Program
Five year Integrated MSc in Mathematics with Minor in Data Sciences

(with effect from 2018-19 AY onwards)

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Programme Outcomes

PO$_1$. Knowledge in Mathematical Science: Understand the basic concepts, fundamental principles and the scientific theories related to mathematical sciences.

PO$_2$. Abstract thinking: Ability to absorb and understand the abstract concepts that lead to various advanced theories in mathematical sciences.

PO$_3$. Modelling and solving: Ability in modelling and solving problems by identifying and employing the appropriate existing theories and methods.

PO$_4$. Design/development of solutions: Design solutions for complex problems and processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO$_5$. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO$_6$. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern tools including prediction and modelling to complex mathematical, analytic and computational activities with an understanding of the limitations.

PO$_7$.Environment and sustainability: Understand the significance of preserving the environment towards sustainable development.

PO$_8$. Ethics: Imbibe ethical, moral and social values in personal and social life leading to highly cultured and civilized personality. Continue to enhance the knowledge and skills in mathematical sciences for constructive activities and demonstrate highest standards of professional ethics.

PO$_9$. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO$_{10}$. Communication: Develop various communication skills such as reading, listening, and speaking which will help in expressing ideas and views clearly and effectively.

PO$_{11}$. Project management and Research: Demonstrate knowledge, understand the scientific and management principles and apply these to one's own work, as a member/ leader in a team to manage projects and multidisciplinary research environments. Also use the research-based knowledge to analyse and solve advanced problems in mathematical sciences.

PO$_{12}$. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Specific Outcomes:

PSO1. Understand the abstract concepts that lead to various advanced theories in Mathematics, Statistics and Computer science.

PSO2. Acquire mathematical ability in modelling and solving problems by identifying and employing the appropriate existing theories and methods

PSO3. Pursue research in challenging areas of pure/applied mathematics

PSO4. Understand advanced theories and methods to design solutions for complex data science problems.

PSO5. Acquire the skills in handling data science programing tools towards problem solving and solution analysis for domain specific problems.

PSO6. Placements in both conventional and software Industries.

PSO7. Scope for doing research for those who aim to be a teacher, or scientist in highly reputed national and international institutions.

PSO8. Acquire deep knowledge of different mathematical disciplines so that they can qualify NET/ GATE examination

PSO9. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings to work as a data scientist

PSO10. Generate publications in reputed scientific journals

Integrated MSc in Mathematics with Minor in Data Sciences

CURRICULUM STRUCTURE

For 2018 admissions onwards

GENERAL INFORMATION

Code Numbering:

Each course is assigned an 8-character Code number. The first two digits indicate the year of curriculum revision. The next three letters indicate the Department offering the course. The last three digits are unique to the course – the first digit indicates the level of the course (100, 200, 300, 400 etc.); the second digit indicates the type of the course, viz. 0, 1 and 2 indicate the core courses; 3,4,5,6 and 7 indicate the Elective courses; 8 indicates the Lab. or practical-based courses and 9 indicates Projects.

ABBREVIATIONS USED IN THE CURRICULUM:

Cat -   Category
Cr   -   Credits
ES   -   Exam Slot
L   -   Lecture

P   -   Practical
T   -   Tutorial

DISCIPLINES

AVP - Amrita Values Programmes
BUS - Business Management
CHY - Chemistry
CMJ - Communication and Journalism
COM -   Commerce
CSA - Computer Science and Applications
CSN - Computer Systems and Network
CUL - Cultural Education
ECO - Economics
ELL - English Language and Literature
ENG - English
ENV - Environmental Sciences
FNA - Fine Arts
HIN - Hindi
KAN - Kannada
LAW -   Law
MAL -   Malayalam
MAT -   Mathematics
MCJ - Mass Communication and Journalism
OEL - Open Elective
PHY - Physics
SAN - Sanskrit

SSK - Soft Skills
SWK   -   Social Work
TAM   -   Tamil

Course Code	Course Title	L T P	Cr	ES	Course Code	Course Title	L T P	Cr	ES	
	SEMESTER 1					**SEMESTER 2**				
18MAT107	Single Variable Calculus	3 1 0	4		18MAT121	Multivariable Calculus	3 1 0	4		
18PHY105	Introduction to Mechanics	3 1 0	4		18MAT123	Ordinary Differential Equations	3 1 0	4		
18MAT108	Vectors and Geometry	3 1 0	4		18MAT112	Discrete Mathematics	3 1 0	4		
18ENG101	Communicative English	2 0 2	3		18CSA112	Introduction to Programming 2	3 0 2	4		
18CSA102	Introduction to Programming 1	3 0 2	4		18ENG121	Professional Communication	1 0 2	2		
	Language 1	1 0 2	2		18CUL111	Cultural Education 2	2 0 0	2		
18CUL101	Cultural Education 1	2 0 0	2		18MAT182	Mathematics Lab 2	0 0 2	1		
18MAT181	Mathematics Lab 1	0 0 2	1			Language 2	1 0 2	2		
	TOTAL		24			TOTAL		23		
	SEMESTER 3					**SEMESTER 4**				
18MAT209	Linear Algebra 1	3 1 0	4		18MAT221	Numerical Methods	3 1 0	4		
18MAT210	Transforms & PDE	3 1 0	4		18MAT218	Real Analysis 1	3 1 0	4		
18MAT207	Introduction to Probability and Statistics	3 1 0	4		18MAT223	Abstract Algebra 1	3 1 0	4		
18CSA209	Data Structures & Algorithms	3 1 0	4		18MAT216	Statistical Inference	3 1 0	4		
18ENV300	Environmental Science and sustainability	3 0 0	3		18MAT285	Python Lab for Numerical Methods	0 0 2	1		
18MAT283	Computing using R (Lab 1)	0 0 2	1		18MAT286	Computing Using R (Lab 2)	0 0 2	1		
18MAT284	Mathematics Lab 3	0 0 2	1		18AVP211	Amrita Value Programme 2	1 0 0	1		
18AVP201	Amrita Value Programme 1	1 0 0	1		18SSK201	Life Skills 1	1 0 2	2		
	TOTAL		22			TOTAL		21		
	SEMESTER 5					**SEMESTER 6**				
18MAT305	Real Analysis 2	3 1 0	4		18MAT317	Linear Algebra 2	3 1 0	4		
18MAT304	Complex Analysis 1	3 1 0	4		18MAT318	ODE & Calculus of Variations	3 1 0	4		
18MAT390	Open Elective / Live in Lab	3 0 0	3		18MAT319	Optimization Techniques	3 1 0	4		
18MAT306	Operations Research	3 1 0	4		18MAT315	Complex Analysis 2	3 1 0	4		
18CSA308	Machine Learning 1	3 1 0	4		18CSA316	Machine Learning 2	3 1 0	4		
18MAT383	OR Lab	0 0 2	1		18CSA387	Machine Learning Lab 2	0 0 2	1		
18CSA386	Machine Learning Lab 1	0 0 2	1		18MAT382	Optimization Lab	0 0 2	1		
18SSK211	Life Skills 2	1 0 2	2							
	TOTAL		23			TOTAL		22		
						TOTAL (for Exit-option students)		135		
	SEMESTER 7					**SEMESTER 8**				
18MAT507	Abstract Algebra 2	3 1 0	4		18MAT516	Measure and Integration	3 1 0	4		
18MAT508	Real Analysis 3	3 1 0	4		18MAT517	Stochastic Processes	3 1 0	4		
18MAT506	Topology	3 1 0	4		18MAT519	Functional Analysis	3 1 0	4		
18MAT509	Multivariate Statistics	3 1 0	4		18MAT518	PDE & Integral Equations	3 1 0	4		
18CSA506	Data Visualization	3 0 2	4		18CSA511	Database Management for Big Data	3 1 0	4		
18CSA581	Computing Using R (Lab 3)	0 0 2	1		18CSA582	Computing Using R (Lab 4)	0 0 2	1		
18MAT591	Seminar									
	TOTAL		21			TOTAL		21		
	SEMESTER 9					**SEMESTER 10**				
	Elective 1	3 0 0	3		18MAT697	Project		15		
	Elective 2	3 0 0	3							
18MAT692	Mini Project		6							
	TOTAL		12			TOTAL		15		
						TOTAL		206		
				LANGUAGES						
	Paper I					**Paper II**				
18HIN101	Hindi I	1 0 2	2		18HIN111	Hindi II	1 0 2	2		
18KAN101	Kannada I	1 0 2	2		18KAN111	Kannada II	1 0 2	2		
18MAL101	Malayalam I	1 0 2	2		18MAL111	Malayalam II	1 0 2	2		
18SAN101	Sanskrit I	1 0 2	2		18SAN111	Sanskrit II	1 0 2	2		
	ELECTIVES									
18MAT633	Algebraic Topology	3 0 0	3							
18MAT635	Commutative Algebra	3 0 0	3							
18MAT660	Graph Theory	3 0 0	3							
18MAT667	Differential Geometry	3 0 0	3							
18MAT668	Advanced Complex Analysis	3 0 0	3							
18MAT669	Analytic Number Theory	3 0 0	3							
18CSA678	Advanced topics in Machine learning	3 0 0	3							

Course Code	Course Title	L – T – P	Cr.	
18CSA679	Advanced topics in Deep learning	3 0 0	3	

OPEN ELECTIVES

Course Code	Course Title	L – T – P	Cr.	ES
18OEL231	Advertising	3 0 0	3	J
18OEL232	Basic Statistics	3 0 0	3	J
18OEL233	Citizen Journalism	3 0 0	3	J
18OEL234	Creative Writing for Beginners	3 0 0	3	J
18OEL235	Desktop Support and Services	3 0 0	3	J
18OEL236	Development Journalism	3 0 0	3	J
18OEL237	Digital Photography	3 0 0	3	J
18OEL238	Emotional Intelligence	3 0 0	3	J
18OEL239	Essence of Spiritual Literature	3 0 0	3	J
18OEL240	Film Theory	3 0 0	3	J
18OEL241	Fundamentals of Network Administration	3 0 0	3	J
18OEL242	Gender Studies	3 0 0	3	J
18OEL243	Glimpses of Indian Economy and Polity	3 0 0	3	J
18OEL244	Graphics and Web-designing Tools	3 0 0	3	J
18OEL245	Green Marketing	3 0 0	3	J
18OEL246	Healthcare and Technology	3 0 0	3	J
18OEL247	History of English Literature	3 0 0	3	J
18OEL248	Indian Writing in English	3 0 0	3	J
18OEL249	Industrial Relations and Labour Welfare	3 0 0	3	J
18OEL250	Introduction to Ancient Indian Yogic and Vedic Wisdom	3 0 0	3	J
18OEL251	Introduction to Computer Hardware	3 0 0	3	J
18OEL252	Introduction to Event Management	3 0 0	3	J
18OEL253	Introduction to Media	3 0 0	3	J
18OEL254	Introduction to Right to Information Act	3 0 0	3	J
18OEL255	Introduction to Translation	3 0 0	3	J
18OEL256	Linguistic Abilities	3 0 0	3	J
18OEL257	Literary Criticism and Theory	3 0 0	3	J
18OEL258	Macro Economics	3 0 0	3	J
18OEL259	Managing Failure	3 0 0	3	J
18OEL260	Media Management	3 0 0	3	J
18OEL261	Micro Economics	3 0 0	3	J
18OEL262	Micro Finance, Small Group Management and Cooperatives	3 0 0	3	J
18OEL263	Negotiation and Counselling	3 0 0	3	J
18OEL264	New Literatures	3 0 0	3	J
18OEL265	Non-Profit Organization	3 0 0	3	J
18OEL266	Personal Effectiveness	3 0 0	3	J
18OEL267	Perspectives in Astrophysics and Cosmology	3 0 0	3	J
18OEL268	Principles of Marketing	3 0 0	3	J
18OEL269	Principles of Public Relations	3 0 0	3	J
18OEL270	Science, Society and Culture	3 0 0	3	J
18OEL271	Statistical Analysis	3 0 0	3	J
18OEL272	Teamwork and Collaboration	3 0 0	3	J
18OEL273	The Message of Bhagwad Gita	3 0 0	3	J
18OEL274	Understanding Travel and Tourism	3 0 0	3	J

18OEL275	Videography	3 0 0	3	J
18OEL276	Vistas of English Literature	3 0 0	3	J
18OEL277	Web-Designing Techniques	3 0 0	3	J
18OEL278	Organic Farming	3 0 0	3	J
18OEL279	Basic Legal Awareness on Protection of Women and Rights	3 0 0	3	J
18OEL280	Ritual Performances of Kerala	3 0 0	3	J
18OEL281	Documenting Social Issues	3 0 0	3	J
18OEL282	Fabrication of Advanced Solar Cell	3 0 0	3	J
18OEL283	Basic Concepts of X-ray Diffraction	3 0 0	3	J
18OEL284	Introduction to FORTRAN and GNUPLOT	3 0 0	3	J
18OEL285	Introduction to Porous Materials	3 0 0	3	J
18OEL286	Forensic Science	3 0 0	3	J
18OEL287	Introduction to solar Physics	3 0 0	3	J
18OEL288	Recycling Recovery and Treatment Methods for Wastes	3 0 0	3	J
18OEL289	Acting and Dramatic Presentation	2 0 2	3	J
18OEL290	Computerized Accounting	2 0 2	3	J
18OEL291	Kerala Mural Art and Painting	2 0 2	3	J
18OEL292	Painting	2 0 2	3	J
18OEL293	Reporting Rural Issues	3 0 0	3	J

EVALUATION SCHEME AND GRADING SYSTEM

R.13 Assessment Procedure

R.13.1The academic performance of each student in each course will be assessed on the basis of Internal Assessment (including Continuous Assessment) and an end-semester examination.

Normally, the teachers offering the course will evaluate the performance of the students at regular intervals and in the end-semester examination.

R.13.2 In theory courses (that are taught primarily in the lecture mode), the weight for the Internal Assessment and End-semester examination will be 50:50. The Internal assessment in theory courses shall consist of at least two periodical tests, weekly quizzes, assignments, tutorials, viva-voce etc. The weight for these components, for theory-based courses shall be 20 marks for the Continuous assessment, comprising of Quizzes, assignments, tutorials, viva-voce, etc. and 15 marks each for both the Periodical Tests.

At the end of the semester, there will be an end-semester examination of three hours duration, with a weight of 50 marks, in each lecture-based subject.

R.13.3 In the case of laboratory courses and practical, the relative weight for internal assessment and End-semester examination will be 80:20.The weight for the components of internal assessment will be decided by the course committee/class committee at the beginning of the course.

Evaluation pattern for course having both Theory and Lab components:

Courses having only one hour per week for lecture/tutorial, be treated as a Lab. course, for evaluation purposes; and evaluation pattern will be 80 marks for continuous assessment of lab work and 20 marks for end-semester lab examination.

Courses having two hours per week for theory and/or tutorials, be given a weight of 60 marks and 40 marks for the Theory and Lab components, respectively; The Lab. component evaluation will be based on continuous evaluation, without any end-semester practical evaluation. 10 marks will be for continuous assessment of the theory portion, 10 marks for each of the two periodical tests, 30 marks for the theory end-semester examination and 40 marks for continuous assessment of lab work and

Courses having three hours per week for theory and/or tutorials, be given a weight of 70 marks and 30 marks for the Theory and Lab components, respectively; The Lab component evaluation will be based on continuous evaluation, without any end-semester practical evaluation. 15 marks will be for continuous assessment of the theory portion, 10 marks for each of the two periodical tests, 35 marks for the theory end-semester examination and 30 marks for continuous assessment of lab work.

R.13.4 It is mandatory that the students shall appear for the end-semester examinations in all theory and weight courses, for completion of the requirements of the course. Those who do not appear in the end-semester examinations will be awarded 'F' grade, subject to meeting the attendance requirement.

At the end of a semester, examinations shall be held for all the subjects that were taught during that semester and those subjects of the previous semester s for which the student s shall apply for supplementary examination, with a prescribed fee.

R.13.5 PROJECT WORK: The continuous assessment of project work will be carried out as decided by the course committee. At the completion of the project work, the student will submit a bound volume of the project report in the prescribed format. The project work will be evaluated by a team of duly appointed examiners.

The final evaluation will be based on the content of the report presentation by student and a viva-voce examination on the project. There will be 40% weight for continuous assessment and the remaining 60% for final evaluation.

If the project work is not satisfactory he/she will be asked to continue the project work and appear for assessment later.

R.14 PUBLICATION / INTERNSHIP
R.14.1 All students, if they are to be considered for award of the Degree at the time of graduation, are required to have published ONE paper in Scopus-indexed Journal/Conference.

R.14.2 Additional 5-10 marks will be awarded for each Publication, subject to a maximum of ONE paper per semester.

The additional marks shall be awarded in the semester in which the paper is published or accepted for publication, if applied for, within 10 days of the publication of results of the concerned semester. The additional marks can be awarded to any course(s) where the student has to improve his/her grade.

R.14.3 All publications shall be in Scopus-indexed Journals/Conferences and shall be as per the guidelines prescribed by the University.

R.14.4 Students who have undergone Internship at reputed organizations or National / International Institutions, with the prior approval of the concerned Departmental Chairperson and the Head of the School, may be considered for waiver of the requirement of publication, for the award of Distinction. However, the decision of the Departmental Chairperson and the Head of the School, in this regard, shall be final.

R.16 Grading

R.16.1 Based on the performance in each course, a student is awarded at the end of the semester, a letter grade in each of the courses registered.

Letter grades will be awarded by the Class Committee in its final sitting, without the student representatives. The letter grades, the corresponding grade points and the ratings are as follows:

Letter Grade	Grade Points	Ratings
0	10.00	Outstanding
A+	9.50	Excellent
A	9.00	Very Good
B+	8.00	Good
B	7.00	Above Average
C	6.00	Average
P	5.00	Pass
F	0.00	Fail
FA	0.00	Failed due to insufficient attendance
I	0.00	Incomplete (awarded only for Lab courses/ Project / Seminar)
W		Withheld

R.16.2 'FA'grade once awarded stays in the record of the student and is replaced with the appropriate grade when he/she completes the course successfully later.

Students who have secured an 'FA' in a course must re-register for the course or register for the course, if offered, under run-time re-do mode.

R.16.3 A student who has been awarded 'I' Grade in a Lab course, due to reasons of not completing the Lab., shall take up additional Lab. whenever offered next and earn a pass grade, which will be reflected in the next semester's grade sheet.

The 'I' grade, awarded in a Project/Seminar course, will be subsequently changed into appropriate grade, when the student completes the requirement during the subsequent semester. If he/she does not complete it in the next semester, it will be converted to 'F' grade.

R.16.4 A student is considered to have successfully completed the course and earned the credit, if he/she scores a letter grade 'P' or better in that course.

R.21 Semester Grade Point Average (SGPA)

On completion of a semester, each student is assigned Semester Grade Point Average (SGPA) which is computed as below for all courses registered by the student during that semester.

Semester Grade Point Average = Σ (Ci x Gpi) / Σ Ci
where Ci is the credit for ith course in that semester and Gpi is the grade point for that course.

The summation is over all the courses registered by the student during the semester, including the failed courses. The SGPA is rounded off to two decimals.

R.22 Cumulative Grade Point Average (CGPA)

The overall performance of a student at any stage of the Degree programme is evaluated by the Cumulative Grade Point Average (CGPA) up to that point of time.

