent Texts 12, Cambridge University Press, 1988. 5. K.E.Smithet. al.,"AnInvitationtoAlgebraicGeometry",Universitext,SpringerVerlag, 2000. 6. R.Hartshorne, "AlgebraicGeometry", Graduate Textsin Mathematics 52, Springer Verlag, 1977.
MTH409 **L-P-T-D[C]** 3-0-1-0[4]	**Algebraic Topology** **Pre Req.: MTH 405** Homotopy Theory: Simply Connected Spaces, Covering Spaces, Universal Covering Spaces, Deck Transformations, Path lifting lemma, Homotopy lifting lemma, Group Actions, Properly discontinuous action, free groups, free product with amalgamation, Seifert-Van Kampen Theorem, Borsuk Ulam Theorem for sphere, Jordan Separation Theorem, Homology Theory: Simplexes, Simplicial Complexes, Triangulation of spaces, Simplicial Chain Complexes, Simplicial Homology, Singular Chain Complexes, Cycles and Boundary, Singular Homology, Relative Homology, Short Exact Sequences, Long Exact Sequences, Mayer-Vietoris sequence, Excision Theorem, Invariance of Domain. **Text Books:** 1. J. R. Munkres, "Topology", Prentice-Hall of India, 2013. 2. A. Hatcher, "Algebraic Topology", Cambridge University Press, 2009. **References:** 1. G. E. Bredon, "Topology and Geometry", Graduates Texts in Mathematics 139, Springer, 2009.
MTH410 **L-P-T-D[C]** 3-0-1-0[4]	**Algebraic Number Theory** **Pre Req.: MTH203** Number Fields and Number rings, prime decomposition in number rings, Dedekind domains, Ideal class group, Galois theory applied to prime decomposition, Gauss reciprocity law, Cyclotomic fields and their ring of integers, finiteness of ideal class group, Dirichlet unit theorem, valuations and completions of number fields, Dedekind zeta function and distribution of ideal in a number ring. **Books Recommended :** 1. D. A. Marcus, "Number Fields", Springer-Verlag 2. G. J. Janusz, "Algebraic Number Fields", American Mathematical Society 3. S. Lang, "Algebraic Number Theory", Springer-Verlag. 4. S. Alaca, K. S. Williams, "Introductory Algebraic Number Theory", Cambridge University Press.
MTH411 **L-P-T-D[C]** 3-0-1-0[4]	**Number Theoretic Cryptography-I** **Pre Req.: None** Time estimates for doing arithmetic, Divisibility and Euclidean Algorithm, Congruencies, Some applications to factoring, finite fields, Quadratic residues and reciprocity, some simple cryptosystems, Enciphering matrices, The idea of public key cryptography, RSA. **Books Recommended :** 1. Neal Koblitz, A course in number theoretic cryptography, springer veriag, GTM No-114 (1987) Chapter : 1,2,3,4, (4.1 and 4.2) only

	2. A.J.Menezes. P.C.Van Oorchot and Scoff A.Vanstone , Hand book of applied cryptography, CRC Press 1987.
MTH412 **L-P-T-D[C]** 3-0-1-0[4]	**Number Theoretic Cryptography-II** **Pre Req.: None** Discretelog, Knapsack, Zero knowledge protocol and oblivious transfer pseudo primes, The rho method, Fermat Factorisation and factor basis, The continued fraction method, The quadratic seive method. **Books Recommended :** 1. Neal Koblitz, A course in number theoretic cryptography, springer veriag, GTM No-114 (1987). 2. A.J.Menezes. P.C.Van Oorchot and Scoff A.Vanstone , Hand book of applied cryptography, CRC Press 1987.
MTH413 **L-P-T-D[C]** 3-0-1-0[4]	**Introduction to Continuum Mechanics** **Pre Req.: None** Introduction to tensors. Stress tensor. Equilibrium equations. Mohr's circle for plane stress. Deformation, Strain tensor, Rate of deformation tensor. Equations of motion. Dynamic similarity. Exact solutions. Laminar boundary layer over a float plat. Vorticity circulation & irrational flow. Torsion of cylindrical bars, Plane elastic waves. **Books Recommended:** 1. G. Thomas Mase, George E. Mase, \Continuum Mechanics for Engineers", CRC Press 2. Y.C. Fung, \A first course in Continuum Mechanics", Prentice Hall
MTH414 **L-P-T-D[C]** 3-0-1-0[4]	**Classical Mechanics** **Pre Req.: None** Review of Newtonian mechanics, Generalized coordinates, The principle of least action, Lagrange's equation, The Lagrangian for a free particle and for a system of particles; Symmetries, Conservation laws and No ethers theorem, Conservation of energy, momentum and angular momentum; Integrating the equations of motion: motion in one dimension, Central force motion and Kepler's problem, Collisions: elastic collisions, scattering and Rutherfords formula. Motion of a rigid body, Angular velocity, Moment of inertia, Angular momentum, Euler angles, Euler's equations. Motion in a non-inertial frame; Small oscillations: simple harmonic, forced, damped and anharmonic oscillations; The Hamilton equations of motion, Legendre transformations, Cyclic coordinates, Routhian; Invariance properties of the Lagrangian and Hamiltonian descriptions, Poisson and Lagrange brackets; Canonical transformations, Group properties and methods of constructing canonical transformations; Hamilton-Jacobi theory and action-angle variables, The harmonic oscillator as an example, The Kepler problem in action angle variables. **Books Recommended:** 1. H. Goldstein, C. Poole and J. Safko, Classical Mechanics, 3rd Ed. Addison- Wesley, 2005. 2. L. D. Landau and E. M. Lifshitz, Mechanics, Vol. 1 of course of Theoretical Physics, Pergamon Press, 2000.

MTH415 **L-P-T-D[C]** 3-0-1-0[4]	**Fluid Dynamics** **Pre Req.: None** Equations of motion for viscous fluid, similarity of flows, Reynolds number, Flow between parallel flat plates, steady flow in pipes, Flow between two concentric cylinders, Application of parallel flow theory, Unsteady flow over a flat plate, Boundary layer concept, Boundary layer equations in two-dimensional flow, Boundary layer flow along the flat plates: Blasius solution, Shearing stress and Boundary layer thickness, Boundary layer on a surface with pressure gradient, Momentum integral theorems for Boundary layer, The Von Karman integral relation, Application of Momentum integral equation to Boundary layers: Von Karman-Pohlhansen method, Separation of boundary layer flow, Boundary layer control, Methods of Boundary layer control, Introduction to turbulent flow: Origin of turbulence, Reynold's modification of Navier-Stoke's equations for turbulent flow, Semiemperical theory of turbulence. **Books Recommeded:** 1. F. Chorlton : Text Book of Fluid Dynamics. 2. D. E. Rutherford : Fluid Mechanics. 3. J. L. Bansal : Viscous Fluid Dynamics. 4. Milne-Thomson : Theoretical Hydrodynamics. 5. G. K. Batchelor : An Introduction to Fluid Dynamics. 6. N. Curle and H. J. Davies : Modern Fluid Dynamics,Vol. I. 7. R. C. Binder : Advanced Fluid Mechanics. 8. Landau and Lifshitz : Fluid Mechanics.
MTH416 **L-P-T-D[C]** 3-0-1-0[4]	**Data Base Management System** **Pre Req.: None** File Organization: Introduction, Physical / logical files Special characters in files, fields & record organization (fixed, variable length) types of file organization (heap, sorted, indexed, hashed), choosing a file organization; Indexed File Organization: Overview of indexes, types of indexes (dense, sparse, clustered, primary, secondary, tree (multilevel indexes, B+ tree); Introduction of DBMS: Overview, File system Vs DBMS, Describing & storing data (Data models (relational, hierarchical, network)), Levels of abstraction, data independence, Queries in DBMS (SQL : DDL, DML,DCL,TCL), Structure of DBMS, People who deal in DBMS, Advantages of DBMS; Conceptual Design (E-R model): Overview of DB design, ER data model (entities, attributes, entity sets, relations, relationship sets), Additional constraints (key constraints, participation constraints, weak entities, aggregation / generalization, conceptual design using ER (entities VS attributes, Entity Vs relationship, binary Vs ternary, constraints beyond ER), Conceptual design for small to large enterprises, Case studies; Relational data model: Relations (concepts, definition), Conversion of ER to Relational model, integrity constraints (key, referential integrity, general constraints). Relational algebra: Preliminaries, Relational algebra (selection, projection, set operations, renaming, joins, division); SQL: DDL (create, drop, alter), forms of a basic SQL query (egs, expressions, strings in SQL), union / intersection / except, nested queries(introduction, correlated queries, set comparison operators), Aggregate operators (group by, having), aggrerate functions, Null values (comparison using NULL, logical connections (AND,OR,NOT) impact on SQL commands, outer joins,

	disallowing NULL), examples on SQL (case studies) **Books Recommended:** 1. Korth, Silberchatz, Sudarshan , .Database System Concepts., McGraw-Hill. 2. Elmasri and Navathe, .Fundamentals of Database Systems., Pearson Education. 3. Raghu Ramakrishnan, Johannes Gehrke, .Database Management Systems., McGraw-Hill 4. Postgresql , O'Reilly publications. 5. Peter Rob and Coronel, .Database Systems, Design, Implementation and Management., Thomson Learning. 6. C.J.Date, Longman, .Introduction To Database Systems., Pearson Education
MTH417 **L-P-T-D[C]** 3-0-1-0[4]	**Operations Research** **Pre Req.: MTH313** Convex functions and their properties. Unconstrained and constrained optimization problems. Fritz-John and Karush-Kuhn-Tucker optimality conditions. Quadratic Programming: Wolfe's and Beale's method. Applications of Quadratic programming. Dorn's Duality for Quadratic programming Problem. Linear and Quadratic Programming Complementary Pivoting Algorithms. Steepest Ascent and Descent Method. Feasible Direction Method. Separable Programming. Linear Fractional Programming. Inventory Model: Deterministic Inventory Control Models: Introduction, Classification of inventories, Advantages of Inventory, Economic ordered quantity model (EOQ model), EOQ with finite supply, EOQ with backorders, EOQ with constraints, All-units quantity discounts model. Queuing Theory: General concepts of a queueing system, measures of performance, arrival and service processes, single and multiple server models, channels in parallel and in series with limited and unlimited queues, Little's formula, Queues with finite waiting room, Queues with impatient customer (Balking and reneging), Markovian queues- M/M/1 with finite and infinite waiting space, M/M/C, Birth and death queuing systems, Finite Source **Books Recommended:** 1. Donald Gross, John F. Shortle, James M. Thompson, Carl M. Harris: Fundamentals of Queueing Theory. 2. Donald Waters: Inventory Control and Management 3. Hamdy A. Taha: Operations Research-An Introduction.
MTH418 **L-P-T-D[C]** 3-0-1-0[4]	**Boolean Algebra and Automata Theory** **Pre Req.: None** Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, lattices as ordered sets, lattices as algebraic structures, sublattices, products and homomorphisms. Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, switching circuits and applications of switching circuits. Introduction: Alphabets, strings, and languages. Finite Automata and Regular Languages: deterministic and non-deterministic finite automata, regular expressions, regular languages and their relationship with finite automata, pumping lemma and closure properties of regular languages. Context Free Grammars and Pushdown Automata: Context free grammars