Cumulative Grade Point Average =Σ (Ci x Gpi) / Σ Ci

where Ci is the credit for ith course in any semester and Gpi is the grade point for that course.

The summation is over all the courses registered by the student during all the semesters up to that point of time, including the failed courses. The CGPA is also rounded off to two decimals.

R.23 Ranking

The ranking of the students in a batch at any intermediate or final stage is based on CGPA. Only those students who have passed all courses up to that stage in the first attempt are considered for ranking. Students are eligible for final ranking, only if the programme is completed within the normal duration, i.e., within two years from joining the programme.

R.24 Classification of successful candidates:

R.24.1 A student shall be considered to have successfully completed the programme, if he/she has:
 i) registered and successfully completed all the core courses, electives and projects as mentioned in the curriculum;
ii) earned the required minimum number of credits as specified in the curriculum corresponding to the programme, within the stipulated time;
 iii) published a paper at a Scopus-indexed Journal/Conference.

R.24.2 Candidates who have successfully completed the programme, within a period of four semesters from entering the programme, shall be classified as follows:
Candidates securing a CGPA of 8.00 and above – FIRST CLASS WITH DISTINCTION *
 Candidates securing a CGPA between 6.50 and 7.99 – FIRST CLASS
and the same be mentioned in the Degree certificate;
(*subject to satisfying the condition mentioned at R.14.1 and having passed all the courses, in the first attempt, in four semesters, from the date of joining the programme)
If the programme is completed after four semesters of study, the candidates securing even a CGPA of 8.00 and above, shall be classified to have completed the programme, only with FIRST CLASS.

Integrated MSc in Mathematics with Minor in Data Science

COURSE OBJECTIVES, COURSE OUTCOMES, SYLLABUS

LANGUAGE COURSES

18AVP201   AMRITA VALUES PROGRAMME I   1 0 0 1

Objectives
The student will gain understanding of the glory of Indian Itihasa (Epics) in general, wherefrom the student get inspired to follow the lifestyle of inspiring characters depicted in Ramayana.

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

CO1	Appreciate the relevance of Ramayana in modern times.
CO2	Understand the family values and ideal human relationships portrayed in the Ramayana.
CO3	Understand Dharma and its universality, emphasizing its applicability in an individual's life.
CO4	Evaluate one's own personal ethics based on benchmarks from the Ramayana
CO5	Apply the spiritual values from Ramayana in resolving personal and social conflicts

18AVP211   AMRITA VALUES PROGRAMME II   1 0 0 1

Objectives

The student will gain understanding of the glory of Indian Itihasa (Epics) in general, wherefrom the student get inspired to follow the lifestyle of inspiring characters depicted in Mahabharata.

Course Outcomes: The course will aim at:

CO1	Understanding the impact of itihasas on Indian civilization with reference to Mahabharata
CO2	Enabling students to appreciate the relevance of Mahabharata and Bhagavad-Gita in the modern world.
CO3	Understanding the four goals of life (Purusharthas) as presented in the Mahabharata
CO4	Assimilating the positive qualities of the characters depicted in the itihasa.
CO5	Analysis of the critical events and turning points in the Mahabharata with emphasis on the underlying values and principles.

Amrita University's Amrita Values Programme (AVP) is a new initiative to give exposure to students about richness and beauty of Indian way of life. India is a country where history, culture, art, aesthetics, cuisine and nature exhibit more diversity than nearly anywhere else in the world.

Amrita Values Programmes emphasize on making students familiar with the rich tapestry of Indian life, culture, arts, science and heritage which has historically drawn people from all over the world.

Students shall have to register for any two of the following courses, one each in the third and the fourth semesters, which may be offered by the respective school during the concerned semester.

Courses offered under the framework of Amrita Values Programmes I and II

Insights into Indian Classical Music
The course introduces the students into the various terminologies used in Indian musicology and their explanations, like Nadam, Sruti, Svaram – svara nomenclature, Stayi, Graha, Nyasa, Amsa, Thala,- Sapta talas and their angas, Shadangas, Vadi, Samavadi, Anuvadi. The course takes the students through Carnatic as well as Hindustani classical styles.
Insights into Traditional Indian Painting

The course introduces traditional Indian paintings in the light of ancient Indian wisdom in the fields of aesthetics, the Shadanga (Sixs limbs of Indian paintings) and the contextual stories from ancient texts from where the paintings originated. The course introduces the painting styles such as Madhubani, Kerala Mural, Pahari, Cheriyal, Rajput, Tanjore etc.

Insights into Indian Classical Dance

The course takes the students through the ancient Indian text on aesthetics the Natyasastra and its commentary the Abhinava Bharati. The course introduces various styles of Indian classical dance such as Bharatanatyan, Mohiniyatton, Kuchipudi, Odissy, Katak etc. The course takes the students through both contextual theory as well as practice time.

Indian Martial Arts and Self Defense

The course introduces the students to the ancient Indian system of self-defense and the combat through various martial art forms and focuses more on traditional Kerala's traditional Kalari Payattu. The course introduces the various exercise technique to make the body supple and flexible before going into the steps and techniques of the martial art. The advanced level of this course introduces the technique of weaponry.

Social Awareness Campaign

The course introduces the students into the concept of public social awareness and how to transmit the messages of social awareness through various media, both traditional and modern. The course goes through the theoretical aspects of campaign planning and execution.

Temple Mural Arts in Kerala

The traditional percussion ensembles in the Temples of Kerala have enthralled millions over the years. The splendor of our temples makes art enthusiast spellbound, warmth and grandeur of color combination sumptuousness of the outline, crowding of space by divine or heroic figures often with in vigorous movement are the characteristics of murals.

The mural painting specially area visual counterpart of myth, legend, gods, dirties, and demons of the theatrical world, Identical myths are popular the birth of Rama, the story of Bhīma and Hanuman, Shiva, as Kirata, and the Jealousy of Uma and ganga the mural painting in Kerala appear to be closely related to, and influenced by this theatrical activity the art historians on temple planes, wood carving and painting the architectural plane of the Kerala temples are built largely on the pan-Indians almost universal model of the vasthupurusha.

Organic Farming in Practice

Organic agriculture is the application of a set of cultural, biological, and mechanical practices that support the cycling of farm resources, promote ecological balance, and conserve biodiversity. These include maintaining and enhancing soil and water quality; conserving wetlands, woodlands, and wildlife; and avoiding use of synthetic fertilizers, sewage sludge, irradiation, and genetic engineering. This factsheet provides an overview of some common farming practices that ensure organic integrity and operation sustainability.

Ayurveda for Lifestyle Modification:

Ayurveda aims to integrate and balance the body, mind, and spirit which will ultimately leads to human happiness and health. Ayurveda offers methods for finding out early stages of diseases that are still undetectable by modern medical investigation. Ayurveda understands that health is a reflection of when a person is living in harmony with nature and disease arises when a person is out of harmony with the cycles of nature. All things in the universe (both living and non-living) are joined together in Ayurveda. This leaflet endow with some practical knowledge to rediscover our pre- industrial herbal heritage.

Life Style and Therapy using Yoga

Yoga therapy is the adaptation of yogic principles, methods, and techniques to specific human ailments. In its ideal application, Yoga therapy is preventive in nature, as is Yoga itself, but it is also restorative in many instances, palliative in others, and curative in many others. The therapeutic effect comes to force when we practice daily and the body starts removing toxins and the rest is done by nature.

Evaluation Pattern – R.13 & R.16

18CUL101   CULTURAL EDUCATION I   2 0 0 2

Objectives

The student will be introduced to the foundational concepts of Indian culture and heritage

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

CO1	Gain a positive appreciation of Indian culture, traditions, customs and practices
CO2	Understand the foundational concepts of Indian civilization like purusharthas, law of karma, etc, which contributes towards personality growth.
CO3	Understand the cultural ethos of Amrita Vishwa Vidyapeetham, and Amma's life and vision of holistic education

CO4	Imbibe spirit of living in harmony with nature
CO5	Get guidelines for healthy and happy living from the great spiritual masters

Unit 1

Introduction to Indian Culture - Introduction to Amma's life and Teachings - Symbols of Indian Culture.

Unit 2

Science and Technology in Ancient India - Education in Ancient India - Goals of Life – Purusharthas - Introduction to Vedanta and Bhagavad Gita.

Unit 3

Introduction to Yoga - Nature and Indian Culture - Values from Indian History - Life and work of Great Seers of India.

TEXTBOOKS:
1. The Glory of India (in-house publication)
2. The Mother of Sweet Bliss, (Amma's Life & Teachings)

Evaluation Pattern – R.13 & R.16

18CUL111 CULTURAL EDUCATION II 2 0 0 2

Objectives

The students will be able to deepen their understanding and further their knowledge about the different aspects of Indian culture and heritage

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

CO1	Get an overview of India and her contribution to the world in the field of science and literature
CO2	Understand the foundational concepts of ancient Indian education system and practices associated with them
CO3	Learn the important concepts of Vedas, Bhagavad-Gita and Yogasutras and their relevance to daily life
CO4	Familiarize themselves with the inspirational characters and anecdotes from the epics and Indian history
CO5	Gain a rational understanding of the underlying principles of Indian spirituality

Unit 1
• Relevance of Sri Rama and Sri Krishna in this Scientific Age
• Lessons from the Epics of India
• Ramayana & Mahabharata

Unit 2
• Who is a Wise Man?
• A Ruler's Dharma
• The Story of King Shibi

Unit 3

- Introduction to the Bhagavad Gita
- Bhagavad Gita – Action without Desire

Unit 4
- Role and Position of Women in India
- The Awakening of Universal Motherhood

Unit 5
- Patanjali's Astanga - Yoga System for Personality Refinement
- Examples of Heroism and Patriotism in Modern India

TEXTBOOKS:
Common Resource Material II (in-house publication)
Sanatana Dharma - The Eternal Truth (A compilation of Amma's teachings on Indian Culture)

Evaluation Pattern – R.13 & R.16

18HIN111   **HINDI II**   1-0-2[2cr]

Objectives:
Appreciation and assimilation of Hindi Literature through Oral & visual technique .

By the end of the course, the students will be able to:

CO1 – Develop the creativity & language competence.

CO2 – To improve the writing and analytical skills

CO3 –Enhancing critical thinking.

CO4 –A good exposure with the different styles of literary writing.

CO5 – To understand the post modern trends of literature.

Unit -1
a) Visheshan- ParibhashaAurBhed.special usage of adverbs, changing voice and conjunctions in sentences.
b) kriya- ParibhashaAurBhed, rupantharkidrushti se-kaal
c) padhparichay.
 d) Vigyapan Lekhan (Advertisement writing),   Saar Lekhan (Precise writing).

Unit -2
Communicative Hindi – MoukhikAbhivyakthi –understanding proper pronunciation, Haptics …etc in Interviews ,short speeches
.

Unit -3
Film review,Audio –Visual-Media in Hindi – Movies appreciation and evaluation.News reading and presentations in Radio and Tv channels in Hindi, samvaadhlekhan,

Unit -4
a) Harishankarparasaiyi- SadacharkaThavis
b) Jayashankarprasadh – Mamata
c) Mannubandari- Akeli
d) Habibtanvir- Karthus

Unit -5
Kavya Tarang
- Himadri thung shrung se (poet- Jayasankar prasad)
- Dhabba (poet- kedarnath sing) ,
- Proxy (poet- Venugopal),
- Machis(poet –Suneeta Jain) ,
- Vakth.   (poet – Arun kamal)
- Fasal (poet- Sarveshwar Dayal Saxena)

18KAN101   **KANNADA I**   1-0-2[2cr]

CO-1: To enable the students to acquire basic skills in functional language.
CO-2: To develop independent reading skills and reading for appreciating literary works.
CO-3: To analyse language in context to gain an understanding of vocabulary, spelling,   punctuation and speech

UNIT – 1
- Railway Nildanadalli – K. S. Narasimha Swamy
- Amma, Aachara Mattu Naanu – K. S. Nisar Ahamad
- Kerege Haara – Janapada
- Simhaavalokana – H.S. Shivaprakash

UNIT – 2
- Dhanwantri Chikitse - Kuvempu
- Mouni - Sethuram
- Meenakshi Maneya Mestru - Kuvempu

UNIT – 3
- Sukha –H.G Sannaguddayya
- Mobile Thenkara Jen Nonagala Jhenkara – Nagesh Hegade
- Namma Yemmege Maatu Tiliyitu – Goruru Ramaswamy Iyangar

UNIT – 4
  Language structure
- Usage of punctuation marks
- Introduction to words (right usage)
- Reading skills
- Sentence formation (simple & complex)
- Translation- English to Kannada

References:
- Kannada Samskruti Kosha – Dr. Chi. C Linganna
- Kannada Sanna Kathegalu – G H Nayak
- Lekhana Kale – N. Prahlad Rao
- Kannada Sahithya Charithre – R. Sri Mugali

Evaluation Pattern – R.13 & R.16

18KAN111   **KANNADA II**   1-0-2[2cr]

Objectives:
CO-1: To enable the students to acquire basic skills in functional language.
CO-2: To develop independent reading skills and reading for appreciating literary works.
CO-3: To develop functional and creative skills in language.
CO-4: To enable the students to plan, draft, edit & present a piece of writing.

UNIT – 1
- Bettada Melondu Maneya Maadi – Akka Mahadevi
- Thallanisadiru Kandya – Kanakadasa

- Avva – P. Lankesh
- Neevallave – K. S. Narasimha Swamy

UNIT – 2
   Gunamukha – Drama by P. Lankesh
UNIT – 3
   Karvalo – Novel by Poornachandra Thejaswi
UNIT – 4
   Letter Writing –
   Personal (congratulation, invitation, condolence etc.)
- Official (To Principal, Officials of various departments, etc.,)
- Report writing
- Essay writing
- Precise writing

Prescribed text:
- Gunamukha by P. Lankesh (Lankesh Prakashana)
- Karvalo by Poornachandra Thejaswi (Mehtha publishing house)

Reference
- Saamanyanige Sahithya Charitre (chapter 1 to 10) – Bangalore University Publication
- Hosa Kannada Saahithya Charithre – L.S Sheshagiri Rao
- Kacheri Kaipidi – Kannada Adhyayana Samsthe (Mysuru University)
- Kannada Sahithya Charithre – R. Sri Mugali
- H.S.Krishna Swami Iyangar – *Adalitha Kannada – Chetana Publication, Mysuru*

Evaluation Pattern – R.13 & R.16

18MAL101   **Malayalam I**

   By the end of the course, the students will be able to:

   CO1 – Inculcate philosophical thoughts and practice.

   CO2 – To understand the post modern trends of literature.

   CO3 –To understand the literary cultural era of a particular region

   CO4 – Familiarise with the Malayalam literary maestro.

   CO5 –Expansion of ideas in writing.

Unit 1
Ancient poet trio:*Adhyatmaramayanam*,*LakshmanaSwanthanam (Lines: valsasoumitre… mungikidakayal),*Ezhuthachan - Medieval period classics – *Jnanappana(Lines:201 to 298)*,Poonthanam.
Unit 2
Modern Poet trio: *EnteGurunathan,* VallatholNarayanaMenon- Critical analysis of the poem.
Unit 3
Short stories from period 1/2/3:*Poovanpazham*-VaikaomMuhammedBasheer-Literary & Cultural figures of Kerala and about their literary contributions.
Unit 4
Literary Criticism: *BharathaParyadanam-VyasanteChiri*–Ithihasa studies-KuttikrishnaMararu-Outline of literary Criticism in Malayalam Literature-Introduction to KuttikrishnaMararu& his outlook towards literature &life.
Unit 5
Error-freeMalayalam: **1**.Language; **2**.Clarity of expression; **3**.Punctuation-Thettillatha
Malayalam – Writing-**a**. Expansion of ideas; **b**.PrecisWriting; **c**. Essay Writing; **d**.Letter writing;
e.RadioSpeech;**f**.Script/Feature/Script Writing;**g**.NewsEditing;**h**.Advertising;**i**.Editing;j.EditorialWriting;**k**.Critical appreciation of literary works (Any one or two as an assignment).

Evaluation Pattern – R.13 & R.16

18MAL111   **Malayalam II**

By the end of the course, the students will be able to:

CO1 – To understand the different cultural influence of linguistic translation.

CO2 – To identify the romantic elements of modern literature.

CO3 –To analyse the autobiographical aspects.

CO4 – To create awareness of the historical,political and socio cultural aspects of literature.

CO5 –Expansion of ideas in writing.

Unit1

Ancient poet trio: *Kalayanasougandhikam,(Lines: kallum marangalum… namukkennarika vrikodara),*KunjanNambiar - Critical analysis of his poetry-Ancient Drama: *Kerala Sakunthalam* (Act 1), Kalidasan (Translated by Attor Krishna Pisharody).
Unit 2
Modern/romantic/contemporary poetry: *Chandanakkattil* –G.Sankara kurupu-Romanticism – modernism.
Unit 3
Memoirs from Modern Poets: *Theeppathi*, Balachandran Chullikkadu-literary contributions of his time.
Unit 4
Partof an autobiography/travelogue: *Kannerum Kinavum*, Chapter: Valarnnu Varunnoratmavu, V.T.Bhattathirippadu-Socio-cultural literature-historical importance.
Unit 5
Error-free Malayalam-**1**.Language; **2**.Clarity of expression; **3**.Punctuation-Thettillatha Malayalam-Writing-**a**.Expansion of ideas;**b**.PrécisWriting;**c.** Essay Writing; **d**.Letter
writing;**e**.RadioSpeech;**f**.Script/Feature/ScriptWriting;**g**.NewsEditing;**h**.Advertising;**i**.Editing;   **j**.EditorialWriting;**k**.Critical appreciation of literary works (Any one or two as an assignment).

Evaluation Pattern – R.13 & R.16

18SAN101   **SANSKRIT I**   **1-0-2[2cr]**

CO-1: To familiarize students with Sanskrit language and literature.

CO-2: To read and understand Sanskrit verses and sentences.

CO-3: Self-study of Sanskrit texts and to practice communication in Sanskrit.

CO-4: To help the students imbibe values of life and Indian traditions propounded by the scriptures.

CO-5: To be able to speak in Sanskrit.

Module I

Introduction to Sanskrit language, Devanagari script - Vowels and consonants, pronunciation, classification of consonants, conjunct consonants, words – nouns and verbs, cases – introduction, numbers, Pronouns, communicating time in Sanskrit. Practical classes in spoken Sanskrit.   (7 hours)

Module II

Verbs- Singular, Dual and plural — First person, Second person, Third person.

Tenses – Past, Present and future – Atmanepadi and parasmaipadi-karthariprayoga.

(8hrs)

Module III

Words for communication and moral stories.   (4 hrs)

Module IV

Chanakya Neethi first chapter (first 15 Shlokas)   (6 hrs)

Module V

Translation of simple sentences from Sanskrit to English and vice versa.(5hs)

Evaluation Pattern – R.13 & R.16

18SAN111   **SANSKRIT II**   **1-0-2[2cr]**

CO-1: To familiarize students with Sanskrit language and literature.

CO-2: To read and understand Sanskrit verses and sentences.

CO-3: Self-study of Sanskrit texts and to practice communication in Sanskrit.

CO-4: To help the students imbibe values of life and Indian traditions propounded by the scriptures.