	(CFG), parse trees, ambiguities in grammars and languages, pushdown automaton (PDA) and the language accepted by PDA, deterministic PDA, Non- deterministic PDA, properties of context free languages; normal forms, pumping lemma, closure properties, decision properties. Turing Machines: Turing machine as a model of computation, programming with a Turing machine, variants of Turing machine and their equivalence. Undecidability: Recursively enumerable and recursive languages, undecidable problems about Turing machines: halting problem, Post Correspondence Problem, and undecidability problems About CFGs. **Books Recommended:** 1. B A. Davey and H. A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990. 2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, (2nd Ed.), Pearson Education (Singapore) P.Ltd., Indian Reprint 2003. 3. Rudolf Lidl and Günter Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004. 4. J. E. Hopcroft, R. Motwani and J. D. Ullman, Introduction to Automata Theory, Languages, and Computation, 2nd Ed., Addison-Wesley, 2001. 5. H.R. Lewis, C.H. Papadimitriou, C. Papadimitriou, Elements of the Theory of Computation, 2nd Ed., Prentice-Hall, NJ, 1997. 6. J.A. Anderson, Automata Theory with Modern Applications, Cambridge University Press, 2006.
MTH419 **L-P-T-D[C]** 3-0-1-0[4]	**Parallel Computing** **Pre Req.: None** Need, Parallelism in uniprocessors systems; Models of Parallel 19 computation; Topology of interconnection networks; review of pipelining, pipelined vector processing methods, Embedding other networks, Parallel algorithm design; Performance and scalability; Algorithms for array processors: sum, prefix computation, matrix multiplication; parallel sorting: odd-even transposition sorting, odd-even merging, enumeration sorting, bitonic sorting, odd-even merging network; Communication algorithms: One-to-all, all-to-one, all-to-all, Multiprocessor interconnection networks and algorithms; Dataflow computers; Parallel algorithms on systolic array; Reconfigurable processor array. Models of distributed computation; Design issues; Operating systems for distributed computing: Distributed algorithms and applications, Clock synchronization algorithms; Distributed memory systems; Message passing; Middleware; Pointto-point communication; Fault Tolerance; Fault tolerant routing. **Books Recommended:** 1. Wilkinson and Allen, Parallel Programming: Techniques and Applications Using Networked Workstations and Parallel Computers, Prentice Hall, 1999. 2. Quinn, M., Parallel Computing: Theory and Practice, McGraw Hill, 1994. 3. V. Kumar, A. Grama, A. Gupta, and G. Karypis, Introduction to Parallel Computing, The Benjamin/Cummings Pub. Co 4. Ian Foster, Designing and Building Parallel Programs, Addison-Wesley Pub. (Available online on Web at www.mcs.anl.gov/dbpp)

	5. K. M. Chandy and Taylor, An Introduction to Parallel Programming, Jones and Bartlett Pub.
MTH420 **L-P-T-D[C]** 3-0-1-0[4]	**Advanced Numerical Methods** **Pre Req.: MTH304** Solution of tridiagonal system, Complex root of non-linear equation, solution of simultaneous non-linear equations, Numerical evaluation of double and triple integrals with constant and variable limits and its application, Solution of integral equations, Solution of initial-value problem by single and multistep methods, Solution of linear and non-linear boundary-value problems, Solution of Characteristics value problems, Solution of Laplace and Poisson equations in two variables by five point formula, Solution of Laplace equation in two variables by ADI method, Solution of mixed boundary value problem, Algorithm for elliptic equation in three variables, Solution of parabolic partial differential equation in two variables by explicit and implicit methods, Solution of parabolic equation in three variables by ADE and ADI methods, Solution of hyperbolic equation in two variables by explicit and implicit methods and algorithm for hyperbolic equation in three variables, Stability of finite difference schemes for parabolic and hyperbolic equations. **Books Recommended:** 1. K. E. Atkinson, \An Introduction to Numerical Analysis" Wiley-India Edition, 2013. 2. M.K. Jain, S.R.K Iyengar, R.K. Jain: Numerical Methods, New age International 3. C. Balachandra Rao and Shantha, C.K: Numerical Methods, University Press 4. Samuel D. Conte, Carl de Boor, \Elementary Numerical Analysis", Tata McGraw-Hill Edition
MTH501 **L-P-T-D[C]** 3-0-1-0[4]	**Mathematical Methods** **Pre Req.: None** Calculus of Variations: Extrema of Functionals, The variation of a functional and its properties - Euler's equation Field of extremals - sufficient conditions for the Extremum of a Functional conditional Extremum Moving boundary problems Discontinuous problems - one sided variations - Ritz method. Perturbation Methods: Perturbation theory, Regular perturbation theory, Singular perturbation theory, Asymptotic matching, Time Scaling Method. **Books Recommended:** 1. Earl A. Coddington, Norman Levinson, \Theory of Ordinary Differential Equations", Tata McGraw Hill Edition 2. M. Gelfand, S.V. Fomin, \Calculus of Variations", Dover Publication Inc. 3. A. H. Neyfeh, " Perturbation Methods", Wiley-VCH
MTH502 **L-P-T-D[C]** 0-0-0-7[12]	**Project - I** **Pre Req.: None**
MTH503 **L-P-T-D[C]** 3-0-1-0[4]	**Integral Equations and Transformations** **Pre Req.: None** Classification of Liner Integral Equations : Fredholm, Volterra, Integro- Differential Equations, Singular Integral Equations, Converting Volterra Equation to ODE,

	Conversion of IVP to Volterra equation Conversion of BVP to Fredholm equation. Fredholm Intergral Equations - Decomposition method, Direct Computation method, successive approximation method, method of successive substitutions, Homogeneous Fredholm Equations, Comparison between alternative methods. Volterra Integral Equation – Adomian Decomposion method, Series solution method, converting Volterra equation to VIP, Successive Approximation method, successive substitution method, comparison between alternative methods Integro-Differential Equations - Introduction, Direct Computation method, Adomian Decomposition Method. Conversion to Fredholm integral Equation. VolterraIntego-Differential equations Series Solution, Decomposition Method, Conversion to IVP. Singular Integral Equations - Abel problem, Genralized Abel Integral Equation, Weakly-singular Volterra Equations. Non Liner Integral Equation`s - Non liner Fredholm Integral equations, Direct Computation, decomposition method, Non liner Volterra Integral Equation, Series solution, Decomposition method. Existence and uniqueness of solutions using fixed-point theorems in cash of Liner and non-liner Volterra and Fredholm integral equations. Fourier Transforms: [FT] Definition Properties evaluation of Fourier and inverse Fourier transforms of functions, Convolution theorem for FT. Sine and Cosine Fourier transforms. Solving differential equations and integral equations using FT.Laplace Transform:Definition Properties, evaluation of Laplace and Inverse Laplace transforms of functions. Convolution theorem for Laplace Transforms.Solving initial value problem using Laplace Transforms. Solving integral equation using Laplace Transforms. **Books Recommended:** 1) A First course in integral equations –A.M. Wazwaz (1997) (worldScientific) 2) Introduction to Integral Equation with Applications –A.J. Jerri (1999) Second edition Wiley Interscience.
MTH504 **L-P-T-D[C]** 0-0-0-7[16]	**Project - II** **Pre Req.: None**
MTH505 **L-P-T-D[C]** 3-0-1-0[4]	**Wavelets: Theory and Applications** **Pre Req.: None** Fourier transforms, Wavelets transforms and time-frequency analysis, Cardinal spline analysis, Scaling functions and wavelets, Cardinal spline wavelets, Orthogonal bases of compactly supported wavelets, Applications to signal analysis. **Book Recommended:** 1. David F. Walnut, " An Introduction to Wavelet Analysis", Springer
MTH506 **L-P-T-D[C]** 3-0-1-0[4]	**Complex Dynamics and Fractals** **Pre Req.: None** Chordal & spherical metrics, Normal families. Iteration of polynomials and rational functions, Periodic points & orbits, Julia & Fatou's sets and their characterizations, Dynamics of Julia and Fatou's sets for quadratic, Rational & entire functions; The Mandelbrot set. Julia sets & fractals, Self-similarity and fractal dimension. **Book Recommended:**

	1. Michael Barnsley, "Fractal Everywhere", Academic Press Inc.
MTH507 **L-P-T-D[C]** 3-0-1-0[4]	**Commutative Algebra** **Pre Req.: MTH301** Commutative rings, ideals, operations on ideals, prime and maximal ideals, nilradicals, Jacobson radicals, extension and contraction of ideals, Modules, free modules, projective modules, exact sequences, tensor product of modules, Restriction and extension of scalars, localization and local rings, extended and contracted ideals in rings of fractions, Noetherian modules, Artinian modules, Primary decompositions and associate primes, Integral extensions, Valuation rings, Discrete valuation rings, Dedekind domains, Fractional ideals, Completion, Dimension theory. **Books Recommended:** 1. M. F. Atiyah, I. G. Macdonald, "Introduction to Commutative Algebra", AddisonWesley Publishing Co., 1969. 2. R. Y. Sharp, "Steps in Commutative Algebra", London Mathematical Society Student Texts, 51. Cambridge University Press, 2000. 3. D. S. Dummit, R. M. Foote, "Abstract Algebra", Wiley-India edition, 2013.
MTH508 **L-P-T-D[C]** 3-0-1-0[4]	**Set Theory & Logic** **Pre Req.: None** Propositional calculus Set theoretic concepts; Truth on algebraic systems; The calculus of predicates; Model theory, Proof Theory, Algorithms and recursive functions. **Books Recommended:** 1. Karel Hrbacek, Thomas Jech, "Introduction to Set Theory", Marcel Dekker, Inc.
MTH509 **L-P-T-D[C]** 3-0-1-0[4]	**Elliptic Curves** **Pre Req.: None** Congruent numbers, Elliptic curves, Elliptic curves in Weierstrass form, Addition law, Mordell–Weil Theorem, Points of finite order, Points over finite fields, Hasse-Weil L-function and its functional equation, Complex multiplication. **Books Recommended :** 1. J. Tate and J. H. Silverman, "Rational Points on Elliptic Curves", Springer-Verlag 2. J. H. Silverman, "The Arithmetic of Elliptic Curves", Springer 3. A. W. Knapp, "Elliptic Curves", Princeton University Press
MTH510 **L-P-T-D[C]** 3-0-1-0[4]	**Mathematical Modeling & Simulations** **Pre Req.: None** Deterministic and stochastic models, Characteristics, Classifications, tools, techniques, modeling approaches, Modeling diagram, Compartmental models, Dynamical systems and its mathematical models, Models from systems of natural sciences: single and interacting populations, prey-predator, competition, Epidemic models, Modeling of physical, Atmospheric and mining systems: Models of Heating and Cooling, Henon-Heiles System, Models for traffic flow, computer data communications, Stock Market, Modeling El Nino, Lorenz's model for global atmospheric circulation, Model for detecting land mines, modeling the ventilation system of a mine, Model for thermal environment of underground shopping Mall, Modeling Engineering systems: Models from Mechanical and Electronics systems, Models for vehicle dynamics, Hunt's

	oscillator, Kicked Harmonic oscillator, RLC Circuit, Chua Circuit, MLC Circuit, Matlab programs to study the dynamics of the developed model systems. **Books Recommended:** 1. J.N. Kapur, \Mathematical Modelling", New Age International (1988)
MTH511 **L-P-T-D[C]** 3-0-1-0[4]	**Computational Fluid Dynamics** **Pre Req.: MTH415** Governing equation of Fluid Dynamics, conservation form, simple CFD techniques, Lax-Wendroff technique, Mac Cormack's techniques, finite volume method, application to Euler equations, upwind difference scheme, viscous flow solutions, staggered grid, SIMPLE Algorithm, SOLA Algorithm, boundary element method and application to potential flows. **Books Recommended:** 1. Wendt, John, \An Introduction Computational Fluid Dynamics", Springer 2. John Anderson, \Computational Fluid Dynamics", McGraw- Hill
MTH512 **L-P-T-D[C]** 3-0-1-0[4]	**Design and Analysis of Algorithms** **Pre Req.: None** Analysis: Algorithm definition, space complexity, time complexity, worst case –best case –average case complexity, asymptotic notation, sorting algorithms (insertion sort, heap sort) , sorting in linear time, searching algorithms, recursive algorithms (Tower of Hanoi , Permutations). Design strategies Divide and conquer: control abstraction, binary search, merge sort, Quick sort, Strassen's matrix multiplication Greedy method: knapsack problem, job sequencing with deadlines, minimum-cost spanning trees, Kruskal and Prim's algorithm, optimal storage on tapes, optimal merge patterns. Huffman coding Dynamic programming: matrix chain multiplication, . single source shortest paths, Dijkstra's algorithm, Bellman- ford algorithm , all pairs shortest path, longest common subsequence, string editing, 0/1 knapsack problem, Traveling salesperson problem. Decrease and conquer: DFS and BFS, Topological sorting, connected components Backtracking: General method, 8 Queen's problem, Sum of subsets problem, graph coloring problem, Hamiltonian cycle Branch and Bound Technique : FIFO, LIFO, LCBB, TSP problem, 0/1 knapsack problem Transform and conquer:- Horner's Rule and Binary Exponentiation – Problem Reduction Problem classification: Nondeterministic algorithm, The class of P, NP, NP-hard and NP- Complete problems, significance of Cook's theorem. **Books Recommended :** 1. Ellis Horowitz, Sartaj Sahni & Sanguthevar Rajasekaran, Computer Algorithms, Galgotia. 2.T. Cormen, C. Leiserson, & R. Rivest, Algorithms, MIT Press, 1990 3. A. Aho, J. Hopcroft, & J. Ullman, The Design and Analysis of Computer Algorithms, Addison Wesley, 1974 4. Donald Knuth, The Art of Computer Programming (3 vols., various editions, 1973-81), Addison Wesley