CO-5: To be able to speak in Sanskrit.

Module I

Seven cases, Avyayas, sentence making with Avyayas, Saptha kakaras. **(5hrs)**

Module II

Kthavathu' Prathyayam, Upasargas, Kthvatha,Thumunnantha, Lyabantha Prathyayam. Three Lakaras – brief introduction, Lot lakara   **(5hrs)**

Module III

New words and sentences for the communication, Slokas, moral stories(panchathanthra) Subhashithas, riddles (Selected from the Pravesha Book)   **(5hrs)**

Module IV

Introduction to classical literature, classification of Kavyas, classification of Dramas - Important five Maha kavyas   **(5hrs)**

Module V

Translation of paragraphs from Sanskrit to English and wise -verse   **(5hrs)**

Module VI

Bhagavad - Geeta fourteenth chapter (all 27 Shlokas)   **(5hrs)**

Essential Reading:

1, Praveshaha; Publisher : Samskrita bharati, Aksharam, 8th cross, 2nd phase, girinagar, Bangalore -560 085
2, Sanskrit Reader I, II and III, R.S. Vadhyar and Sons, Kalpathi, Palakkad
3, PrakriyaBhashyamwritten and published by Fr. John Kunnappally
4, Sanskrit Primer by Edward Delavan Perry, published by Ginn and Company Boston
5, Sabdamanjari, R.S. Vadyar and Sons, Kalpathi, Palakkad
6, Namalinganusasanam by Amarasimha published by Travancore Sanskrit series
7, SubhashitaRatnaBhandakara by Kashinath Sharma, published by Nirnayasagarpress

Evaluation Pattern – R.13 & R.16

Soft skills and its importance: Pleasure and pains of transition from an academic environment to work-environment. Need for change. Fears, stress and competition in the professional world. Importance of positive attitude, self motivation and continuous knowledge upgradation.

Self Confidence: Characteristics of the person perceived, characteristics of the situation, Characteristics of the Perceiver. Attitude, Values, Motivation, Emotion Management, Steps to like yourself, Positive Mental Attitude, Assertiveness.

Presentations: Preparations, Outlining, Hints for efficient practice, Last minute tasks, means of effective presentation, language, Gestures, Posture, Facial expressions, Professional attire.

Vocabulary building: A brief introduction into the methods and practices of learning vocabulary. Learning how to face questions on antonyms, synonyms, spelling error, analogy etc. Faulty comparison, wrong form of words and confused words like understanding the nuances of spelling changes and wrong use of words.

Listening Skills: The importance of listening in communication and how to listen actively.

Prepositions and Articles: A experiential method of learning the uses of articles and prepositions in sentences is provided.

Problem solving; Number System; LCM & HCF; Divisibility Test; Surds and Indices; Logarithms; Ratio, Proportions and Variations; Partnership; **Time speed and distance; work time problems;**

Data Interpretation: Numerical Data Tables; Line Graphs; Bar Charts and Pie charts; Caselet Forms; Mix Diagrams; **Geometrical Diagrams and other forms of Data Representation.**

Logical Reasoning: **Family Tree**; Linear Arrangements; Circular and Complex Arrangement; Conditionalities and Grouping; Sequencing and Scheduling; Selections; Networks; Codes; Cubes; Venn Diagram in Logical Reasoning.

TEXTBOOKS:
1. *A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.*
2. *Adair J (1986) - "Effective Team Building: How to make a winning team", London, U.K: Pan Books.*
3. *Gulati S (2006) - "Corporate Soft Skills", New Delhi, India: Rupa & Co.*
4. *The Hard Truth about Soft Skills, by Amazone Publication.*

REFERENCES:
1. *Quantitative Aptitude, by R S Aggarwal, S Chand Publ.*
2. *Verbal and Non-verbal Reasoning, R S Aggarwal, S Chand Publ.*
3. *Data Interpretation, R S Aggarwal, S Chand Publ.*
4. *Nova GRE, KAPAL GRE, Barrons GRE books;*
5. *Quantitative Aptitude, The Institute of Chartered Accountants of India.*
6. *More Games Teams Play, by Leslie Bendaly, McGraw-Hill Ryerson.*
7. *The BBC and British Council online resources*
8. *Owl Purdue University online teaching resources*
9. *wwwthe grammarbook.com online teaching resources*
10. *www.englishpage.com online teaching resources and other useful websites.*

Evaluation Pattern – R.13 & R.16

18SSK211   **LIFE SKILLS II**   **1 0 2 2**

Professional Grooming and Practices: Basics of Corporate culture, Key pillars of Business Etiquette. Basics of Etiquette: Etiquette – Socially acceptable ways of behaviour, Personal hygiene, Professional attire, Cultural Adaptability. Introductions and Greetings: Rules of the handshake, Earning respect, Business manners. Telephone Etiquette: activities during the conversation, Conclude the call, To take a message. Body Language: Components, Undesirable body language, Desirable body language. Adapting to Corporate life: Dealing with people.

Group Discussions: Advantages of Group Discussions, Structured GD – Roles, Negative roles to be avoided, Personality traits to do well in a GD, Initiation techniques, How to perform in a group discussion, Summarization techniques.

Listening Comprehension advanced: Exercise on improving listening skills, Grammar basics: Topics like clauses, punctuation, capitalization, number agreement, pronouns, tenses etc.

Reading Comprehension advanced: A course on how to approach middle level reading comprehension passages.

Problem solving – Money Related problems; Mixtures; Symbol Based problems; Clocks and Calendars; Simple, Linear, Quadratic and Polynomial Equations; Special Equations; Inequalities; Functions and Graphs; Sequence and Series; Set Theory; Permutations and Combinations; Probability; Statistics.

Data Sufficiency: Concepts and Problem Solving.

Non-Verbal Reasoning and Simple Engineering Aptitude: Mirror Image; Water Image; Paper Folding; Paper Cutting; Grouping Of Figures; Figure Formation and Analysis; Completion of Incomplete Pattern; Figure Matrix; Miscellaneous.

Special Aptitude: Cloth, Leather, 2D and 3D Objects, Coin, Match Sticks, Stubs, Chalk, Chess Board , Land and geodesic problems etc., Related Problems

TEXTBOOKS:
1.   *A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.*
2.   *Adair J (1986) - "Effective Team Building: How to make a winning team", London, U.K: Pan Books.*
3.   *Gulati S (2006) - "Corporate Soft Skills", New Delhi, India: Rupa & Co.*
4.   *The Hard Truth about Soft Skills, by Amazone Publication.*

REFERENCES:
1.   *Quantitative Aptitude, by R S Aggarwal, S Chand Publ.*
2.   *Verbal and Non-verbal Reasoning, R S Aggarwal, S Chand Publ.*
3.   *Quantitative Aptitude by Abjith Guha, Tata McGraw hill Publ..*
4.   *More Games Teams Play, by Leslie Bendaly, McGraw-Hill Ryerson.*
5.   *The BBC and British Council online resources*
6.   *Owl Purdue University online teaching resources*
7.   *www.the grammarbook.com online teaching resources*
8.   *www.englishpage.com online teaching resources and other useful websites.*

18SSK301   **LIFE SKILLS III**   **1 0 2 2**

Team Work: Value of Team work in organisations, Definition of a Team, Why Team, Elements of leadership, Disadvantages of a team, Stages of Team formation. Group Development Activities: Orientation, Internal

Problem Solving, Growth and Productivity, Evaluation and Control. Effective Team Building: Basics of Team Building, Teamwork Parameters, Roles, Empowerment, Communication, Effective Team working, Team Effectiveness Criteria, Common characteristics of Effective Teams, Factors affecting Team Effectiveness, Personal characteristics of members, Team Structure, Team Process, Team Outcomes.

Facing an Interview: Foundation in core subject, Industry Orientation/Knowledge about the company, Professional Personality, Communication Skills, activities before interview, upon entering interview room, during the interview and at the end. Mock interviews.

Advanced Grammar: Topics like parallel construction, dangling modifiers, active and passive voices, etc.

Syllogisms, Critical reasoning: A course on verbal reasoning. Listening Comprehension advanced: An exercise on improving listening skills.

Reading Comprehension advanced: A course on how to approach advanced level of reading, comprehension passages. Exercises on competitive exam questions.

Specific Training: Solving campus recruitment papers, National level and state level competitive examination papers; Speed mathematics; Tackling aptitude problems asked in interview; Techniques to remember (In Mathematics). Lateral Thinking problems. Quick checking of answers techniques; Techniques on elimination of options, Estimating and predicting correct answer; Time management in aptitude tests; Test taking strategies.

TEXTBOOKS:
1. *A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.*
2. *Adair J (1986) - "Effective Team Building: How to make a winning team", London, U.K: Pan Books.*
3. *Gulati S (2006) - "Corporate Soft Skills", New Delhi, India: Rupa & Co.*
4. *The Hard Truth about Soft Skills, by Amazon Publication.*

REFERENCES:
1. *Speed Mathematics, Secrets of Lightning Mental Calculations, by Bill Handley, Master Mind books;*
2. *The Trachtenberg Speed System of Basic Mathematics, Rupa & Co., Publishers;*
3. *Vedic Mathematics, by Jagadguru Swami Sri Bharati Krsna Tirthayi Maharaja, Motilal Banarsidass Publ.;*
4. *How to Ace the Brainteaser Interview, by John Kador, Mc Graw Hill Publishers.*
5. *Quick Arithmetics, by Ashish Agarwal, S Chand Publ.;*
6. *Quicker Maths, by M tyra & K Kundan, BSC Publishing Co. Pvt. Ltd., Delhi;*
7. *More Games Teams Play, by Leslie Bendaly, McGraw-Hill Ryerson.*
8. *The BBC and British Council online resources*
9. *Owl Purdue University online teaching resources*
10. www.the *grammarbook.com online teaching resources*
11. www.englishpage.com *online teaching resources and other useful websites.*

Evaluation Pattern – R.13 & R.16

Semester1

18MAT107   **Single Variable Calculus**   **3-1-0-4**

Course Outcome:

CO1: Understand the elementary functions and concepts of limit, continuity, derivative and

integral

CO2: Study techniques of differentiation and use it in optimization problems and curve sketching

CO3: Defining Integral as a sum and review integration techniques

CO4: Use of integrals for the computation of areas, volumes and arc length

CO5: Discuss some basic concepts in the theory of infinite series with some insight to Power series.

Unit 1

Functions-domain, range, graphs of elementary functions, limits - left limit, right limit, continuity, definition of derivative, derivative as rate of change, implicit differentiation, review of differentiation techniques.

Unit 2

Extreme values of functions, critical points, graphing with and $y^{''}$, asymptotes, optimization problems, linearization and differentials, L'Hospital's Rule. Riemann sums and definite integrals (just some elementary examples, not the proof), Area, Fundamental theorem of Calculus.

Unit 3

Review of Integration techniques, Area between curves, Volumes of solids of revolution – washer method and cylindrical shell method, Length of plane curves.

Unit 4

Areas of surfaces of revolution, Moments and centres of Mass,Sequences, Infinite series as a limit of sequence, Integral test, Comparison tests, Ratio and Root tests.

Unit 5

Alternating Series, Absolute and Conditional convergence, Power series, Taylor and Maclaurin Series, Error estimates, Applications of Power Series.

Textbook:

Thomas and Finney, *Calculus and Analytic Geometry*, 11th edition, Pearson.

References:

N. Piskunov, *Differential and Integral Calculus Vol. I and II*, CBS Publishers.

H. Anton, I. Bivens, S. Davis, *Calculus,* Wiley.

Evaluation Pattern – R.13 & R.16

18MAT108   **Vectors and Geometry**   **(3-1-0-4)**

Course Outcome:

CO1: Understand the parametric equations of curves and surfaces ,find the vector equations of the lines and planes**.**

CO2: Understand to describe the velocity and acceleration associated with a vector-valued function Use vector-valued function to analyze projectile motion

CO3 Understand to set up and evaluate definite integrals in two dimensions using polar coordinates. Change from polar to rectangular coordinates and vice versa

CO4: Understand to find unit tangent vector at a point on a space curve ,the tangential and normal components of acceleration, arc length of a space curve the curve at a point on the curvature .
CO5: Understand to use cylindrical and spherical coordinates to represent surfaces in space

Unit1

Review of Conic Sections, Eccentricity, Quadratic Equations and Rotations, Parametrization of plane curves, Polar coordinates, Graphing in polar coordinates, Areas and Lengths in polar coordinates, Conic Sections in Polar Coordinates.

Unit 2

Review of vectors (Dot product, Cross product, Unit vector), Lines and Planes in Space, Cylinders and Quadric Surfaces, level curves.

Unit 3

Vector Functions, Modeling projectile motion, Arc length, Unit Tangent Vector, Curvature and Unit Normal Vector.

Unit 4

Double integrals, Areas, Moments and Centers of mass, Double integrals in polar form, Triple integrals in Rectangular Coordinates.

Unit 5

Applications, Triple integrals in cylindrical and spherical coordinates, Change of variables.

Textbook:

Thomas and Finney, *Calculus and Analytic Geometry*, 11th edition, Pearson.

References:

N. Piskunov, *Differential and Integral Calculus Vol. I and II*, CBS Publishers.

H. Anton, I. Bivens, S. Davis, *Calculus,* Wiley.

Evaluation Pattern – R.13 & R.16

18PHY105   Introduction to Mechanics   3 1 0 4

Course Outcome:

CO1: apply to the concepts of measurements, estimating order of magnitudes, vectors, kinematics in one dimension, projectile and circular, and relative motions.

CO2: apply Newton's law of motion to solve, with the help of a free-body diagram, for forces of equilibrium or acceleration, under contact forces, uniform gravity, for rectilinear and circular motions.

CO3: apply the concepts of kinetic energy, work – dot product of force and displacement, work-kinetic energy theorem for constant, spring and general variable forces, power, potential energy and relation to conservative forces, conservation energy, identify types of equilibrium,

CO4: apply Newton's law for center of mass motion, linear momentum and its conservation for collision problems.

CO5: apply concepts of rotation – angle, angular velocity, angular acceleration, torque, inertia, angular oscillations, angular momentum and its conservation, describe gyroscope motion.

CO6: apply Hooke's law, simple harmonic motion, free, damped and forced oscillations, resonance, describe aspects of wave motion, speed, wave equation, traveling waves, interference, standing waves, resonance.

Unit 1 Measurement: standards of mass, length and time, dimensional analysis, estimation and order of magnitude calculations.

Kinematics: Motion in one dimension; Vectors; Motion in 2D:vectors of displacement, velocity and acceleration, projectile and uniform circular motion; relative motion, relative velocity and relative acceleration.

Unit 2 Laws of motion: concepts of force and mass, Newton's laws, reference frames, gravitational force, free body diagram analysis for simple applications, friction and contact forces; drag force and terminal speed, uniform circular motion.

Unit 3 Work and kinetic energy: scalar product of two vectors, kinetic energy and work-kinetic energy theorem, work done by gravitational and spring forces, power; Work and potential energy, conservative and nonconservative forces, conservative forces from potential energy, energy diagrams and equilibrium; Conservation of energy: examples without and with friction, power.

Unit 4 Linear momentum and Conservation: linear momentum and conservation in an isolat-ed system of two particles, impulse, elastic and inelastic collisions in 1D; basic ideas (simple exercises only) on the concepts of centre of mass and dynamics of system of particles.

Rotational motion about fixed axis: Rotational variables, linear and angular variables, rota-tional kinetic energy and inertia, torque, Newton's law for rotation, work; rolling – combined translation and rotation; elementary discussions on angular momentum and its conservation.

Unit 5 Oscillations: simple harmonic motion, linear spring and Hooke's law, motion of mass on a spring, angular frequency, period, phase, angular oscillations and pendulums, small an-gle (linear) approximation, connection with uniform circular motion, average kinetic and po-tential energies, friction and damping, damped and forced oscillations, resonance, power ab-sorption, Q-value, superposition principle.

Introduction to wave motion (selected topics and simple exercises only): propagation of dis-turbance, traveling wave on string, speed, reflection and transmission, energy transfer, linear wave equation; Sound: Basic description of sound as travelling wave of pressure variations, elementary discussions on superposition and interference, boundary conditions, standing waves and quantization of frequency, sonometer, resonance in sonometer.

Textbook/References

1. Serway and Jewett, Physics for Scientists and Engineers, 9E, Cengage Learning, 2013. Ch. 1 – 8, Ch. 9, 10 (lightly), Ch. 15, topics culled from Ch. 16 – 18.

2. C. Kittel et al, Mechanics – Berkeley Physics Course Vol. 1, 2E, Ch. 1 – 7, McGraw-Hill

3. D. Halliday, R. Resnick and J. Walker, Fundamentals of Physics, 10E, Ch. 2 – 11, 15 – 17.

4. Halliday, Resnick, and Krane, Physics, Vol. 1, 5th Ed., Wiley Indian Reprint, 2007

5. Feynamn, Leighton and Sands, The Feynman Lectures on Physics, Vol.1, Narosa, 200

Evaluation Pattern – R.13 & R.16

Semester2

18MAT112   **Discrete Mathematics**   **(3-1-0-4)**

Course Outcome:

. CO1:Understand how to write an argument using logical notation and determine if the   argument is or is not valid.

CO2 : Understand the basic principles of sets and operations in sets.

CO3: Ability to demonstrate an understanding of relations and functions and be able to   determine their properties.

CO4 : Ability to demonstrate different traversal methods for trees and graphs

CO5: Ability to Model problems in Computer Science using graphs and tree.

Unit 1

Logic Mathematical Reasoning and Counting: Logic, Prepositional Equivalence, Predicate and Quantifiers, Theorem Proving, Functions, Mathematical Induction, Recursive Definitions, Recursive Algorithms, Basics of Counting, Pigeonhole Principle, Permutation and Combinations.

Unit 2

Relations and their properties: Representing Relations, Closure of Relations, Partial Ordering, Equivalence relations and Partitions.

Unit 3

Advanced Counting Techniques and Relations: Recurrence Relations, Solving Recurrence Relations, Generating Functions, Solution of Homogeneous Recurrence relations, Divide and Conquer relations, Inclusion-Exclusion.

Unit 4

Graph Theory: Introduction to Graphs, Graph Operations, Graph and Matrices, Graph Isomorphism, Connectivity.

Unit 5

Euler and Hamilton Paths, Shortest Path Problem, Planar Graph, Graph Coloring.

Textbook:

Kenneth H. Rosen, *Discrete Mathematics and its Applications*, McGraw-Hill.

References:

R.P. Grimaldi, *Discrete and Combinatorial Mathematic*, Pearson.

Evaluation Pattern – R.13 & R.16

18MAT121   **Multivariable Calculus**   **(3-1-0-4)**

Course Outcome:

CO1:Understand the basic concepts of vector valued functions, limits ,derivatives and it's   geometrical interpretations.

CO2:Understand the concept of scalar and vector field

CO3: Understand the concept of Line integrals and its independence of path

CO4:Understand and apply the concepts of double integrals to various problems including   Green's theorem for plane

CO5;Understand the concepts of surface integrals, divergence theorem and Stokes   theorem.

Unit 1

Limits and continuity of Functions of Severable Variables, Partial derivatives, Differentiability of Functions, Chain rule.

Unit 2

Directional derivatives, Gradient and tangent planes, Extreme values and saddle points, Lagrange multipliers.

Unit 3

Line integrals, Vector fields, Circulation and Flux, Path independence, Potential Functions and Conservative Fields. Green's theorem in a Plane.

Unit 4

Parameterized Surfaces, Surface Areas and Surface Integrals, Orientation of Surfaces

Unit 5

Stoke's Theorem and Divergence Theorem (no proof just applications).

Textbook:

Thomas and Finney, *Calculus and Analytic Geometry*, 11th edition, Pearson.

References:

N. Piskunov, *Differential and Integral Calculus Vol. I and II*, CBS Publishers.

H. Anton, I. Bivens, S. Davis, *Calculus,* Wiley.

Evaluation Pattern – R.13 & R.16

18MAT123   **Ordinary Differential Equations**   **(3-1-0-4)**

Course Outcome:

CO1: Ability to recognize and solve linear, separable and exact first-order differential equations

CO2: understand the use of differential equations in modelling engineering problems

CO3 Ability to recognize and solve first-order and higher order differential equations, analyze trajectories, and comment on the stability of critical points

CO4 Understand to determine the Laplace transforms for basic functions, derivatives, integrals and periodic functions and find inverse transforms

CO5 Ability to use Laplace transforms to solve initial value problems, integral equations .

Unit 1

First order ODEs, Modelling, Direction Fields, Separable ODEs, Exact ODEs and Integrating Factors, Linear ODEs and Modelling. (Sections: 1.1 to 1.5)

Unit 2

Second Order Differential Equations: Homogeneous and non-homogeneous linear differential equations of second order, Modelling a Spring-Mass System, Euler-Cauchy Equations, Existence and Uniqueness of solutions (statement), Wronskian, Solution by Undetermined Coefficients and Variation of Parameters, Modelling. (Sections 2.1, 2.2, 2.4 to 2.10)

Unit 3

Homogeneous and non-homogeneous Higher Order Linear ODEs, Wronskian, Constant-Coefficent Systems, Phase plane method, Criteria for Critical points and Stability. (Sections 3.1, 3.2, 3.3, 4.0 to 4.4)

Unit 4

Laplace Transforms: Linearity, first and Second Shifting theorems, Dirac delta functions, Convolution and Integral Equations. (Sections 6.1 to 6.5)

Unit 5

Differentiation and Integration of Transforms, ODEs with Variable Coefficients, Systems of ODEs. (Sections 6.6 to 6.9)

Textbook:

Erwin Kreyszig, *Advanced Engineering Mathematics*, 10th edition, Wiley.

W.E. Boyce and R.C. DiPrima, *Elementary Differential Equations and Boundary Value Problems*, 7th edition, Wiley.

References:

M.D. Raisinghania, *Ordinary and Partial Differential Equations,* S Chand Publications.

Dennis Zill, *A First Course in Differential Equations,* Cengage.

Evaluation Pattern – R.13 & R.16

Semester3

18MAT207   **Introduction to Probability and Statistics**   **(3-1-0-4)**

CO1: Able to understand the basic statistical concepts and measures

CO2; Able to understand the basic knowledge on fundamental probability concepts, including   random variable, probability of an event, additive rules and conditional probability and   Bayes' theorem

CO3: Able to understand several well-known distributions, including Binomial, Geometrical,   Negative Binomial, Pascal, Normal and Exponential Distribution

CO4: A good understanding of the basic concepts of statistical inference

CO5: A good understanding of the Central Limit Theorem and its applications

Unit 1
Introduction to Statistics: Data Collection and Descriptive Statistics, Populations and Samples, describing data sets, summarizing data sets, Normal Data Sets, Paired Data Sets and the Sample Correlation Coefficient.(1.2-1.4, 2.2-2.6 of Text)

Unit 2
Elements of Probability: Introduction, random experiments, sample space, events and algebra of events. Axioms of Probability, Sample Spaces Having Equally Likely Outcomes, Conditional Probability, Bayes' Formula, Independent Events.(3.2-3.8 Text)

Unit 3
Random Variables and Expectation, Random Variables, Types of Random Variables, Jointly Distributed Random Variables, Independent Random Variables, Conditional Distributions, Expectation, Properties of the Expected Value, Expected Value of Sums of Random Variables, Variance, Covariance and Variance of Sums of Random Variables, Moment Generating Functions, Chebychev's Inequality and weal law of large numbers.(4.1-4.9 of Text)

Unit 4
Special Random Variables, the Bernoulli and Binomial Random Variables, Computing the Binomial Distribution Function, The Poisson Random Variable, the Hypergeometric Random Variable, the Uniform Random Variable, Normal Random Variables, Exponential Random Variables, The Chi-Square distribution, the t-distribution, the F-distribution. (5.1-5.8 Text).

Unit 5 $\bar{X}$
Distributions of Sampling Statistics, The Sample Mean, The Central Limit Theorem, The Sample Variance, Sampling Distributions from a Normal Population, Distribution of the Sample Mean, Joint Distribution of $\bar{X}$ and S^2 from a Finite Population (6.1 to 6.6 of Text)

Textbook:
Ross S.M.,*Introduction to Probability and Statistics for Engineers and Scientists*, 3rd edition, Elsevier Academic Press.

References:
D.C. Montgomery and G.C. Runger, *Applied Statistics and Probability for Engineers*, John Wiley and Sons.
J. Ravichandran,*Probability and Statistics for Engineers*, Wiley.
Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, *Probability and Statistics for Engineers and Scientists*, Pearson.
Hogg, R.V., Tanis, E.A. and Rao J.M.,*Probability and Statistical Inference*, Seventh Ed, Pearson Education, New Delhi.

K.L. Chung, *Elementary Probability Theory: With Stochastic Processes and an Introduction to Mathematical Finance,* Springer.

Evaluation Pattern – R.13 & R.16

<u>**Learning Outcomes:**</u>

This course provides an elementary *introduction to probability and statistics* with applications. These modules aims to lay foundations in *probability* and distribution theory, data analysis and the *use* of a *statistical* software package, These concepts helps to develop the Ablity to understand the basic statistical concepts and measuresAble to understand the basic knowledge on fundamental probability concepts, including random variable, probability of an event, additive rules and conditional probability and
        Bayes' theorem. Able to understand several well-known distributions, including Binomial, Geometrical, Negative Binomial, Pascal, Normal and Exponential Distribution. A good understanding of the basic concepts of statistical inference. A good understanding of the Central Limit Theorem and its applications

18MAT209   **Linear Algebra 1**   **(3-1-0-4)**

Course Outcome:

CO1: Understand the basic arithmetic operations on vectors and matrices, including inversion and determinants,   using technology where appropriate;

CO2 :Ability to solve systems of linear equations, using technology to facilitate row reduction

CO3 Ability to understand the basic terminology of linear algebra in Euclidean spaces, including linear independence, spanning, basis, rank, nullity, subspace, and linear transformation;

CO4 : Ability to understand and. find Eigen values and eigenvectors of a matrix or a linear transformation, and using them to diagonalize a matrix

CO5: Ability to understand Orthogonally diagonalize symmetric matrices and quadratic forms

Unit 1

Matrices, Operations on Matrices-Addition, Multiplication, Transpose, Special types of matrices. systems of linear equations.

Unit 2

Gaussian elimination and row operations, Echelon form of a matrix, Elementary matrices and rank of a matrix, Existence of solution of AX=B.

Unit 3

Properties of determinants, Cofactor expansion, Inverse of a matrix. Vector spaces, Subspaces.

Unit 4

Span and linear independence, Basis and dimension, Row and column space of a matrix, Change of Basis. Linear transformations, Range space and rank, null space and nullity, Matrix representation, Isomorphism.

Unit 5

Eigen values and Eigenvectors, Systems of ODEs, Wronskian, Diagonalization and Similar Matrices, Quadratic Forms.

Textbook:

David C. Lay, *Linear Algebra and its Applications*, Pearson.

References:

Gilbert Strang, *Linear Algebra and its Applications*, Cengage.

H. Anton, C. Rorres, *Elementary Linear Algebra,* Wiley.

Derek Robinson, *A Course in Linear Algebra with Applications*, Allied publishers.

Evaluation Pattern – R.13 & R.16

18MAT210   **Transforms and PDE**   **(3-1-0-4)**

Course Outcome:

CO1: Ability to understand the series solution of certain differential equations give rise to special   functions

CO2: Ability to understand the basic concepts of Fourier series for periodic functions .

CO3:Model mathematically One and Two Dimensional Wave and Heat Equations and solve using Fourier series

CO4: Ability to understand the general principle in boundary value problems for PDEs to choose   coordinates that make the formula for the boundary as simple as possible

CO5: Ability to   solve the boundary value problems in Polar, Cylindrical and Spherical co-   ordinates.

Unit 1

Series Solutions of ODEs: Power Series method, Legendre's equation and Legendre Polynomials, Extended Power Series method – Frobenius method. (Sections 5.1 to 5.3)

Unit 2

Bessel's equation and Bessel Functions, General Solution, Fourier Series—Even and Odd functions, Half range expansions, Approximation by Trigonometric Polynomials. (Sections 5.4,5.5, 11.1 to 11.4)

Unit 3

Sturm-Liouville problems, Generalized Fourier Series, Fourier Integral and Fourier transforms. (Sections 11.5 to 11.10)

Unit 4

Basic concepts of PDEs, Solution by Separating Variables, D'Alembert's Solution of the Wave Equation, Heat Equation, Solution By Fourier Series, 2D Heat Equation and Dirichlet Problem, Heat equation for long bars, Solution by Fourier Integrals and Transforms. (Sections 12.1 to 12.7)

Unit 5

Two Dimensional Wave Equation, Laplacian in Polar Coordinates, Fourier Bessel Series, Laplace's equation in Cylindrical and Spherical Coordinates, Solution of PDEs by Laplace Transforms. (Sections 12.8 to 12.12)

Textbook:

Erwin Kreyszig, *Advanced Engineering Mathematics*, 10th edition, Wiley.

Dennis Zill, *A First Course in Differential Equations,* Cengage.

References:

W.E. Boyce and R.C. DiPrima, *Elementary Differential Equations and Boundary Value Problems*, 7th edition, Wiley.

M.D. Raisinghania, *Ordinary and Partial Differential equations*, S Chand Publications.

Evaluation Pattern – R.13 & R.16

18CSA209 **Data Structures and Algorithms** **3-1-0-4**

Course Outcome:

CO-1: Understand asymptotic analysis and different methods.
CO-2 : Understand linear data structures and its applications.
CO-3: Understand different non-linear data structures and its applications
CO-4: Understand divide and conquer strategy for various sorting and searching techniques.
CO-5: Understand and apply the greedy approach for various problems.

Unit 1

Introduction: Overview of Data Structures – A Philosophy of Data Structures - The Need for Data Structures – Cost and Benefits - Abstract Data Types and Data Structures - Principles, and Patterns. Basic complexity analysis – Best, Worst, and Average Cases - Asymptotic Analysis - Analysing Programs – Space Bounds. Recurrence Relations: Analysis using Recurrence Tree based Method.

Unit 2

Arrays. Linked Lists: Using Arrays - Lists - Array based List Implementation – Linked Lists – LL ADT – Singly Linked List – Doubly Linked List – Circular Linked List. Stacks and Queues: Stack ADT - Array based Stacks, Linked Stacks – Implementing Recursion using Stacks, Queues - ADT, Array based Queue, Linked Queue, Double-ended queue, Circular queue.

Unit 3

Trees: Tree Definition and Properties – Tree ADT - Basic tree traversals - Binary tree - Data structure for representing trees – Linked Structure for Binary Tree – Array based implementation. Graphs: ADT- Data structure for graphs - Graph traversal - Transitive Closure - Directed Acyclic graphs - Weighted graphs – Shortest Paths - Minimum spanning tree.

Unit 4

Sorting and Searching. Bubble sort, Insertion sort, Heap Sort - Merge Sort - Quick Sort. Binary search. Divide and Conquer Strategy.
Unit 5

Greedy Method. Elements of Greedy Method. Fractional knapsack problem, scheduling problem. Applications of greedy method.

Textbook:

Goodrich M T, Tamassia R and Michael H. Goldwasser*, "Data Structures and Algorithms in Python",* Wiley publication, 2016.

References:

Clifford A. Shaffer, *"Data Structures and Algorithm Analysis"*, Third Edition, Dover Publications, 2012.

Tremblay J P and Sorenson P G*, "An Introduction to Data Structures with Applications",* Second Edition, Tata McGraw-Hill, 2002.

Evaluation Pattern – R.13 & R.16

Learning outcomes: Data structures provide a means to manage large amounts of **data** efficiently for **uses** such as large databases and internet indexing services. ... Some formal design methods and programming languages emphasize **data structures**, rather than **algorithms**, as the key organizing factor in software design. Understand asymptotic analysis and different methods. Understand linear data structures and its applications.

Understand different non-linear data structures and its applicationsUnderstand divide and conquer strategy for various sorting and searching techniques. Understand and apply the greedy approach for various problems.

Semester4

| 18MAT216 | Statistical Inference | (3-1-0-4) |

Course Outcome:

CO1: Understand the properties of desirable estimators and methods for assessing estimator behavior.

CO2 : Understand the concept of statistical likelihood and its use in parameter estimation

CO3: Ability to explain and demonstrate the plausibility of pre-specified ideas about the parameters of the model by examining the area of hypothesis testing.

CO4: Ability to explain in detail and demonstrate the use of non-parametric statistical methods, wherein estimation and analysis techniques are developed .

CO5:Ability to demonstrate computational skills to implement various statistical inferential approaches.

Unit 1
Parameter Estimation: Introduction, Maximum Likelihood Estimators, Interval Estimates, Estimating the Difference in Means of Two normal populations, Approximate Confidence Interval for the Mean of a Bernoulli random variable, Confidence Interval of the Mean of the Exponential Distribution, Evaluating a Point Estimator, The Bayes Estimator. (7.2-7.8 of Text)

Unit 2
Hypothesis Testing –Introduction, Significance Levels, Tests Concerning the Mean of a Normal Population, Testing the Equality of Means of Two Normal Populations, Hypothesis Tests Concerning the Variance of a Normal Population, Tests Concerning the Mean of a Poisson Distribution. (8.2-8.7Text)

Unit 3
Regression: Introduction, Least Squares Estimators of the Regression Parameters, Distribution of the Estimators, Statistical Inferences about the Regression Parameters, the Coefficient of Determination and the Sample Correlation Coefficient, Analysis of Residuals, transforming to Linearity, Weighted Least Squares, Polynomial Regression, Multiple Linear Regression, Predicting Future Responses, Logistic Regression Models for Binary Output Data. (9.2-9.11of Text)

Unit 4

Analysis of Variance- Introduction, One-Way Analysis of Variance, Two-Factor Analysis of Variance: Parameter Estimation and Testing Hypotheses, Two-Way Analysis of Variance with Interaction (10.3-10.6 of Text)

Unit 5

Goodness of Fit Tests and Categorical Data Analysis, Goodness of Fit tests when all parameters are Specified, Goodness of Fit Tests When Some Parameters are unspecified, Tests of Independence in Contingency Tables, Tests of Independence in Contingency Tables having fixed marginal totals, The Kolmogorov–Smirnov Goodness of Fit Test for Continuous data.

Nonparametric Hypothesis Tests: The sign test, the signed rank test, the two-sample problem, the runs test for randomness. (11.2- 11.6, 12.2-12.5 of Text)

Text Book:
Ross S.M., *Introduction to Probability and Statistics for Engineers and Scientists*, 3rd edition, Elsevier Academic Press.

References:
Douglas C. Montgomery and George C. Runger*, Applied Statistics and Probability for Engineers*, John Wiley and Sons Inc., 2005

Ravichandran, J. *Probability and Statistics for engineers*, First Reprint Edition, Wiley India, 2012

Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, *Probability and Statistics for Engineers and Scientists*, 8th Edition, Pearson Education Asia, 2007

Hogg, R.V., Tanis, E.A. and Rao J.M., *Probability and Statistical Inference*, Seventh Ed, Pearson Education, New Delhi

Evaluation Pattern – R.13 & R.16

<u>Learning outcomes</u>: **Statistical inference** is the process of using data analysis to deduce properties of an underlying probability distribution. Inferential **statistical** analysis infers properties of a population, for example by testing hypotheses and deriving estimates. Understand the properties of desirable estimators and methods for assessing estimator behavior.

Understand the concept of statistical likelihood and its use in parameter estimation

Ability to explain and demonstrate the plausibility of pre-specified ideas about the parameters of the model by examining the area of hypothesis testing.

Ability to explain in detail and demonstrate the use of non-parametric statistical methods, wherein estimation and analysis techniques are developed .

Ability to demonstrate computational skills to implement various statistical inferential approaches.

| 18MAT218 | Real Analysis 1 | (3-1-0-4) |

Course Outcome:

CO1: Understanding the set theoretic statements and the completeness property of R.

CO2: Understanding the concepts of sequences, series and Limits. Apply the tests for convergence, absolute convergence and analyzing the convergence criteria.

CO3: Defining Limits, continuity and monotonicity of a function and understanding the theorems related to them.

CO4: Understanding the concepts of extreme values, Mean value theorem and applying Taylor's theorem for approximating functions.

CO5: Understanding Riemann Sum and apply it to approximate integrations

Unit 1

Properties of real number system,Upper and Lower bounds, Least upper bound property and its applications, Absolute value and Triangle inequality Cantor's proof of uncountability of R.

Unit 2

Sequences and Their Convergence, Cauchy sequences, Subsequences and Bolzano-Weierstrass Theorem, Cauchy criterion.

Unit 3

Continuity, Uniform Continuity. Derivative of functions, Mean Value Theorem, L'Hospital Rule, Taylor's Theorem. Infinite Series: Conditional and Absolute Convergence, Tests for Absolute Convergence of Infinite Series, Alternating Series Test, Rearrangement of terms in an infinite Series.

Unit 4

Riemann Integration: Integral and its properties, Fundamental theorems of Calculus, Sum of an infinite series as an integral, Improper Riemann integrals.

Unit 5

Sequences and Series of Functions: Pointwise and Uniform Convergence of sequences, Properties of Uniformly Convergent Sequences, Uniform Convergence of Series of Functions, Cauchy Criterion and Weierstrass M-test.

Textbook:

S. Kumaresan and Ajit Kumar, *A Basic Course in Real Analysis*, CRC Press.

References:

V.K. Krishnan, *Fundamentals of Real Analysis,* Pearson.

Robert G. Bartle and Donald R. Sherbert, *Introduction to Real Analysis*, 3rd edition, Wiley.

Terence Tao, *Analysis I*, Hindustan Book Agency.

Terence Tao, *Analysis II*, Hindustan Book Agency.

Evaluation Pattern – R.13 & R.16

18MAT221   **Numerical Methods**   **(3-1-0-4)**

Course Outcome:

CO-1: Understand the basic concepts of root finding methods, system of equations and their solutions.
CO-2: Understand the concepts of interpolation and construction of polynomials.
CO-3: Application of numerical methods to understand the concept of Calculus (Differentiation and Integration).
CO-4: Application of numerical concepts to solve ODEs and PDEs.
CO-5: Usage of software tools to solve various problems numerically.

Unit 1

Solution of Nonlinear Equations: Bisection and False position Methods, Newton Raphson and Secant Methods, Rate of Convergence.