	5.The Algorithm Manual, Steven Skiena, Springer ISBN:9788184898651 6.Graphs, Networks and Algorithms, Jungnickel, Springer, ISBN: 3540219056
MTH513 **L-P-T-D[C]** 3-0-1-0[4]	**Non-Linear Dynamics and Chaos** **Pre Req.: None** Dynamical systems- Central manifold and Normal form, attractors, SIC, 1D map, Logistic map, Poincare' maps, generalized Baker's map, circle map. Bifurcations- Saddlenode, Transcritical, pitchfork, Hopf-bifurcation, Global bifurcations, Melnikov's method for homoclinic orbits, Strange attractors & fractals dimentions, Henon map and Rossler\ system, Box-counting, pointwise and correlation, hausdorff dimensions, Lyapunov exponent, Horseshoe map and symbolic dynamics, chaotic transitions, intermittency, crisis, quasiperiodicity, controlling & synchronization of chaos. **Books Recommended:** 1. S.H.Strogatz Nonlinear dynamics and Chaos Addison-Wesley. 2. R.C.Hilborn, Chaos and Nonlinear Dynamics, Oxford University Press. 3. R.K. Upadhyay, SRK Iyengar, \ Introduction to Mathematical Modeling and Chaotic Dynamics", CRC Press
MTH514 **L-P-T-D[C]** 3-0-1-0[4]	**Discrete Dynamical Systems** **Pre Req.: None** Phase Portraits, Periodic Points and Stable Sets, Sarkovskii's Theorem, Hyperbolic, Attracting and Repelling Periodic Points. Families of Dynamical Systems, Bifurcation, Topological Conjugacy. The Logistic Function, Cantor Sets and Chaos, Period-Doubling Cascade. Symbolic Dynamics. Newton's Method. Numerical Solutions of Differential Equations. Complex Dynamics, Quadratic Family, Julia Sets, Mandelbrot Set. Topological Entropy, Attractors and Fractals, Theory of Chaotic Dynamical systems. **Books Recommended:** 1. M W Hirsch, S Smale and R L Devaney Differential equations, Dynamical systems and an Introduction to Chaos, Elsevier Academic Press. 2. R L Devaney An introduction chaotic Dynamical System, Addison-Wesley. 3. A.Katok and B.Hasselblatt, Introduction to the Modern theory of Dynamical Systems, Cambridge University of Press.
MTH515 **L-P-T-D[C]** 3-0-1-0[4]	**Sampling Theory** **Pre Req.: None** Basic methods of sample selection, simple random sampling with replacement (SRSWR), simple random sampling without replacement (SRSWOR)**,** probability proportional sampling with and without replacement, systematic sampling, estimation problems, Horwitz- Thompson estimator and its properties, Stratification: Allocation problems and estimation problems, formation of strata and number of strata, method of collapsed strata. Use of supplementary information for estimation, ratio and regression estimators with their properties and generalizations, Jackknife methods. Cluster sampling, multistage-sampling. Double sampling procedures, Ratio and regression estimators, stratification. Non-sampling errors, response and non-response errors and their treatments, randomized response.

	Books Recommended: 1. Des Raj and Chandhok, P. (1998). Sample Survey Theory (Narosa) 2. Sukhatme P.V, Suktatme, B.V., Sukhatme S. and Asok C. (1984). Sampling Theory of Surveys with Applications (Indian Soc. for Agricultural Statistics, New Delhi). 3. Cochran, W.G. (1984). Sampling Techniques (Wiley) 4. Murthy, M.N. (1977). Sampling Theory and Methods
MTH516 **L-P-T-D[C]** 3-0-1-0[4]	**Statistical Pattern Recognition** **Pre Req.: None** Linear classifiers: linear discriminant function (LDF) for minimum squared error, LDF for binary outputs, perception learning algorithm. Nearest neighbour decision rules: description, convergence, finite sample considerations, use of branch and bound methods. Probability of errors: two classes, normal distributions, equal covariance matrix assumptions. Chernoff bounds and Bhattacharya distance, estimation of probability of error. Feature selection and extraction: interclass distance measures, discriminant analysis, probabilistic distance measures, principal components. **Books Recommended:** 1. Duda, R.O. and Hart, P.E. (1973). Pattern Recognition and Scene Analysis. (Wiley). Fukunaga,K. (1990). Introduction to Statistical Pattern Recognition, 2nd Ed. (Academic Press). 2. McLachlan, G.J. (1992). Discriminant Analysis and Statistical Pattern Recognition. (Wiley). 3. Ripley, B.D. (1996). Pattern Recognition and Neural Networks. (Cambridge University Press).
MTH517 **L-P-T-D[C]** 3-0-1-0[4]	**Statistical Simulations** **Pre Req.: None** Stochastic simulations: generating random variables, simulating normal, gamma and beta random variables. Comparison of algorithms to generate random variables. Generating random variables from failure rates. Simulating multivariate distributions, MCMC methods and Gibbs sampler, Simulating random fields, simulating stochastic processes. Variance reduction techniques: importance sampling for integration, control variates and antithetic variables. Simulating a non-homogeneous Poisson process. Optimization using Monte Carlo methods, simulated annealing for optimization. Solving differential equations by Monte Carlo methods. **Books Recommended:** 1. Fishman, G.S. (1996) Monte Carlo: Concepts, Algorithms, and Applications. (Springer). 2. Rubinstein, R.Y. (1981); Simulation and the Monte Carlo Method. (Wiley). 3. Ripley B.D. (1987) Stochastic Simulations (Wiley) 4. Ross, S.M.(2002) Simulation (Third Edition) (Academic)
MTH518 **L-P-T-D[C]** 3-0-1-0[4]	**Medical and Health Statistics** **Pre Req.: None** Study designs in epidemiology. Measures of disease occurrence and association, variation and bias. Identifying non-causal association and confounding. Defining and assessing heterogeneity of effects, interaction. Sensitivity and specificity of diagnostic