Unit 2

Solution of Linear Systems AX=B and Eigen value problems (12 hours): Direct methods, Gaussian Elimination, Gauss Jordan method, LU Factorisation, Jacobi & Gauss Seidel iterative Methods.

Unit 3

Interpolation, Curve Fitting (12 hours): Taylor's Series calculation of Functions, Lagrange's Polynomial Approximation and Interpolation, Newton Polynomial Approximation using divided differences and Interpolation, Error, Newton-Gregory forward and backward difference interpolation,Hermite interpolation, Piecewise and Spline interpolation, Polynomial approximation and Weierstrass theorem, Principle of Least Squares.

Unit 4

Numerical Differentiation and Integration (10 hours):Numerical Differentiation using Lagrange, Finite difference interpolation and Undetermined coefficient method, Numerical Integration using Newton-Cotes method, Gauss-Legendre Integration method, Trapezoidal and Simpson method, Quadrature, Composite Trapezoidal and Simpson's Rule, Romberg Integration, Orthogonal polynomials and Gaussian integration.

Unit 5

Solution of Ordinary Differential Equations (10 hours): Euler method,Modified-Euler mid point method, Taylor series method, Runge-Kutta methods, Error analysis.

Textbook:

Jain M.K., Iyengar S.R.K. and Jain R.K., *Numerical Methods for Engineering and Scientific*

Computation, 3rd edition, New Age International (P), New Delhi, 1995.

References:

John H. Mathews, Kurtis D. Fink, *Numerical Methods Using Matlab*, 4th edition, Prentice-Hall.

Rudra Pratap, *Getting Started with MATLAB 7: A Quick Introduction for Scientists and Engineers*, Oxford University Press, 2005.

Evaluation Pattern – R.13 & R.16

18MAT223 **Abstract Algebra 1** **(3-1-0-4)**

Course Outcome:

CO1: Ability to demonstrate insight into abstract algebra with focus on axiomatic theories

CO2:Ability to apply algebraic ways of thinking

CO3: Ability to demonstrate knowledge and understanding of fundamental concepts including groups, subgroups, normal subgroups, homomorphisms and isomorphism

CO4: Ability to demonstrate knowledge and understanding of rings, fields and their properties

CO5: Ability to prove fundamental results and solve algebraic problems using appropriate techniques

Unit 1

Number Theory: Mathematical induction, Division Algorithm, Greatest Common Divisor, Euclidean Algorithm for finding GCD, Linear Diophantine Equation, Primes Numbers and Fundamental Theorem of

Arithmetic, Euclid's proof of Infinitude of Primes.Basic properties of Congruences, Linear Congruences and Chinese Remainder Theorem, Fermat's Little theorem, Wilson's Theorem, Euler ϕ Function and its Properties, Euler's Theorem.

Unit 2

Definition and examples of Groups, some elementary properties of groups, Order of a Group, Subgroups, Cyclic Groups, Classification of Subgroups of Cyclic Groups,Permutation Groups, Cycle Notation, Properties of Permutations, Isomorphism of Groups.

Unit 3

Left and Right Cosets, Properties of Cosets, Lagrange's Theorem and consequences, Normal Subgroups and Factor / Quotient Groups, Group Homomorphisms, Kernel.

Unit 4

Rings, Properties of Rings, Subrings, Integral Domains, Fields, Characteristic of a Ring.

Unit 5

Ideals and Factor / Quotient Rings, Prime Ideals and Maximal Ideals, Ring Homomorphisms and Field of Quotients.

Textbook:

David M. Burton, *Elementary Number Theory*, 7th edition, McGraw-Hill.

Joseph A. Gallian, *Contemporary Abstract Algebra*, 4th edition, Narosa.

References:

John B. Fraleigh, *A First Course in Abstract Algebra*, 7th edition, Pearson.

I.N. Herstein, *Topics in Algebra*, 2nd edition, John Wiley.

Evaluation Pattern – R.13 & R.16

Semester5

18M AT304   Complex Analysis 1   **(3-1-0-4)**

Course Outcome:

CO1: Ability to understand basic concepts of the complex numbers

 CO2:Understand about complex integrations
CO3:Understand about the singularities and Residues
CO4:Understand the evaluation of different type integrals
CO5:Understand the concept of complex mappings and Linear transformations**.**
Unit 1 Complex Numbers: Definition, Algebra of complex numbers, Geometric representation, Conjugates, Absolute values, properties, Polar form. Complex Functions: Introduction, Limits, Continuity, Differentiability, Analytic functions, Cauchy-Riemann Equations in Carteisan and polar coordinates.

Unit 2

Elementary functions, exponential and Logarithmic functions, Branches of logarithm, Trigonometric and Hyperbolic functions.

Unit 3

Complex Integration: Definitions, Line integrals, Cauchy Gorsat theorem, Cauchy's integral formula, Derivatives of analytic functions, Morera's theorem, Liouville's theorem, Fundamental theorem of Algebra, Gauss' mean value theorem, Maximum modulus principle.

Unit 4

Power Series: Definitions, Taylor's series, Laurent's series, circle and radius of convergence. Contour Integration: Zeros and Singularities of Analytic functions, types of singularities, Poles, Meromorphic functions, principle of argument, Rouche's theorem, Fundamental theorem of Algebra, Residues, Evaluation of residues at a pole, Cauchy's residue theorem.

Unit 5

Evaluation of Real definite integrals by Contour integration, Evaluation of improper integrals, Jordan's lemma, Mappings by elementary functions, Linear fractional Transformation: Image of a line and circle.

Textbook:

R. V. Churchill and J. W. Brown, *Complex Variables and Applications*, Tata McGraw-Hill.

References:

Dennis Zill, *Complex Analysis*, Jones and Bartlett.

Ahlfors, *Complex Analysis*, McGraw-Hill.

Anant R Shastri, *Basic Complex Analysis of one Variable,* Lakshmi Publications.

18MAT305   **Real Analysis 2**   **(3-1-0-4)**

Course Outcome:

CO1:To introduce the abstract set theory at a level and depth appropriate for providing a prerequisite   for introducing the concepts of Real Analysis and its applications

CO2:To introduce the basic concepts of the analysis on the real line such as limits convergence,   continuity, Riemann theory of Integration at a level and providing a prerequisite for the   forth coming courses of higher mathematics, like Differential Geometry, Functional   Analysis, Complex Analysis Topology etc..

CO3:To introduce the student to what it means to do mathematics, as opposed to learning about   mathematics or to learning to do computational exercises.

CO4:To help the student equip themselves with the techniques and rigor of Analysis and to   learn   how to write mathematical text according to the standards of the profession and   inspiring them to study higher-level mathematics and to become a professional mathematician

Unit 1

Definition of a of a Set, Continuous Functions, Equivalent definitions of Continuity, Uniform Continuity, Limit of a Function, Open and Closed Maps Metric and Examples, Open Balls and Open Sets, Convergent Sequences, Limits and Cluster Points, Cauchy Sequences and Completeness, Bounded sets, Dense Sets, Boundary.

Unit 2

Compact spaces: Definition and Examples, Compact subspaces of R and Heine Borel Theorem, Continuous Functions on Compact Spaces.

Unit 3

Characterisation of Compact Metric Spaces, Lebesgue Covering Lemma, Arzela-Ascoli Theorem.

Unit 4

Connected Spaces: Definition and Examples, Connected Subsets of R, Path Connected Spaces.

Unit 5

Complete Metric Spaces, examples, Nested Interval Theorem, Cantor's Intersection Theorem, Completion of a metric space, Baire Category Theorem, Banach's Contraction Principle.

Textbook:

S. Kumaresan, *Topology of Metric Spaces*, Wiley.

References:

W. Rudin, *Principles of Mathematical Analysis*, Tata McGraw-Hill.

E.T. Copson, *Metric Spaces*, Cambridge.

Evaluation Pattern – R.13 & R.16

| 18MAT306 | Operations Research | 3-1-0-4 |

Course Outcome:

CO1: Ability to understand Methodology of Operations Research.
CO2: Understand the basic concepts of linear programming ,theory of duality and methods for solving linear programming problems.
CO3: Understand the Mathematical formation of transportation and assignment problems and solution methods.
CO4: Ability to solve Dynamic programming problems
CO5: Understand the network representation of project works and computation of PERT-CPM

Unit 1
Basics of Operational Research: Origin & Development of Operational Research, Definition and Meaning of Operational Research, Different Phases of an Operational Research Study, Scope and Limitations of Operational Research, Mathematical Modeling of Real Life Problems.
Unit 2
Linear Programming: Linear Programming Problem Formulation, solution by Graphical Method, Theory of Simplex Method, Simplex Algorithm, Two phase Method, Charnes-M Method, Degeneracy, Theory of Duality, Dual-simplex method.
Unit 3
Transportation problem (TP) and its formulation. Finding basic feasible solution of TP using North-West Corner Rule, Least Cost and Vogel's Approximation Method, MODI method for finding optimal solution for TP, Assignment problem and its formulation, Hungarian method for solving Assignment problem, Transshipment and Travelling salesmen problem.

Unit 4

Introduction to Dynamic Programming. The recursive Equation Approach, Characteristics of Dynamic Programming, Recursive nature of computations in Dynamic programming problem –Forward and Backward Recursion, Cargo-loading Model–Work-Force size model – Equipment Replacement model.

Unit 5

Network Representation, Critical Path (CPM)computations, Construction of the Time Schedule, Linear programming formulation of CPM - PERT calculations. Concepts of Game problem, Two- person zero-sum game, Pure and Mixed strategies, Saddle point and its existence Dominance. Fundamental Theorem of Rectangular games. Concept of Dominance. and Graphical method of solving Rectangular games. Relationship between rectangular game and Linear Programming Problem. Solving rectangular game by Simplex method.

Text Books:
  • Hamdy A. Taha, *Operations Research - An Introduction*, 8ᵗʰEdition, Prentice Hall.
  • KantiSwarup, P.K. Gupta and Man Mohan, *Operations Research,* 9ᵗʰEdition, S Chand and Sons.
References:
 A. Ravindran, D. T. Phillips and James J. Solberg: *Operations Research- Principles and Practice*, John Wiley & Sons, 2005.
F.S. Hillier. G.J. Lieberman*, Introduction to Operations Research- Concepts and Cases*, 9th Edition, Tata Mc-Graw Hill, 2010
Ronald L. Rardin,*Optimization in Operations Research*, Prentice Hall, 1998

Evaluation Pattern – R.13 & R.16

Semester 6

18MAT315   **Complex Analysis 2**   **(3-1-0-4)**

CO1 To understand the basic idea of analytic functions, power series etc.

 CO2 Ability to understand power series representation of Analytic function And zero's of analytic functions

CO3:Undersatand. Cauchy's Theorem and integral formula, Homotopic version of Cauchy's Theorem

CO4: To understand Singularities and Residue theorem

CO5: The extended plane and its spherical representation, Analytic function as mapping, Mobius transformations

Unit 1

Elementary properties and examples of analytic functions, Power series, Analytic function, Riemann Stieltjes integrals.(Chapter 3 Sections 1, 2 and Chapter 4 Section 1 of Text)

Unit 2

Power series representation of an analytic function, Zeros of an analytic function, Liouville's Theorem, Maximum Modulus Theorem, Index of a closed curve.(Chapter 4 – Sections 2, 3 and 4 of Text)

Unit 3

Cauchy's Theorem and integral formula, Homotopic version of Cauchy's Theorem, Simple connectivity, Counting zeros: The open Mapping Theorem, Goursat's Theorem. (Chapter 4 Sections 5, 6, 7 and 8 of Text)

Unit 4

Singularities: Classification, Removable, Pole and Essential Singularity, Laurent Series, Casorati Weierstrass Theorem, Residue theorem, The argument principle, Rouche's Theorem. (Chapter 5 Sections 1, 2, and 3 of Text)

Unit 5

The extended plane and its spherical representation, Analytic function as mapping, Mobius transformations, The maximum principle, Schwarz's Lemma.(Chapter 1 Section 6, Chapter 3 Section 3, Chapter 6 Section 1 and 2 of Text)

Textbooks:

John B Conway, Functions of One Complex Variable, Springer.

References:

Elias Stein and Rami Shakarchi, Complex Analysis, New Age Publishers.

Lars V Ahlfors, Complex Analysis,Tata McGraw-Hill.

Evaluation Pattern – R.13 & R.16

18MAT317   **Linear Algebra 2**   **3-1-0-4**

CO1: Ability to understand the basic concepts of vector and matrix algebra, including linear dependence / independence, basis and dimension of   a subspace, for analysis of matrices and systems of linear equations
CO2:.Ability to find the dimension of spaces such as those associated with   matrices and linear transformations
CO3:Ability to understand Dual Space, subspaces, sub space of a linear   transformation Minimal and Characteristic Polynomial
CO4; To understand the construction of matrices for a linear transformation in the   triangular/ Jordan form
CO 5: Apply the decomposition theorem in context of mathematical applications to subspaces

Unit 1

Fields, System of Linear Equations, Matrices and Elementary Row Operations, Row Reduced Echelon Matrices, Elementary Matrices, Invertible Matrices. Vector Space over a Field, Definition and Examples, Subspaces, Spanning set, Linear Independence, Basis and Dimension of a Vector Space.

Unit 2

Ordered Basis and Coordinates, Row Space and Row Equivalent Matrices. Linear Transformations: Properties, Rank and Nullity of a Linear transformation, Algebra of Linear Transformations, Isomorphism of Vector Spaces, Representation of Linear Transformations by Matrices, Similar Matrices.

Unit 3

Linear Functionals, Dual Space, Annihilators of subspaces, Transpose of a Linear Transformation, Characteristics value and Characteristic polynomial of a Linear Operator, Minimal and Characteristic Polynomial.

Unit 4

Cayley Hamilton Theorem,Invaraiant Subspaces of an Operator, Diagonalizability of an Operator, Simultaneous Diagonalization.

Unit 5

Direct Sum Decompositions, Invariant Direct Sums, Primary Decomposition Theorem, Cyclic Subspaces and Annihilators, Cyclic Decomposition Theorem and Rational Form, Jordan Form.

Textbook:

K. Hoffman and R. Kunze, *Linear Algebra*, Prentice Hall.

References:

Sheldon Axler, *Linear Algebra Done Right,* 2nd Edition, Springer.

Dummit and Foote, *Abstract Algebra*, Wiley.

M. Artin, *Algebra*, Prentice Hall.

Evaluation Pattern – R.13 & R.16

18MAT318   **ODE and Calculus of Variations**   **(3-1-0-4)**

CO1: To understand variational problems and the necessary condition for extremal namely Euler equation. To apply these conditions in evaluations of extremal of functionals for several variables.
CO2: To apply the variational problems in solving physical problems which involves the Principle of Least Action, Conservation Laws, The Hamilton-Jacobi Equation.
CO3: To understand the concept of weak and strong extremum. To apply in the Field of a Functional, Hilbert's Invariant Integral, The Weierstrass E-Function.
CO4: To apply these techniques in solving differential equations by the Ritz Method and the Method of Finite Differences. To solve the Sturm-Liouville Problem using variational method.
CO5: To understand the idea of solving various integral equations and to apply these tools to solve Fredholm and Volterra Integro - Differential equation by the methods of the Green's function. Decomposition, direct computation, Successive approximation, series solution, successive approximation**.**

Unit 1

Existence and Uniqueness: Picard's method of successive approximation, Problems of existence and

uniqueness, Lipschitz condition, Existence and Uniqueness Theorem, Cauchy-Peano's Theorem. Linear equations: Basic theory, Homogeneous equation, Wronskian, method of Variation of parameters, equations with constant coefficients and method of undetermined coefficients, Cauchy Euler equation.

Unit 2

Power series solution: Ordinary and Singular points, Gauss's Hypergeometric Equation, Chebyshev Polynomials, Frobenius's method, Bessel equation and Bessel functions, Legendre Polynomials, Gamma Functions.

Unit 3

Systems of Linear Differential equations: Differential operators, Operator method for linear systems with constant coefficients, Matrix method for homogeneous linear systems with constant coefficients.

Unit 4

Sturm-Liouville Boundary value problems: Definition and examples, Characteristic values and characteristic functions, Orthogonality of characteristic functions, series of orthonormal functions. Calculus of Variations: Introduction, Variation and its properties, Variational problems with the fixed boundaries, Euler's equation, the fundamental lemma of the calculus of variations, Functionals involving more than one dependent variables.

Unit 5

Variational problems in parametric form, Isoperimetric problems,Variational problems with moving boundaries, Moving boundary problems with more than one dependent variables, One-sided variations, Field of extremals, central field of extremals, Jacobi's condition, The Weierstrass function, The Legendre condition, weak extremum, strong extremum.

Textbooks:

Shepley L. Ross, *Differential Equations*, Wiley.

M.D. Raisinghania, *Advanced Differential equations*, S Chand Publications.

References:

G.F. Simmons, *Differential Equations with Applications and Historical Notes*, McGraw-Hill.

I.M.Gelfand, S.V.Fomin, *Calculus of Variations,* Dover.

L.D.Elsgolc, *Calculus of Variations,* Dover.

Evaluation Pattern – R.13 & R.16

18MAT319   **Optimization Techniques**   **(3-1-0-4)**
Course Out Comes:

> **CO1:**Understand different types of Optimization Techniques in engineering problems. Learn Optimization methods such as Bracketing methods, Region elimination methods,Point estimation methods.
> **CO2:**Learn gradient based Optimizations Techniques in single variables as well as multi-variables (non-linear).
> **CO3:**Understand the Optimality criteria for functions in several variables and learn to apply OT methods like Unidirectional search and Direct search methods.
> **CO4:**Learn constrained optimization techniques. Learn to verify Kuhn-Tucker conditions and Lagrangian Method.

CO5: Familiarize the concept of optimization in practical applications to find the best feasible solutions in practical applications

Unit 1
Introduction to Optimization, Historical Development, Applications of Optimization, Statement of an Optimization Problem, Classification of Optimization Problems, Optimization Techniques.

Unit 2
Single Variable Optimization- Optimality criteria, bracketing methods-exhaustive search method, bounding phase method- region elimination methods- interval halving, Fibonacci search, golden section search, point estimation-successive quadratic search, gradient based methods.

Unit 3
Multivariable Optimization, optimality criteria, unconstrained optimization-solution by direct substitution, unidirectional search-direct search methods, evolutionary search method, simplex search method, Hook-Jeeves pattern search method.

Unit 4
Gradient based methods-steepest descent, Cauchy's steepest descent method, Newton's method, conjugate gradient method-constrained optimization Multivariable Optimization with no constraints, Multivariable Optimization with Equality Constraints, Solution by Direct Substitution

Unit 5
Solution by the Method of Lagrange Multipliers- Multivariable Optimization with Inequality Constraints, Kuhn–Tucker Conditions, Constraint Qualification, Convex Programming Problem.

Textbook:
Edwin K.P. Chong, Stanislaw H. Zak, "An introduction to Optimization", 2nd edition, Wiley, 2013.

S.S. Rao, "Optimization Theory and Applications", Second Edition, New Age International (P) Limited Publishers, 1995.

References:

Kalyanmoy Deb, "Optimization for Engineering Design Algorithms and Examples", Prentice Hall of India, New Delhi, 2004.