	test, .Cohort Study designs, statistical power and sample size computations. Log-linear models, 2xK and 2x2x2 contingency tables. Logistic model. Analysis of binary data. Cross-control study designs, matched case-control studies Survival data: Proportional hazards model, multivariate survival data. Causal Inference, Longitudinal data. Communicating results of epidemiological studies, ethical issues in epidemiology. **Books Recommended:** 1. Selvin : Statistical analysis of epidemiological data. 2. Diggle, Liang and Zeger : Analysis of longitudinal data 3. Piantadosi : Clinical trials 4. Agresti : Categorical Data Analysis. 5. Clayton and Hills : Statistical methods in Epidemiology 6. McCullagh and Nelder : Generalized Linear Models. 7. Brookemeyer and Gail : AIDS Epidemiology : A Quantitative Approach 8. Zhou, Obuchowski and McClish : Statistical Methods in Diagnostic Medicine
MTH519 **L-P-T-D[C]** 3-0-1-0[4]	**Reliability Modeling and Analysis** **Pre Req.: None** Basic concepts in reliability: Failure rate, mean, variance and percentile residual life, identities connecting them; Notions of ageing - IFR, IFRA, NBU, NBUE, DMRL, HNBUE, NBUC etc and their mutual implications. TTT transforms and characterization of ageing classes. Non monotonic failure rates and mean residual life functions, Study of life time models viz. exponential, Weibull, lognormal, generalized Pareto, gamma with reference to basic concepts and ageing characteristics; Bath tub and upside down bath tub failure rate distributions. Discrete time failure models:- Definition of basic functions and their properties; Ageing classes and their mutual implications, Reliability systems with dependents components:-Parallel and series systems, k out of n systems, ageing properties with dependent and independents components. concepts and measures of dependence in reliability - RCSI, LCSD, PF2, WPQD. Reliability estimation using MLE - exponential, Weibull and gamma distributions based on censored and non censored samples; UMVUE estimation of reliability function; Bayesian reliability estimation of exponential and Weibull models. **Books Recommended:** 1. Lai, C.D and Xie, M. (2006) Stochastic ageing and dependence in reliability (Relevant topics) Springer. 2. Sinha S K (1986) Reliability and Life Testing, Wiley Eastern. 3. Barlow, R.E. and Proschan, F. (1975) Statisical Theory of Reliability and Life Testing, Holt, Reinhart and Winston. 4. Marshall, A.W. and Olkin, I. (2007) Life Distributions, Springer 5. Galambos, J. and Kotz, S. (1978) Characterization of Probability distributions, Springer
MTH520 **L-P-T-D[C]** 3-0-1-0[4]	**Design of Experiments** **Pre Req.: None** Block Designs and optimality, the C-Matrix, E-optimality, A-optimality, D- optimality. Plackett Burman Designs and their properties. Experimental Designs for fitting response surfaces. Design criterion involving bias and variance. Restricted Surface

	Methods and Taguchi's Parameter Design. Restricted Region Simplex Designs. Mixture experiments involving process variables. Weighing Designs. **Books Recommended:** 1. Bapat, R.B. (1993): Linear Algebra and Linear Models, Hindustan Book Agency Publishers, 2. Box, G.E.P. & Draper, N.R. (1989): Empirical Model-Building and Response Surfaces, John Wiley & Sons. 3. Cornell, John, A. (1990): Experiments with mixtures; Design, Models and the Analysis of Mixture data. John Wiley & Sons, New York. 4. Khuri, A. I. & Cornell, John, A. (1996): Response Surfaces: Design and Analysis, Marcel Dekker. 5. Lin, D.K. J. & Draper, N.R. (1999): Projection Properties of Placket and Burman Designs, Technometrices Vol. 34 pp.423-428. 6. Myers, R.H. and Montgomery, D.C.(1995): Response Surface Methodology, Process and Product Optimization Using design of Experiments. John Wiley & Sons, 1WC, New York. 7. Raghavarao, D. (1971): Construction and Combinatorial Problems of Design of Experiments, John Wiley & Sons, New York.
MTH521 **L-P-T-D[C]** 3-0-1-0[4]	**Order Statistics** **Pre Req.: MTH 306** Conditional distributions, Order Statistics and Markov chain, Order Statistic for independent non-identically distributed variates, permanent expressions for densities of order statistics. Discrete order statistics, Dependence structure in the discrete case, Geometric order statistics, order statistics from a without replacement sample. Bounds and approximations for moments of order statistics, Bounds in the case of dependent variates, Approximations to moments in terms of the inverse c.d.f. and its derivatives. Statistics expressible as maxima with applications, order statistics for exchangeable variates. Concomitants of order statistics, order statistics in estimation and hypothesis testing, Distribution-free confidence and tolerance intervals. Characterizations using order statistics. Recurrence relations and identities for moments of order statistics from an arbitrary continuous distribution and those from some specific distributions, viz. exponential, Logistic, Normal, Half logistic, right-truncated exponential and doubly truncated exponential. Order statistics from a sample containing a single outlier: Distributions of Order Statistics, Recurrence relations for single and product moments, Functional behaviour of order statistics in cases of location and scale-outlier models. Asymptotic theory, the asymptotic joint distribution of sample quantiles, the asymptotic distribution of extreme values. **Books Recommended:** 1. Arnold, B.C. Balakrishanan, N. and Nagaraja, H.N. (1989): Relations, Bounds Approximations for Order Statistics. Lecture Notes in Statistics, Vol., 53 Springer-Verlag. 2. Arnold, B.C., Balakrishanan, N. and Nagaraja, H.N. (1992): A First Course in Order Statistics, John Wiley. 3. David, H.A. (1981): Order Statistics (2nd Ed.) John wiley.