M. Asghar Bhatti(2000), *Practical optimization methods*, Springer.

Evaluation Pattern – R.13 & R.16

Learning Outcomes:

In *computing*, *optimization* is the process of modifying a system to make some features of it work more efficiently or use fewer resources. In *computing*, *optimization* is the process of modifying a system to make some features of it work more efficiently or use fewer resources. Understand different types of Optimization Techniques in engineering problems. Learn Optimization methods such as Bracketing methods, Region elimination methods,Point estimation methods. Learn gradient based Optimizations Techniques in single variables as well as multi-variables (non-linear). Understand the Optimality criteria for functions in several variables and learn to apply OT methods like Unidirectional search and Direct search methods. Learn constrained optimization techniques. Learn to verify Kuhn-Tucker conditions and Lagrangian Method. Familiarize the concept of optimization in practical applications to find the best feasible solutions in practical applications.

18CSA102   **Introduction to Programming I**   **3-0-2-4)**

Corse Outcome:

CO1: Understand the foundation concepts of information and information processing in computer systems, data representation, coding systems.

CO2: Understand programming language syntax and its definition by example of Python.

CO3: Adequately use standard programming constructs: repetition, selection, functions, composition, modules, aggregated data (arrays, lists, etc.)

CO4: Identify and repair coding errors in a python program

CO5: Use library software for (e.g.) building a graphical user interface, or mathematical software.

CO6: Understand function concept and how to deal with function arguments and parameters

Unit 1

Introduction to Computers and Programming: Hardware and software; binary representation of numbers, working of a program, high-level languages, compilers and interpreters; Installing python, editors, integrated development environment, writing and running programs.

Introduction to programming: Designing a program: development cycle, pseudo code, flowcharts and algorithm development; variables, numerical data types and literals, strings, assignment and reassignment, input/output, formatted output, reading numbers and strings from keyboard; performing calculations: floating point and integer division, converting math formulas to programming statements, standard mathematical functions, mixed-type expressions and data type conversions.

Unit 2

Program Decision and Control Structures: Boolean expressions, relational expressions, logical operators, Boolean variables; if, if-else, if-elif-else, inline-if statements, nested structures, and flowcharts; use of temporary variables, application: arranging a few numbers in increasing or non-decreasing, decreasing or non-increasing orders, etc.

Unit 3

Repeated calculations and Looping: condition-controlled and count-controlled loops, while-loop (condition-controlled), infinite loops; for-loop (count-controlled), applications: calculating summation of series, Taylor expansion of mathematical functions, etc; nested loops.

Unit 4

Functions: void and value returning functions, defining and calling functions, local and global variables and constants, scope, returning one or more values, Math module, use of standard math libraries and functions, passing functions as arguments, the Main program, Lambda functions, example: numerical integration, testing and test functions; Measuring CPU time and efficiency assessment; examples.

Unit 5

Arrays, Lists and Tuples: lists, index, iterating over a list with for-loop, operations with lists, built-in functions, finding index, sorting, etc., processing lists; Arrays: vectors and tuples, vector arithmetic, arrays, Numerical Python arrays – Numpy, curve plotting: matplotlib, SciTools, making animations and videos; Higher-dimensional arrays: two and three dimensional arrays, matrix objects and matrix operations: inverse, determinant, solving linear systems using standard libraries.

Lab Exercises to be done along with the course:

- Using computer: Hardware: input/output devices, ports, memory units; Software: Operating systems, File system, application software; Word processor: formatting, including tables, pictures, drawing in a canvas, equations; Spread sheet program: rapidly calculating with formulas and filling columns, etc,

plotting; Presentation tools (2 weeks)

- Start programing: keyboard input, assigning and printing variables – numbers, strings, names, etc.; Converting formulas into programming statements: examples of conversion from one unit to another unit, Calculating distances, areas and volumes; Formatted output, scientific notation; Program to (a) find the roots of a quadratic equation (both real and imaginary root), (b) make tables of mathematical functions like sin x, tan x, exp(x), etc. (3 weeks)
- Control, Looping and Functions: Programs to illustrate logical expressions, arranging a few numbers in a given order; looping statements: summing a numbers from keyboard input, calculating summation of power series of functions, error estimation; Defining custom functions: examples; returning multiple values, passing functions as arguments. (3 weeks)
- Introducing Sage or equivalent Computer Algebra System: using it as calculator, symbolic mathematics, derivatives and integrals, solving linear system of equations, summing series, plotting functions, surfaces, Arrays, vectors and matrix operations. (2 weeks)
- Programs for vector and matrix operations: Define arrays, dot product and cross product of vectors; sum, product, and other operations of two n×n matrices; Sorting numbers, searching the index of a sorted set of numbers; Programs to plot mathematical and user defined functions. (2 weeks)

Textbooks/References
- Tony Gaddis, Starting Out with Python, 3E, Pearson, 2015.Book contains flowcharting and pedagogical program development in an introductory Python book. Ch. 1 to 5, Ch 7.
- Hans Petter Langtangen, A Primer on Scientific Programming with Python, 5E, Springer, 2016. Ch. 1 to 3, Ch. 4 (carefully selected material appropriate for first year students)
- Mark Newman, Computational Physics, Ch. 1 to 3.
- One material and tutorials: www.python.org ; https://www.learnpython.org; www.vpython.org.

Evaluation Pattern – R.13 & R.16

Learning Outcomes:

A computer is a computational device which is used to process the data under the control of a computer *program*. *Program* is a sequence of instruction along with data. While executing the *program*, raw data is processed into a desired output format.

The comopents of this course is useful to Understand the foundation concepts of information and information processing in computer systems, data representation, coding systems.: Understand programming language syntax and its definition by example of Python. Adequately use standard programming constructs: repetition, selection, functions, composition, modules, aggregated data (arrays, lists, etc.) Identify and repair coding errors in a python program
 Use library software for (e.g.) building a graphical user interface, or mathematical software.
 Understand function concept and how to deal with function arguments and parameters

18CSA112   **Introduction to Programming II**   **(3-0-2-4)**
Course Outcome

CO1: Understand defensive programming concept. Ability to handle possible errors during program execution
CO2: Write code in Python to perform mathematical calculations and scientific simulations.
CO3: Understand the concepts of object-oriented programming as used in Python: classes, subclasses, properties, inheritance, and overriding.

CO4: Have knowledge of basic searching and sorting algorithms. Have knowledge of the basics of vector computation
CO5:Understand the concept of recursion and solve problems using recursion.

CO6: Implement a given algorithm as a computer program (in Python)

Unit 1

Review of basics (2 hours); Files: reading from a command-line, option-value pairs, file input and output, filenames and file objects, opening and writing / appending /reading data to a file, writing and reading numerical data, loop operations and file processing; Handling errors and exceptions: try, except, finally statements and catching exceptions; Making modules, example: bisection and root finding.

Unit 2

More about Strings: basic string operations, slicing, testing, searching, manipulating;
Dictionaries: creating dictionaries, retrieving values, using for-loop to iterate over a dictionary, etc.; Sets: creation and operations on a set.

Unit 3

Classes: Introduction to procedural and object oriented programming, definition, attributes, methods, examples, instances, accessor and mutator methods, passing objects as arguments; function classes for mathematical computations, complex number class, static methods and attributes.

Unit 4

Object-Oriented Programming: Inheritance: generalization and specialization, examples; Polymorphism: definition, general examples, mathematical examples, Inheritance and class hierarchies; classes for numerical differentiation and integration; subclasses.

Unit 5

Recursion: Introduction and problem solving with recursion, examples: factorials, Fibonacci series, Euclid's algorithm of gcd calculation, recursion versus looping; A couple of sorting and and searching algorithms; Glimpses of advanced data structures, GUI programming.

Lab Exercises to be done along with the course:
* More about Computer Algebra System: Problem solving , multiple integrals, vector calculus (3 weeks)
* Programs: (3 weeks)
  * To fit a straight line through the given set of data points using least square fitting algorithm.
  * To sort a given list containing the name of students and their total marks and print the rank list.
  * To searching a sorted list and print the details of the sought item.
* Program to (a) integrate a given function using Simpson's rule and Trapezoidal rules, (b) determine derivative table of a smooth function. (3 weeks)
* Program to solve elementary differential equations: (3 weeks)
  * To compute the trajectory of the projectile thrown at various angles.
  * To compute position and velocity of a spherical body in a viscous fluid, e.g., falling of rain drop, terminal velocity.
  * To study the motion of a body under a central force field: planetary motion - elementary approach.

Textbooks/References
* Tony Gaddis, Starting Out with Python, 3E, Pearson, 2015.Book contains flowcharting and pedagogical program development in an introductory Python book. Ch. 6, Ch. 8 to 12. (text)
* Hans Petter Langtangen, A Primer on Scientific Programming with Python, 5E, Springer, 2016. Ch. 4, 6, 7, 9 (text)
* Mark Newman, Computational Physics, Ch. 1 to 3.
* One material and tutorials: www.python.org; https://www.learnpython.org; www.vpython.org.

Evaluation Pattern – R.13 & R.16

Learning Outcomes:

A computer is a computational device which is used to process the data under the control of a computer *program*. *Program* is a sequence of instruction along with data. While executing the *program*, raw data is processed into a desired output format. This component is useful to understand defensive programming concept. Ability to handle possible errors during program execution Write code in Python to perform mathematical calculations and scientific simulations. Understand the concepts of object-oriented programming as used in Python: classes, subclasses, properties, inheritance, and overriding. Have knowledge of basic searching and sorting algorithms. Have knowledge of the basics of vector computation. Understand the concept of recursion and solve problems using recursion. Implement a given algorithm as a computer program (in Python).

18CSA308	**Machine Learning 1**	(3-1-0-4)

CO1: Understand the domain of machine learning with respect to the regression and classification and its huge potential for providing solutions to real-life problems.

CO2: Have a good understanding of the fundamental issues and challenges in basic machine learning algorithms in terms of data, model selection, and complexity.

CO3: Understand the problem of Curse of Dimensionality and different methods to tackle it.

CO4: Understand the mathematical framework for machine learning (both supervised and un-supervised learning) and methods to tackle under fitting & overfitting.

CO5: Learn the motivation and theory behind learning an artificial neural networks for machine learning applications.

CO6: Be able to design and implement right machine learning algorithm for a given real-world problem.

CO1: Have a good understanding of the fundamental issues and challenges of machine learning data, model selection, model complexity,etc.

CO2:Have an understanding of the strengths and weakness of many popular machine learning approaches.

CO3:To understand the mathematical relationships within and across Machine Learning algorithms and the paradigms of supervised and un-supervised learning

CO4:Be able to design and implement various machine learning algorithms in a range of real-world applications

Unit 1

Introduction, Simple Linear regression, Multiple linear regression, Extensions of the linear model, Classification: overview, Logistic regression, Linear discriminant analysis, comparison of classification methods.

Unit 2

Resampling methods: Cross validation and the bootstrap, Linear model selection and Regularization: Subset selection, Shrinkage methods, Dimension reduction methods, Considerations in high dimensions.

Unit 3

Polynomial regression, step functions, basis functions, regression splines, smoothing splines, local regression, generalised additive models for regression and classification problems, Regression trees,

Classification trees, comparison of trees and linear models, Bagging, Random Forests, Boosting.

Unit 4

Support Vector Machines: Hyperplane, Maximum Margin Classifier, Support Vector Classifiers, Support Vector Machines, One vs One Classification and One vs All Classification, Relationship to Logistic Regression. Unsupervised Learning: Principal Component Analysis and its applications, K-Means Clustering and Hierarchical Clustering.

Unit 5

Neural Networks: Introduction, Projection Pursuit Regression, Neural Networks, Fitting Neural Networks, Some issues in Training Neural Networks-Starting Values, Overfitting, Scaling of the Inputs, Number of Hidden Units and Layers, Multiple Minima.

Textbooks:

G. James, R. Tibshirani, *An Introduction to Statistical Learning: with applications in R*, Springer.

T. Hastie, R. Tibshirani, *Elements of Statistical Learning: Data mining, Inference and Predicton*, Springer.

References:

Kevin Murphy, *Machine Learning: A Probabilistic Perspective*, MIT Press.

Evaluation Pattern – R.13 & R.16

Learning Outcomes:

Machine learning is an **application** of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. **Machine learning** focuses on the development of computer programs that can access data and **use** it learn for themselves. These comonents are useful to Understand the domain of machine learning with respect to the regression and classification and its huge potential for providing solutions to real-life problems. Have a good understanding of the fundamental issues and challenges in basic machine learning algorithms in terms of data, model selection, and complexity. Understand the problem of Curse of Dimensionality and different methods to tackle it. Understand the mathematical framework for machine learning (both supervised and un-supervised learning) and methods to tackle under fitting & overfitting. Learn the motivation and theory behind learning an artificial neural networks for machine learning applications.: Be able to design and implement right machine learning algorithm for a given real-world problem.

18CSA316   **Machine Learning 2**   **(3-1-0-4)**

CO1: To understand the computing capacity of single layer neural networks, and the need for multi-layer neural networks.

CO2: Learn to tackle the under-fitting, overfitting, and getting into local optimal solutions when learning an artificial neural network.

CO3: Learn about the deep neural networks, CNN to understand how it differ from a deep traditional FFN both in terms of the number of parameters to be learned and in terms of the learning by back-propagation.

CO4: Learn to design and use CNN both as a stand-alone classifier and in transfer learning settings.

CO5: Learn the necessary theory behind different recurrent neural networks and its applications to sequential data analysis.

Unit 1

Machine learning Basics and introduction, Capacity, Overfitting and under fitting, Hyper parameters, Estimator, Bias and Variance, Maximum likelihood estimation, Stochastic Gradient descent

Unit 2

Deep feedforward networks, Learning XOR, Hidden units, Architecture design, Backpropagation

Unit 3

Regularization, L1 and L2 regularization, Noise robustness, Semi supervised learning, Parameter typing and sharing, Sparse representation, Dropout

Unit 4

Optimization, Challenges in neural network optimization, Parameter initialization strategy, Adaptive learning rates, Optimization algorithms

Unit 5

Convolution operator, Pooling, Structured outputs, Efficient convolution algorithms, Unsupervised features, Convolution Neural networks, Recurrent Neural Networks, Encoder-decoder, LSTM and memory architectures, Optimization for long term dependency

Textbooks:

Ian Goodfellow, Yoshua Bengio and Aaron Courville, *Deep Learning*, MIT Press. (Chapters 5-10).

. Evaluation Pattern – R.13 & R.16

Learning outcomes: At its core, **data science** is a field of study that aims to **use** a **scientific** approach to extract meaning and insights from **data**. ... **Machine learning**, on refers to a group of techniques used by **data scientists** that allow computers to learn from **data**. To understand the computing capacity of single layer neural networks, and the need for multi-layer neural networks. Learn to tackle the under-fitting, overfitting, and getting into local optimal solutions when learning an artificial neural network. Learn about the deep neural networks, CNN to understand how it differ from a deep traditional FFN both in terms of the number of parameters to be learned and in terms of the learning by back-propagation. Learn to design and use CNN both as a stand-alone classifier and in transfer learning settings.Learn the necessary theory behind different recurrent neural networks and its applications to sequential data analysis.

18CSA386   **Machine Learning Lab I**   **0 0 2 1**
Course Outcome:

CO1:To Understand Introduction to R: Basic Commands, Graphics, Indexing Data, Loading Data
 CO2:To understand &analyze large number of data's using Simple Linear Regression, Multiple Linear Regression Logistic Regression, Linear Discriminant Analysis, Quadratic Discriminant Analysis in software CO3; Ability to understand analyze and interpret the data usingPrincipal Components Regression, Partial Least Squares methods using –R
 CO4: Ability to understand Decision Trees, Fitting Classification Trees and Regression Trees, Bagging and Random Forests how to use in software.
1. Introduction to R: Basic Commands, Graphics, Indexing Data, Loading Data.
2. Linear Regression: Libraries, Simple Linear Regression, Multiple Linear Regression.
3. Logistic Regression, Linear Discriminant Analysis, Quadratic Discriminant Analysis.
4. Cross Validation and Bootstrap, Validation set approach, Leave-One-Out Cross Validation
5. K-Fold Cross Validation, Bootstrap.
6. Subset Selection Methods, Best Subset Selection, Forward and Backward Stepwise Selection.
7. Ridge Regression and the Lasso.

8. Principal Components Regression, Partial Least Squares.
9. Non Linear Modelling, Polynomial Regression and Step Functions, Splines, GAMS.
10. Decision Trees, Fitting Classification Trees and Regression Trees, Bagging and Random Forests.

Evaluation Pattern – R.13 & R.16

Learning Outcomes

Machine learning is an application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. Logistic Regression is a Machine Learning algorithm which is used for the classification problems, it is a predictive analysis algorithm and based on the concept of probability. It helps to Understand Introduction to R: Basic Commands, Graphics, Indexing Data, Loading Data. To understand &analyze large number of data's using Simple Linear Regression, Multiple Linear Regression Logistic Regression, Linear Discriminant Analysis, Quadratic Discriminant Analysis in software Ability to understand analyze and interpret the data usingPrincipal Components Regression, Partial Least Squares methods using –R. Ability to understand Decision Trees, Fitting Classification Trees and Regression Trees, Bagging and Random Forests how to use in software.

18CSA387   **Machine Learning Lab II**   **0 0 2 1**

Course Outcome:

CO1: Ability to understand the procedure Principal Component Analysis and Clustering in software:

CO2: Ability to understand Principal Component Analysis and Clustering. Applications in R

CO3: Ability to apply Gradient Descent Algorithm and Backpropagation in softwareR

CO4: Ability to apply Neural Network Optimization 1 and2 using software:

Co5: Ability to understand applications of Recurrent.and Convolution Neural Networks inR:

1. Support Vector Classifier, Support Vector Machine, ROC Curves, SVM with Multiple Classes.
2. APrincipal Component Analysis and Clustering.
3. Overfitting and Underfitting Bias and Variance.
4. Gradient Descent Algorithm.
5. Backpropagation.
6. Neural Network Optimization 1.
7. Neural Network Optimization 2.
8. Convolution Neural networks.
9. Recurrent Neural Networks.
10. LSTM and memory architectures.

Evaluation Pattern – R.13 & R.16

Learning Outcomes: Machine learning is an application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. Combined Support Vector Machine (SVM) and Principal Component Analysis (PCA) was used to recognize the infant cries with asphyxia. ... The PCA was applied to reduce dimensionality of the vectors that serve as inputs to the SVM. These compononents of lab develops the sbility to understand the procedure Principal Component Analysis and Clustering in software. Ability to understand Principal Component Analysis and Clustering. Applications in R. Ability to apply Gradient Descent Algorithm and Backpropagation in softwareR. Ability to apply Neural Network Optimization 1 and2 using software. Ability to understand applications of Recurrent.and Convolution Neural Networks inR

Semester 7

18MAT506   **Topology**   **(3-1-0-4)**

Course outcomes

CO1:To introduce the concept of Metric spaces as a generalization of the analysis on the real line   at a level and depth appropriate for introducing Topological spaces

CO2 providing a prerequisite for the forth coming courses like Differential Geometry, Functional Analysis, Complex Analysis etc..

CO3:To introduce the student to what it means to do mathematics, as opposed to learning about mathematics or to learning to do computational exercises.

CO4:To help the student learn how to write mathematical text according to the standards of the profession.

CO5 Inspiring them to study higher-level mathematics and to become a professional mathematician

Unit 1

Topological spaces, Definition and examples, Interior, Closure and Boundary, Basis and Sub-basis, Continuity, Topological Equivalence, Subspaces.

Unit 2

Connected Spaces, Theorems on Connectedness, Connected subsets of Real line, Applications of Connectedness, Path Connected Spaces.

Unit 3

Compact spaces, Compactness and Continuity, Properties of Compact Spaces, One-Point Compactification.

Unit 4

Finite and arbitrary Products, Tychnoff's theorem, Comparison of topologies, Quotient Spaces, T_0, T_1 and T_2 Spaces, Regular Spaces, Normal Spaces, Separation by Continuous functions.

Unit 5

Urysohn's Lemma and Tietze Extension Theorem, Nets, Filters and Convergence, Tychnoff's Theorem.

Textbook:

Fred H. Croom, *Principles of Topology,* Cengage Learning.

J.R. Munkres, *Topology*, PHI.

Sidney A. Morris, *Topology Without Tears*, Ebook.

References:

K.D. Joshi, *Introduction to General Topology,* New Age Publishers.

Sheldon W Davis, *Topology,* Tata McGraw-Hill.

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

Evaluation Pattern – R.13 & R.16

<u>Learning outcomes</u>: Topology is used in many branches of mathematics, such as differentiable equations, dynamical systems, knot theory, and Riemann surfaces in complex analysis. It is also used in string theory in physics, and for describing the space-time structure of universe.:To introduce the concept of Metric spaces as a generalization of the analysis on the real line   at a level and depth appropriate for introducing Topological spaces providing a prerequisite for the forth coming courses like Differential Geometry, Functional Analysis, Complex Analysis etc..:It is used To introduce the student to what it means to do mathematics, as opposed to learning about mathematics or to learning to do computational exercises. To help the student learn how to write mathematical text according to the standards of the profession. Inspiring them to study higher-level mathematics and to become a professional mathematician

18MAT507   **Abstract Algebra 2**   **(3-1-0-4)**

Course outcomes

CO 1; Understand the familiarity with the concepts of ring and field, and their main algebraic properties;

CO 2 Understand Correctly use the terminology and underlying concepts of Galois theory in a problem-solving context

CO 3 Ability to Reproduce the proofs of its main theorems and apply the key ideas in similar arguments;

CO 4 Ability to Calculate Galois groups in simple cases and to apply the group-theoretic information to deduce results about fields and polynomials

CO 5 Ability to Demonstrate the capacity for mathematical reasoning through analyzing, proving and explaining concepts from field extensions and Galois Theory and apply problem –solving in diverse situation in physics, engineering and other mathematical contexts.

Unit 1

Review of Groups, Normal subgroups, Factor or Quotient Groups and Homomorphisms.Isomorphism of Groups, Cayley's Theorem. External Direct Products, Fundamental theorem of Finite Abelian Groups. Groups acting on themselves by Conjugation- Class Equation, Sylow's Theorem and its applications, Simple Groups, Non Simplicity Tests.

Unit 2

Review of Rings: Integral domains, Quotient Ring and Ideals, Properties of ideals, Prime and Maximal ideals, Chinese remainder theorem,Ring homomorphisms, Polynomial rings, Polynomial rings over Fields, Division algorithm.

Unit 3

Principal ideal domain, Factorisation of Polynomials, Gauss's lemma, Eisenstein's irreducibility criteria, Unique Factorisation in Z[x],Euclidean domain, Unique factorization domain.

Unit 4

Field extensions, Fundamental theorem of Field theory, Splitting fields, Zeros of an irreducible polynomial, Algebraic and Transcendental extensions, Finite extensions, Properties of Algebraic extensions.

Unit 5

Finite fields, Classification of Finite fields, Structure of Finite fields, Subfields of a Finite field.Galois Theory: Automorphims of fields, Galois group, examples, Fundamental theorem of Galois Theory and its applications, Cyclotomic extensions, Solving of Polynomials by Radicals, Insolvability of Quintic.

Textbook:

Joseph A. Gallian, *Contemporary Abstract Algebra*, 4th edition, Narosa.

References:

Dummit and Foote, *Abstract Algebra*, Wiley.

M. Artin, *Algebra*, Prentice Hall.

I.N.Herstein, *Topics in Algebra,* Wiley.

N. Jacobson, *Basic Algebra 1 & 2,* Dover.

Evaluation Pattern – R.13 & R.16

Learning Outcomes

Abstract algebra is used in many fields of mathematics and science. For instance, algebraic topology uses algebraic objects to study topologies. It is useful to understand the familiarity with the concepts of ring and field, and their main algebraic properties; Understand Correctly use the terminology and underlying concepts of Galois theory in a problem-solving context.   Ability to Reproduce the proofs of its main theorems and apply the key ideas in similar arguments. Ability to Calculate Galois groups in simple cases and to apply the group-theoretic information to deduce results about fields and polynomials. Ability to Demonstrate the capacity for mathematical reasoning through analyzing, proving and explaining concepts from field extensions and Galois Theory and apply problem –solving in diverse situation in physics, engineering and other mathematical contexts

18MAT508　　　　　　　　　**Real Analysis 3**　　　　　　　　**(3-1-0-4)**

Course outcomes

CO1 To understand the basics of Real analysis and apply the acquired knowledge in signals and Systems,　　　　Digital Signal Processing. Etc

CO2 Knowledge and Understanding: Learn the theory of Riemann-Stieltjes integrals, to be acquainted　　with the ideas of the total variation and to be able to deal with functions of bounded variation.

CO3 Intellectual Skills: Develop a reasoned argument in handling problems about functions, especially　　those　　that　　are　　of bounded variation.

CO4 General and Transferable Skills: Develop the ability to reflect on problems that are quite significant　　　　　in the field of real analysis.

CO5 Devolep the ability to consider problems that could be solved by implementing concepts from　　　　different　　areas　　in mathematics and identify, formulate, and solve problems.

Unit 1

Properties of monotonic functions, Functions of bounded variation, Total variation, Rectifiable paths and arc-length, Equivalence of paths, Change of parameter.(6.1-6.12 of Text 2)

Unit 2

Riemann Stieltjes Integral, Definition and Existence of the Integral, Properties of the Integral, Integration by parts, Reduction to a Riemann Integral, Step Functions, Riemann's Condition, Upper and Lower Integrals, Integrators of Bounded Variation, Sufficient and Necessary Conditions for Existence of Riemann Integrals.(7.1-7.17 of Text 2)

Unit 3

Mean Value Theorems, Fundamental Theorem of Calculus, Change of Variable, Integrals depending on a Parameter, Differentiation under the Integral, Measure Zero Sets, Lebesgue's Criterion for Riemann Integrability.(7.18-7.26 of Text 2)

Unit 4

Sequences and Series of Functions: Sequence of functions and its point-wise limit, Discussion of main problems, Uniform convergence, Uniform convergence and continuity, Uniform convergence and Integration, Uniform convergence and Differentiation, Equicontinuity and Stone-Weierstrass Theorem, Power Series. (Chapter 7, 8.1 of Text 1)

Unit 5

Functions of Several Variables, Directional Derivatives, Continuity, Derivative as a Linear Transformation, Jacobian Matrix, Chain rule, Derivatives of Higher Order, Taylor's Formula, Inverse Function theorem, Implicit Function Theorem.(12.1-12.14, 13.1-13.4 of Text 2)

Textbooks:

- W. Rudin, *Principles of Mathematical Analysis,* Tata McGraw-Hill.

- Apostol, *Mathematical Analysis*, Narosa.

References:

S.R. Ghorpade and B.V. Limaye, *A Course in Multivariable Calculus and Analysis,* Springer.

Evaluation Pattern – R.13 & R.16

<u>**Learning Outcomes**</u> Requirement for teaching Profession. Necessary background for measure theory. It is concerned with studying the behavior and properties of functions, sequencs and sets.   This components are useful for :Understanding Riemann-Stieltjes Integral and applying it to evaluate length of the   Rectifiable curves   Understanding Equicontinuous Families of Functions and The Stone-Weierstrass   Theorem.Understanding special functions and algebraic completeness of the complex field. Applying the concept of derivatives in functions of several variables.   Understanding Contraction principle, The inverse function theorem, The implicit function theorem.

18MAT509	Multivariate Statistics	(3-1-0-4)

Course outcomes
CO1:Ability to compute the characteristic functions of some well known distributions and use multivariate characteristic functions to investigate properties of various distributions.

CO2: Ability to Derive various multivariate sampling distributions and use exterior forms where appropriate to make the necessary changes of variables.

CO3:. Understand how the Wishart distribution arises in multivariate sampling and how to use it.

 CO4:Understand how to use various multivariate statistical methods (for example: test for significant differences between populations, use principal component analysis and factor analysis, discriminant analysis, cluster analysis and canonical correlation analysis)

CO5:Understand the limitations of these multivariate analysis methods.

Unit 1
Bivariate Normal Distribution (BVN), probability density function of bivariate normal distribution properties marginal and conditional probability density function bivariate normal distribution, Multivariate Data: Random Vector: Probability mass/density functions, Distribution function, Mean vector & Dispersion matrix, Marginal & Conditional distributions. (5.4 of Reference 4)
Unit 2
Multivariate Normal distribution and its properties. Sampling distribution for mean vector
and variance- covariance matrix. Multiple and partial correlation coefficient and their properties (2.2-2.6, 3.2-3.4 of Text book 1).
Unit 3
The Generalized T^2 and its distribution, Uses of T^2 statistic, the distribution of T^2 under alternative hypothesis, two sample problem with unequal covariance matrices, classification of observations, classification in to one of two known multivariate normal populations, classification in to one of two known multivariate normal populations when parameters are estimated, Probabilities of misclassification, Classification in to one of several populations, Classification in to one of several multivariate normal

populations. (5.1-5.6, 6.1-6.9 of Text book 1)

Unit 4

Applications of Multivariate Analysis: Definition of Principal Components in the population, Maximum likelihood estimators of the principal components and their variance, computation of maximum likelihood estimates of the principal components and their variance, Statistical Inference, Testing hypothesis about the characteristic root of a covariance matrix. (11.1-11.7 of Text book 1)

Unit 5

Factor Analysis- Maximum likelihood estimators for random orthogonal factors, estimation for fixed factors, factor interpretation and transformation, estimation for identification by specifies zeros, estimation of factor scores. (14.1-14.7 of Text book 1)

Text Books:
- Anderson, T.W. (2003), *An Introduction to Multivariate Statistical Analysis*, John Wiley.
- Johnson, R and Wichern (1992): *Applied Multivariate Statistical Analysis*, Prentice Hall, India, 6th edition.

References:
- Alvin C. Rencher (2002), *Methods of multivariate analysis*, 2nd edition, John Wiley and Sons, INC
- Brian Everitt and Torsten Hothorn (2011), *An introduction to applied multivariate analysiswith R*, Springer.
- Douglas C. Montgomery and George C. Runger, *Applied Statistics and Probability for Engineers*, John Wiley, 2005.

Evaluation Pattern – R.13 & R.16

Learning Outcomes

Multivariate statistics is used to include all statistics where there are more than two variables simultaneously analyzed. You are already familiar with bivariate statistics such as the Pearson product moment correlation coefficient and the independent groups t-test. Ability to compute the characteristic functions of some well known distributions and use multivariate characteristic functions to investigate properties of various distributions. Ability to Derive various multivariate sampling distributions and use exterior forms where appropriate to make the necessary changes of variables. Understand how the Wishart distribution arises in multivariate sampling and how to use it. Understand how to use various multivariate statistical methods (for example: test for significant differences between populations, use principal component analysis and factor analysis, discriminant analysis, cluster analysis and canonical correlation analysis) .Understand the limitations of these multivariate analysis methods.

18CSA506   **Data Visualization**   **(3-0-2-4)**

Course outcomes

CO1: Able to design visualizations that represent the relationships contained in complex data sets and adapt them to highlight the ideas you want to communicate

CO2:Able to Support the visualizations with written and verbal explanations on their interpretation.

CO3:Able to Use leading open source software packages to create and publish visualizations

CO4: Able to Identify the statistical analysis needed to validate the trends present in data visualizations.

CO5: Enable clear interpretations of big, complex and real world data

Unit 1

Goals of data visualization, Data plotting softwares like matplotlib (python) and Gnuplot(available in linux enviornment), Syntax of the codes in these softwares

Unit 2

Different kinds of plots, Plots and subplots, Histogram, Probability density plots, Bar graphs, Pie charts

Unit 3

3D data visualization in 2D, Bubble Plot, Color density plot, 2D Histograms, 4D Data visualization in 3D, making animated plots and movies for data

Unit 4

Graph and Networks visualization, Introduction to software Graphviz, Syntax in grahviz, Drawing small and big networks in graphviz, Introduction to software Cytoscape, Different plotting layouts in cytoscape, visualizing large datasets in cytoscape with examples

Unit 5

Online data visualization, Introduction to D3 JSON, Plotting a dataset online

References: Data Visualizations

Evaluation Pattern – R.13 & R.16

Learning Outcomes:

> **Data visualization** refers to presenting data in a graphical or pictorial form, such as a pie chart. This allows audiences to recognize patterns more quickly. Interactive visualizations allow decision-makers to drill down through the layers of detail. : This components are useful to design visualizations that represent the relationships contained in complex data sets and adapt them to highlight the ideas you want to communicate.Able to Support the visualizations with written and verbal explanations on their interpretation. Able to Use leading open source software packages to create and publish visualizations Able to Identify the statistical analysis needed to validate the trends present in data visualizations. Enable clear interpretations of big, complex and real world data

Semester8:

18MAT516　　　　　　**Measure and Integration**　　　　　　**(3-1-0-4)**

Course outcomes

CO1 :	Demonstrate capacity for mathematical reasoning through analysing, proving and explaining concepts.
CO2 :	Introduces the notion of a sigma algebra, introduces measurable functions, measures, and examine their properties..
CO3 :	Study in detail the properties of the Lebesgue integral ,and also fundamental convergence theorems in Measure and integration namely Lebesgue's Monotone Convergence Theorem and Lebesgue's dominated Convergence Theorems.
CO4 :	In L^p spaces ,study in detail about the fundamental inequalities namely Holders and Minkowski's and hence derive the important fact that L^p spaces are complete metric spaces.
CO5	Introduce the total variation of a complex measure, positive and negative variations of a

: real measure, and then construct Lebesgue Radon Nikodym theorem which has important applications in Probability theory

CO6: Given two measurable spaces and measures on them , obtain a product measurable space and a product measure on this space.

Unit 1

Lebesgue Outer Measure, Measurable sets, Regularity, Measurable functions, Borel and Lebesgue Measurability. (2.1-2.5 of Text)

Unit 2

Integration of Non-negative functions, The General Integral, Integration of Series, Riemann and Lebesgue Integrals, The Four Derivatives, Lebesgue's Differentiation Theorem, Differentiations and Integration. (3.1 to 3.4, 4.1, 4.4 (statements only),4.5 of Text)

Unit 3

Abstract Measure Spaces: Measures and Outer Measures, Extension of a measure, Uniqueness of the Extension, Completion of the Measure, Measure spaces, Integration with respect to a Measure (5.1-5.6 of Text)

Unit 4

The Lp Spaces, Convex Functions, Jensen's Inequality, The Inequalities of Holder and Minkowski, Completeness of Lp (µ). (6.1-6.5 of Text)

Unit 5

Convergence in Measure, Signed Measures and the Hahn Decomposition, The Jordan Decomposition, The Radon-Nikodym Theorem, Some Applications of the Radon-Nikodym Theorem. (7.1, 8.1-8.4 of Text)

Textbook:

De Barra G, *Measure Theory and Integration*, New Age Publishers.

References:

Elias M Stein, *Real Analysis: Measure Theory, Integration and Hilbert Spaces*, New Age Publishers.

H.L. Royden and P.M. Fitzpatrick, *Real Analysis*, PHI.

Evaluation Pattern – R.13 & R.16

Learning Outcomes:

Requirement for teaching Profession. Topology is used in many branches of mathematics, such as differentiable equations, dynamical systems, knot theory, and Riemann surfaces in complex analysis.these components are useful to understand the notion of measure of a set on the real line and the measurable sets and functions. To understand the notion of Lebesgue Integrals as a generalization of Riemann Integrals. To understand abstract measure spaces and integration with respect to a measure. To understand and apply various inequalities to establish the completeness. To under.stand Raydon-Nikodym Theorem its Applications.

18MAT517   **Stochastic Processes**   **(3-1-0-4)**

Course outcomes

Co1: Understand to Illustrate and formulate fundamental probability distribution and density functions, as well as functions of random variables

CO2: Ability to explain the concepts of expectation and conditional expectation, and describe their properties

CO3: Ability to analyze continuous and discrete-time random processes Explain the concepts of stationary and wide-sense stationarity, and appreciate their significance

CO4: Ability to apply the theory of stochastic processes to analyze linear systems

CO5: Ability to apply the above knowledge to solve basic problems in filtering and prediction

Unit 1

Random variables and stochastic Processes, Probability Generating functions-mean and variance, generating function of bivariate distributions, Laplace transform,
Laplace (Stieltjes) transform of probability distribution, Classification of distributions-Hazard rate function, mean residual life, Properties, Stochastic Process: Introduction, Stationary and non-stationary processes.

Unit 2

Markov Chains: Definition of Markov Chain and examples, higher transition probabilities, Generalization of independent Bernoulli trials, Classification of states and chains, Determination of higher transition probabilities-limiting behavior, stability of a Markov System-Computation of equilibrium probabilities, Markov chains with denumerable number of states, Reducible Markov chains.

Unit 3

Poisson Process, Poisson process and related distributions, Generalization of Poisson process, Birth and death process, Markov process with discrete state space(Continuous time Markov Chains), Chapman-Kolmogorov equations, limiting distributions.

Unit 4

Applications in stochastic models, Queuing systems and models, Birth and death process in queueing theory, M/M/1 and M/M/s models with finite and infinite system capacity, Reliability models, system reliability, Markovian models in reliability theory.

Unit 5

Simulation, generation of pseudorandom numbers, Evaluation of integrals using random numbers, generation of continuous random variables, Inverse transform method, rejection method, Simulation of discrete random variables, generation of Bernoulli, binomial, geometric and Poisson random variables, simulation of discrete parameter stochastic processes, Markov chain Monte Carlo, Simulation of Poisson processes, Simulation of queueing systems.

Text Book:

J. Medhi, *Stochastic Processes*, New Age International Publishers.

References:

S. Karlin & H.M. Taylor, *A First course in Stochastic processes*, Academic press, 1975.

Sheldon M. Ross, *Stochastic Processes*, 2nd Edition John Wiley and Sons, Inc.2004

William Feller, *An Introduction to Probability Theory and its Applications*, Vo1.I, Wiley.

Sheldon M Ross, *Simulation*, 4th edition, Elsevier.