	4. Galambos J. (1987): The Asymptotic Theory of Extreme Order Statistics (2nd Ed.). Krieger, F.L. 5. Gumbel, E.J. (1958): Statistics of Extremes, Columbia University Press, New York. 6. Sarhan, A.E. and Greenberg, B.G. (Eds.) (1962): Contributions to Order Statistics, Wiley, New York.
MTH522 **L-P-T-D[C]** 3-0-1-0[4]	**Advance Linear Algebra** **Pre Req.: MTH103** Simultaneous diagonalization/ Triangulazation, direct sum decomposition, primary decomposition theorem, rational and Jordan canonical form, Inner product spaces and norms, Gram-Schmidt orthogonalisation process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator, Least Squares Approximation, minimal solutions to systems of linear equations, Normal and self-adjoint operators, Orthogonal projections and Spectral theorem. **Books Recommended:** 1. K. Hoffman, R. Kunze, \Linear Algebra", Prentice-Hall of India, 2012. 2. Stephen H. Friedberg, Arnold J. Insel & Lawrence E. Spence (2003). Linear Algebra (4th edition). Prentice-Hall of India Pvt. Ltd.
MTH601 **L-P-T-D[C]** 3-0-1-0[4]	**Sobolev Spaces** **Pre Req.: None** Introduction, Test function spaces, Calculus with distributions, supports of distributions, Structure theorems, convolutions, Fourier transforms, L_1 , L_2 theory of Fourier Transform, Tempered distributions, Applications of distributions theory and Fourier transform to differential equations. Hilbert Space, The Sobolev Space, $H^{m,\,p}(\Omega)$, The Sobolev Space $H^s(\ ^n)$, Product and Convolution in $H^s(\ ^n)$, The space H^{-s}, The Sobolev Space $H^1(\Omega)$, L^P − Sobolev Space of order *s*. **Books Recommended:** 1. R.S. Pathak, " A Course in Distribution Theory and Applications", Narosa Publication
MTH602 **L-P-T-D[C]** 3-0-1-0[4]	**Operator Theory** **Pre Req.: MTH404** Bounded Operator on a Hilbert Space: Bounded operator, a commutativity theorem, resolutions of identity, the Spectral Theorem, Eigen values of normal operators, positive operators and square roots, the group of invertible operator, characterisation of B*-algebras, an ergodic theorem. Unbounded operators: Graphs and symmetric operators, the Cayley transform, resolutions of the identity, spectral theorem, semi groups of operators. **Books Recommended:** 1. W. Rudin, "Functional Analysis", McGraw Hill
MTH603 **L-P-T-D[C]** 3-0-1-0[4]	**Advanced Complex Analysis** **Pre Req.: MTH303** Review of basic complex Analysis: Cauchy –Riemann equations, Cauchy's Theorem and estimates, power series expansions, maximum modulus principle, classification of singularties and calculus of residues. Spaces of continuous functions, Arzela's theorem,

	spaces of analytic functions, spaces of meromorphic functions, Riemann maping theorem.Weierstrass Factorization theorem, Runge's theorem, Simple connectedness, Mittag-Leffler's theorem, Analytic continuations, Schwarz reflection principle, Mondoromy theorem, Jensen's formula, Genus and order of an entire function, Hadamard factorization theorem, Bloch's theorem, Little Picard theorem, Great Picard theorem, Schotty's theorem,Harmonic functions. Books Recommended : 1. J.B. Conway, "Functions of once complex vaniables", Springer international students Edition 2. L. Alhfors, "Complex Analysis", Tata McGraw-Hill
MTH604 **L-P-T-D[C]** 3-0-1-0[4]	**Lie Groups and Lie Algebras** **Pre Req.: MTH201** Linear Lie groups: the exponential map and the Lie algebra of linear Lie group, some calculus on a linear Lie group, invariant differential operators, finite dimensional representations of a linear Lie group and its Lie algebra. Examples of linear Lie group and their Lie algebras, e.g., Complex groups: GL(n, C), SL(n, C), SO(n, C), Groups of real39matrices in those complex groups: GL(n, R), SL(n, R), SO(n, R), Isometry groups of Hermitian forms SO(m, n),U(m, n), SU(m, n). Finite dimensional representations of su(2)and SU(2) and their connection. Exhaustion using the lie algebra su(2). Lie algebras in general, Nilpotent, solvable, semisimple Lie algebra, ideals, Killing form, Lies and Engels theorem. Universal enveloping algebra and Poincare-Birkho-Witt Theorem (without proof). Semisimple Lie algebra and structure theory: Definition of Linear reductive and linear semisimple groups. Examples of Linear connected semisimple/ reductive Lie groups along with their Lie algebras (look back at 2 above and find out which are reductive/ semisimple).Cartan involution and its differential at identity; Cartan decomposition g = k + p, examples of k and p for the groups discussed above. Definition of simple and semisimple Lie algebras and their relation, Cartans criterion for semisimplicity. Statements and examples of Global Cartan decomposition, Root space decomposition; Iwasawa decomposition; Bruhat decomposition. **Books Recommended :** 1. Bagchi S.C., Madan S., Sitaram A. and Tiwari U.B., "A first course on representation theory and linear Lie groups", University Press 2.J.E Humphreys, "*Introduction to Lie algebras and representation theory*", GTM (9) ,Springer-Verlag\ 3. Knapp W. , *"Representation theory of semisimple groups. An overview based on examples",* Princeton University Press
MTH605 **L-P-T-D[C]** 3-0-1-0[4]	**Stochastic Processes** **Pre Req.: None** Discrete Markov chains with countable state space; Classification of states: recurrences, transience, periodicity, Stationary distributions, reversible chains, Several illustrations including the Gambler's Ruin problem, queuing chains, birth and death chains etc. Poisson process, continuous time Markov chain with countable state space, continuous time birth and death chains. **Books Recommended:** 1. P.G.Hoel,S.C.Port,C.J.Stone,"IntroductiontoStochasticProcesses",Houghton Mifflin Co., 1972.

	2. R.Durrett,"EssentialsofStochasticProcesses",SpringerTextsinStatistics,Springer, 2012. 3. G. R. Grimmett, D. R. Stirzaker, "Probability and Random Processes", Oxford University Press, 2001. 4. S. M. Ross, "Stochastic Processes", Wiley Series in Probability and Statistics: Probability and Statistics, John Wiley & Sons, 1996 5. J. Medhi, " Stochastic Processes", New Age International
MTH606 **L-P-T-D[C]** 3-0-1-0[4]	**Bio-Mathematics** **Pre Req.: None** Biofluid dynamics; Blood flow & arterial diseases; Transport in intestines & lungs; Diffusion processes in human systems; Mathematical study of nonlinear Volterra equations, Stochastic & deterministic models in population dynamics Epidemics. **Books Recommended:** 1. James D. Murray, "Mathematical Biology: 1. An Introduction Third Edition", Springer 2. J. C Mishra, " Biomathematics Modelling and Simulation", World Scintific
MTH607 **L-P-T-D[C]** 3-0-1-0[4]	**Statistical Ecology** **Pre Req.: None** **1) Population Dynamics** **1.1.**Introduction: Ecology, Statistical Ecology. **1.2.**Linear Growth $dN_t/dt = C$, Interpretation and limitation. **1.3.**Exponential Model: Solving $dN_t/dt = KN_t$, $K > 0$, $K < 0$ cases. Properties, Interpretation, Scope and Limitation. **1.4.**Logistic Growth Model: Density dependence, solving differential equation, Theta-Logistic Model **1.5.** $dN_t/dt = a.N_t(K-N_t)$ Properties, Carrying Capacity, Interpretation, Scope and Limitation. **1.6.** Geompertz Curve: Solving Differential equation $dN_t/dt = a.\log(K/N_t)$, Asymptotically stable Equilibrium, Properties, Interpretation, Scope and Limitation. Fitting the above growth models to data by linearization and regression. Harvesting model: different types of Harvesting **1.7.** Life tables: Force of mortality stable population and stationary population. Cohort, columns of life table, interrelation between columns interpretation, construction of life table, uses and application. **1.8.** Leslie matrix Models: fecundity and survival matrix, $n_t = M_t\, n_0$, future projections, stable age distribution, interpretation of largest sign value of M. **2) Smoothing Procedures** **2.1.** Poisson forest, Aggregated, Regular spatial point pattern, estimation of population density by quadrate sampling, nearest neighbor distances (Point to individual, individual to individual), i-th order nearest neighbor distance. $\lambda = n/\Pi X_i^2$, mle for Poisson forest, Bias and S.E. of λ estimate. **2.2.** Line Transect Method: Drawing random line transect, exponential detection function, mle of population density, other detection functions. **2.3.** Capture – recapture models: Closed population, Open population, Peterson

	estimator for single recapture, multiple captures, irative method to find mle of N, Population size. **2.4.** Removal Method: Zippin's estimator for closed population. **3) Diversity Indices** **a.** Concept of Biodiversity, need to protect it. **b.** Richness indices, Simpson's index, Shannon's index. **c.** Rare fraction Curves, Real life examples for computing these indices. **4) Distribution Models** **4.1.**Use of geometric distribution, lognormal distribution in ecology. **Books Recommended:** 1. Pielou,E.C.(1977):An Introduction to Mathematical Ecology, Wiley. 2. Seber,G.A.F.(1982): The estimation of animal abundance and related parameters, C. Griffin. 3. Ludwig,J.A. and Reynold J.F.: Statistical Ecology, A primer on methods and computing. 4. Gore,A.P. and Prajpe, S.A. : A First Course on mathematical and Statistical Ecology.
MTH608 **L-P-T-D[C]** 3-0-1-0[4]	**Celestial Mechanics** **Pre Req.: None** The Two Body Problem: Formulation of the two body problem. Integrals of area, angular momentum and energy. Equation of the relative orbit and its solution. Kepler's equation and its solution. Heliocentric and geocentric co-ordinates, computation of ephemeris. Parabolic and hyperbolic orbits. f and g series. Orbit computation by Laplace and Gauss methods. The Three Body problem: Lagrange's solution for the motion of three bodies. Restricted three body problem. Surfaces of zero relative velocity. Double points. Stability of straight line and equilateral triangle solutions. N - Body problem: The ten integrals of motion of the n-body problem. Transfer of origin to one of the particles. The perturbing function. Virial theorem. **Books Recommended:** 1. F.R. Moulton, "An Introduction to Celestial Mechanics", Dover publication 2. Richard Fitzpatrick, "An Introduction to Celestial Mechanics", Cambridge press
MTH609 **L-P-T-D[C]** 3-0-1-0[4]	**Solid Mechanics** **Pre Req.: None** Analysis of stress, principal stresses, principal plances, maximum shearing stresses, Mohr's circle diagram, equations of deformation and strain, strain in form of displacement, compatibility concept, need and physical significance, stress-strain relation, Generalized Hook's Law, different types of symmetry, density function, Airy's stress function, wave propagation in unbounded elastic medium **Books Recommended:** 1. C.L. Dym, "Solid Mechanics ", Springer
MTH610 **L-P-T-D[C]** 3-0-1-0[4]	**Statistical Genetics** **Pre Req.: None** Introduction, Mendel's Laws, Linkage and Crossing cover, Linkage Maps, Statistical

	Analysis for Segregation and Linkage: Single Factor Segregation, Two factor segregation. Defection of Linkage, Estimation of Linkage. Random mating: Hardy-Weinberg law of equilibrium. Single Locus, Sex-linked genes, Autopraploids, Forces affecting gene frequency, Fisher's fundamental theorem, inbreeding: Mutation and migration different approaches, concepts and definition, Path Coefficients, Stochastic Process of gene-frequency change, Diffusion approach, Transition matrix approach. Genetic components of variance: Relationship between phenotype and genotype, Different approaches, Genetic components of covariance between Track; Linkage effects, Sex-linked genes, Maternal effect, Epistatic interaction, Genotype X Environment interaction. Heritability, Estimation of Heritability, Precision of Heritability estimates. Repeatability, Estimates of Genetic correlation, Generalized Heritability Relation between phenotypic selection and genotypic selection, Intensity of selection correlated, Response to selection. Selection for improving several characters. **Books Recommended:** 1. Narain, P. (1990). Statistical Genetics, Wiley, Chapters 1-5, 7, 8, 9, 10, 14. 2. Liu, B.H. (1998). Statistical Genomics, CRC Press, New York. 3. Falconer, D.S. (1970). Introduction to Genetics, Oliver & Boyd.