Taha, H. (1995),*Operations Research: An Introduction*, Prentice- Hall India

J. Ravichandran, *Probability and Random Processes for Engineers*, IK International, 2015

Evaluation Pattern – R.13 & R.16

Learning Outcomes:

Requirement for *Teaching Profession.* **Random processes** are used to model random experiments that evolve in time: This component is useful to understand to Illustrate and formulate fundamental probability

distribution and density functions, as well as functions of random variables Ability to explain the concepts of expectation and conditional expectation, and describe their properties. Ability to analyze continuous and discrete-time random processes Explain the concepts of stationary and wide-sense stationarity, and appreciate their significance

Ability to apply the theory of stochastic processes to analyze linear systems. Ability to apply the above knowledge to solve basic problems in filtering and prediction .

18MAT518   **PDE and Integral Equations**   **(3-1-0-4)**

Course outcomes

CO1: Develops an understanding for the construction of proofs and an appreciation for deductive logic.

 CO2: Explore the already familiar properties of the derivative and the Riemann Integral, set on a more   rigorous and formal footing which is central to avoiding inconsistencies in engineering applications.

CO3: Explore new theoretical dimensions of uniform convergence, completeness and important   consequences as interchange of limit operations.

CO4: Develop an intuition for analyzing sets of higher dimension (mostly of the R^n type) space.

CO5: Solve the most common PDEs, recurrent in engineering using standard techniques and   understanding of an appreciation for the need of numerical techniques.

Unit 1

Formation of PDEs, Classification of First order PDEs, Complete, general and Singular integrals, Lagrange's or quasi linear equations, Integral surfaces through a given curve, Orthogonal surfaces to a given system of surfaces, Characteristic curves.

Unit 2

Pfaffian differential equations, Compatible systems, Charpit's method, Jacobi's method, Linear equations with constant coefficients, Reduction to canonical forms.

Unit 3

Classification of second order PDEs,Method of separation of variables: Laplace, Diffusion and Wave equations in Cartesian, Cylindrical and Spherical polar coordinates.

Unit 4

Boundary value problems for transverse vibrations in a string of finite length and heat diffusion in a finite rod, Maximum and Minimum Principles,Integral equations: Fredholm and Volterra integral equations of first, second and third kind, conversion of ODEs into integral equations.

Unit 5

Fredholm equations of second kind with separable kernels, Fredholm alternative theorem, eigen values and eigen functions, Method of successive approximation for Fredholm and Volterra equations, Resolvent kernel.

Textbooks:

T. Amaranath, *An Elementary Course in Differential equations*, Narosa.

M.D. Raisinghania, *Integral equations and Boundary value problems*, S Chand Publications.

References:

I.N. Sneddon, *Elements of Partial Differential equations*, Dover.

M.D. Raisinghania, *Advanced Differential equations*, S Chand Publications.

Evaluation Pattern – R.13 & R.16

<u>Learning Out Comes:</u>

Requirement for teaching Profession. Complex analysis also has applications in engineering fields such as nuclear, aerospace, mechanical and electrical engineering This components are useful to Understand the concept of the Schwarz Reflection by complex conjugation, and its ApplicationsUnderstand the Riemann Mapping theorem.Understand the Analytic Continuation.:To understand about the entire function and Meromorphic function.Understand about the Elliptic functions

18MAT519	**Functional Analysis**	(3-1-0-4)

Course outcomes

CO1 : Demonstrate capacity for mathematical reasoning through analysing, proving and explaining concepts.

CO2 : Students will have a firm knowledge of real and complex normed vector spaces with their geometric and topological properties. They will be familiar with the notions of completeness, separability , will know the properties of a Banach space and will be able to prove results relating to the Hahn Banach theorems. They will have developed an understanding of the theory of bounded linear operators on a Banach space
.

CO3 : The Hahn Banach theorem is a central tool in functional analysis. It allows the norm preserving extension of bounded linear functional defined on a subspace of some vector space to the whole space and it also shows that there are enough continuous linear functionals defined on every normed vector space to make the study of the dual space interesting.

CO4 : The Uniform boundedness principle is one of the fundamental results in functional analysis. Together with the Hahn-Banach theorem and the open mapping theorem it is considered one of the cornerstones of the field. In its basic form , it asserts that for a family of continuous linear operators and thus bounded operators whose domain is a Banach space , pointwise boundedness is equivalent to uniform boundedness in operator norm. The completeness of a norm is exploited to obtain four major theorems, namely the Uniform boundedness principle, the closed graph theorem, the open mapping theorem and the bounded inverse theorem.

CO5 : Inner products allow us to think about geometric concepts in vector spaces. Gram Schmidt processes explain how the basis of a normed linear space can be converted into an orthonormal basis. Complete inner product spaces(that is Hilbert spaces) are studied in detail.

CO6: Apply problem solving using functional analysis techniques applied to diverse situations in Physics, Engineering and other mathematical contexts.

Unit 1

Review of metric spaces, completion of metric spaces, Normed space, Banach space, properties of Normed spaces, Finite dimensional normed spaces and subspaces, Equivalent norms, compactness and finite dimension.

Unit 2

Norm of a linear operator, Bounded and continuous linear operators, Linear functionals, Normed spaces of operators, Dual spaces, Computing Dual of some Banach Spaces.

Unit 3

Inner product space, Hilbert space, Orthogonal complements and direct sums, Orthonormal sets, Bessel inequality , Gram-Scmidt Orthonormalisation, Orthonormal basis, Functionals on Hilbert spaces, Riesz's theorem, Projection and Riesz representation theorem, Adjoint operator, Self adjoint, Unitary and Normal Operators.

Unit 4

Hahn-Banach theorem, Baire's Category theorem and Uniform boundedness principle, Open Mapping Theorem, Closed Graph Theorem, Bounded Inverse Theorem, Adjoint Operator, Strong and Weak Convergence, Convergence of sequence of Operators and Functionals.

Unit 5

Spectrum of Bounded Operators, Compact Linear Operators, Spectrum of a Compact Operator, Spectrum and Numerical Range, Spectrum of Bounded Self-Adjoint Operators.

Textbook:

Kreyszig, *Introductory Functional Analysis with Applications*, Wiley.

B.V. Limaye, *Functional Analysis*, Wiley.

References:

M. Thamban Nair, *Functional Analysis- A First Course,* PHI.

A.L.Brown, A.Page, *Elements of Functional Analysis,* Van Nostrand.

Evaluation Pattern – R.13 & R.16

Learning Out Comes:

Requirement for teaching Profession. It has applications in problems related to ordinary and partial differential equations, numerical analysis, calculus of variations, approximation theory, integral equations, and so on. These components are useful to understand the concepts of linear space, metric space and normed linear space. To analyze the spaces which has both linear structure and metric structure. To apply this new structure on set of all transformations and operators, so that continuity and boundedness becomes equivalent. By applying these results, we obtain a new normed spaces of all bounded linear transformations. To understand and review the concepts from real analysis such as Integration and Differentiation, Compact Spaces and separability of compact metric Spaces. To apply and evaluate the corresponding results in this normed spaces. To understand finite dimensional normed spaces and operators on it. To understand and

apply Stone Weierstrass Theorem, Ascoli-Arzela Theorem and Peano's Theorem. To understand dual spaces and reflexive spaces. To understand and apply Hahn Banach Theorem.To understand convex sets. To understand and apply The Riesz Representation Theorem and Hergoltz's Theorem.

Semester9

18MA T633   Algebraic Topology   (3-0-0-3)

Course outcomes

 CO1:Understand the basic concepts of set-theoretic topology and continuous mappings and construct new topologies from given topologies; to know special classes of topological spaces and their special characteristics like CW complexes, simplicial complexes and manifolds

CO2 : Apply basic concepts of category theory to topological spaces and use concepts of functors to obtain algebraic invariants of topological spaces and mappings.

CO3: Acquire the knowledge of fundamental group and the covering theory as well as the basic methods for the computation of fundamental groups and mappings between them, homology and cohomology, and calculate those for important examples and with the aid of these deduce non-existence of mappings as well as fixed-point theorems .

CO4: calculate homology and cohomology with the aid of chain complexes and deduce algebraic characteristics of homology and cohomology with the aid of homological algebra.

CO5: Get acquainted with connections between analysis and topology, apply algebraic structures to deduce special global characteristics of the cohomology of a local structure of manifolds.

Unit 1

Geometric Complexes and Polyhedra, Orientation of Geometric complexes, Chains, cycles, Boundaries, Homology groups, examples of Homology Groups.

Unit 2

The structure of Homology Groups, The Euler Poincare Theorem, Pseudo manifolds and the Homology Groups of Sn.

Unit 3

Simplicial Approximation, Induced Homomorphisms on the Homology groups, the BrowerFixed Point Theorem.

Unit 4

Homotopic Paths and the Fundamental Group, Covering Homotopy Property for S1, Examples of Fundamental Groups.

Unit 5

Covering Spaces – Definition and examples, basic properties of Covering Spaces, Classification of Covering Spaces, Universal Covering Spaces.

Textbook :

Fred H. Croom,*Basic Concepts of Algebraic Topology*, Springer.

References:

I.M Singer, J.A Thorpe, *Lecture Notes on Elementary Topology and Geometry*, Springer.

SatyaDeo, *Algebraic Topology A Primer*, Hindustan Book Agency.

Allen Hatcher, *Algebraic Topology*, Cambridge University Press.

Evaluation Pattern – R.13 & R.16

18MAT635   Commutative Algebra   3-0-0-3

Course outcomes

CO-1: To understand the basic definitions of rings, ideals and modules through examples; To construct new modules by tensor product, Hom, direct sum/product.

CO-2: To understand the fractions of modules and apply the fractions to construct the field from integral domain. To familiarize the decomposition of rings/modules.

CO-3: To familiarize the concept of integral dependence of extension ring and chain conditions of modules. To understand the definitions of valuations / Noetherian / Artin rings through examples.

CO-4: To study the basic properties of Noetherian/Artin rings;

CO-5: To understand the basic definitions of discrete valuation rings and Dedekind domains. To familiarize the concept of dimension theory of rings/modules.

Unit 1
Modules, Free and Projective Modules, Tensor Products, Flat Modules (Chapter 1 of Text)
Unit 2
Ideals, Local rings, Localization and applications. (Chapter 2 of Text)
Unit 3
Noetherian Rings, Primary decomposition, Artinian Modules (Chapter 3 of Text)
Unit 4
Integral domains, Integral extensions, Integrally closed domain, Finiteness of integral closure. (Chapter 4 of Text)
Unit 5
Valuation rings, Discrete Valuation Rings, Dedekind domain (Chapter 5 of Text)
Textbook:
N.S Gopalakrishan, Commutative Algebra, Orient Balckswan.
References:
M.F.Atiyah and I.G.MacDonald, Introduction to Communication Algebra, Addison Wesley.
T.W Hungerford, Algebra, Springer.
mons, *Introduction to Topology and Modern Analysis*, McGraw-Hill.
Evaluation Pattern – R.13 & R.16

18MAT692 Mini Project   6cr

Semester10

18MAT697   Project   15cr

18CSA511   **Database Management for Big Data**   **(3-1-0-4)**

Course outcomes

CO1: Understand the basic concepts of database and bigdata.

CO 2.: Understand the database models and its implementation techniques.

CO 3: Ability to learn big data implementation platforms

 CO 4: Ability to learn data base technologies associated with big data.

CO5.: Ability to apply Data Intensive tasks using the Map Reduce Paradigm

Unit 1

Introduction: Overview of DBMS, File vs DBMS, elements of DBMS. Database design: E-R model, Notations, constraints, cardinality and participation constraints

Unit 2

Relational Data Model: Introduction to relational model, Structure of relational mode, domain,keys, tuples to relational models, sql queries.Relational Database Design: Functional dependency, Normalization: 1NF,2NF,3NF,BCNF,table joins.

Unit 3

Introduction to Big Data: Types of Digital Data - Characteristics of Data – Evolution of Big Data - Definition of Big Data - Challenges with Big Data-3Vs of Big Data - Non Definitional traits of Big Data - Business Intelligence vs. Big Data - Data warehouse and Hadoop environment - Coexistence.

Unit 4

Big Data Analytics: Classification of analytics - Data Science - Terminologies in Big Data - CAP Theorem - BASE Concept. NoSQL: Types of Databases – Advantages – NewSQL - SQL vs. NOSQL vs NewSQL.

Unit 5

Introduction to Hadoop: Features – Advantages – Versions - Overview of Hadoop Eco systems - Hadoop distributions - Hadoop vs. SQL – RDBMS vs. Hadoop - Hadoop Components – Architecture – HDFS - Map Reduce: Mapper – Reducer – Combiner – Partitioner – Searching – Sorting - Compression. Hadoop 2 (YARN): Architecture - Interacting with Hadoop Eco systems.

Textbooks:

Silberschatz A, Korth H F and Sudharshan S, *"Database System Concepts",* Sixth Edition, Tata McGraw-Hill Publishing Company Limited, 2010.

Seema Acharya, Subhashini Chellappan, *"Big Data and Analytics",* Wiley Publication, 2015.

References:

Judith Hurwitz, Alan Nugent, Dr. Fern Halper, Marcia Kaufman, *"Big Data for Dummies",* John Wiley & Sons, Inc., 2013.

Tom White, *"Hadoop: The Definitive Guide",* O'Reilly Publications, 2011.

Evaluation Pattern – R.13 & R.16

Semester9:
Learning Outcomes.
Big data is a field that treats ways to analyze, systematically extract information from, or otherwise deal with data sets that are too large or complex to be dealt with by traditional data-processing application software.Managing *big data* requires a different approach to *database management* systems because of the wide variation in data structure. Understand the basic concepts of database and bigdata. Understand the database models and its implementation techniques.Ability to learn big data implementation platformsAbility to learn data base technologies associated with big data. Ability to apply Data Intensive tasks using the Map Reduce Paradigm

18CSA581   **PRACTICALS/ LAB WORKUSING R**   **0-0-2-1**

Course outcomes
CO1:Install and use R for simple programming tasks.
CO 2. Extend the functionality of R by using add-on packages
CO 3. Extract data from files and other sources and perform various data manipulation tasks on them.
CO 4. Code statistical functions in R.
CO 5. Use R Graphics and Tables to visualize results of various statistical operations on data .
CO6. Apply the knowledge of R gained to data Analytics for real life applications.

List of Practical

1. Multiple Correlation
2. Partial Correlation
3. Bivariate Normal Distribution,
4. Multivariate Normal Distribution
5. Multi linear regression analysis
6. Clustering and Classification problems
7. Multivariate Analysis of Variance
8. Principal Components Analysis
9. Factor Analysis

Evaluation Pattern – R.13 & R.16

Learning Outcomes:

R has a handy package called a Markov Chain that can handle a vast array of Markov chain types. ... This code instantiates a Markov chain object by defining the transition matrix as well as the names of the states. It also displays the Markov chain and the transition probabilities. Install and use R for simple programming tasks. Extend the functionality of R by using add-on packages. Extract data from files and other sources and perform various data manipulation tasks on them.Code statistical functions in R. Use R Graphics and Tables to visualize results of various statistical operations on data. Apply the knowledge of R gained to data Analytics for real life applications.

18CSA582 **PRACTICAL/LAB. WORK USING R** **0-0-2-1**

. Course Outcome
CO1: Ability to Calculation of transition probability matrix Using R- software.
CO2: : Ability to understand Stationarity of Markov chain and graphical representation of Markov chain using software.
Co3: Calculation of probabilities for given birth and death rates and vice versaand
 Calculation of probabilities for Birth and Death Process
 CO4:: Understand to implement Queueing Model problems.
 CO5: Understand the Evaluation of integrals using Monte Carlo method using software
CO6; Understand Simulation of discrete random variables using inverse transform method in   software

List of Practical

1. Calculation of transition probability matrix
2. Identification of characteristics of reducible and irreducible chains.
3. Identification of types of classes
4. Identification of ergodic transition probability matrix
5. Stationarity of Markov chain and graphical representation of Markov chain
6. Computation of probabilities in case of generalizations of independent Bernoulli trials
7. Calculation of probabilities for given birth and death rates and vice versa
8. Calculation of probabilities for Birth and Death Process
9. Calculation of probabilities for Yule Furry Process
10. Computation of inter-arrival time for a Poisson process.
11. To determine the performance measures for M/M/1 queuing model.

12. To determine the performance measures for M/M/1/N queuing model.
13. To determine the performance measures for M/M/C/ queuing model.
14. To determine the performance measures for M/M/C/N queuing model.
15. Calculation of hazard rate, MTBF for series & parallel system.
16. Calculation of hazard rate, MTBF for Mixed configuration
17. Generate random numbers using multiplicative congruence method
18. Evaluation of integrals using Monte Carlo method
19. Generating uniform random numbers
20. Simulation of discrete random variables using inverse transform method
21. Generation of continuous random variables inverse transform method and acceptance rejection method.

Evaluation Pattern – R.13 & R.16

Learning Outcomes:

R has a handy package called a Markov Chain that can handle a vast array of Markov chain types. ... This code instantiates a Markov chain object by defining the transition matrix as well as the names of the states. It also displays the Markov chain and the transition probabilities. Ability to Calculation of transition probability matrix Using R-software. Ability to understand Stationarity of Markov chain and graphical representation of Markov chain using softwarr Calculation of probabilities for given birth and death rates and vice versaand Calculation of probabilities for Birth and Death Process. Understand to implement Queueing Model problems. Understand the Evaluation of integrals using Monte Carlo method using software. Understand Simulation of discrete random variables using inverse transform method in software

18ENV300   ENVIRONMENTAL SCIENCE AND SUSTAINABILITY   3 0 0 3

Course outcomes:
CO1: Integrate facts and concepts from ecological, physical and social sciences to characterize some common socio-environmental problems.
CO2: Develop simple integrated systems and frameworks for solving common interconnected socio-environmental problems.
CO3: Reflect critically about their roles and identities as citizens, consumers and environmental actors in a complex, interconnected world.
CO4: Identify the ethical underpinnings of socio-environmental issues in general.

Unit 1
State of Environment and Unsustainability, Need for Sustainable Development,
Traditional conservation systems in India, People in Environment, Need for an
attitudinal change and ethics, Need for Environmental Education, Overview of
International Treaties and Conventions, Overview of Legal and Regulatory
Frameworks.
Environment: Abiotic and biotic factors, Segments of the Environment, Biogeochemical
Cycles, Ecosystems (associations, community adaptations, ecological succession,
Food webs, Food chain, ecological pyramids), Types of Ecosystems – Terrestrial
ecosystems, Ecosystem Services, Economic value of ecosystem services, Threats
to ecosystems and conservation strategies.
Biodiversity: Species, Genetic & Ecosystem Diversity, Origin of life and significance
of biodiversity, Value of Biodiversity, Biodiversity at Global, National and Local Levels,
India as a Mega-Diversity Nation (Hotspots) & Protected Area Network, Community
Biodiversity Registers. Threats to Biodiversity, Red Data book, Rare, Endangered
and Endemic Species of India. Conservation of Biodiversity. People's action.
Impacts, causes, effects, control measures, international, legal and regulatory

frameworks of: Climate Change, Ozone depletion, Air pollution, Water pollution, Noise pollution, Soil/ land degradation/ pollution

Unit 2

Linear vs. cyclical resource management systems, need for systems thinking and design of cyclical systems, circular economy, industrial ecology, green technology. Specifically apply these concepts to: Water Resources, Energy Resources, Food Resources, Land & Forests, Waste management.

Discuss the interrelation of environmental issues with social issues such as: Population, Illiteracy, Poverty, Gender equality, Class discrimination, Social impacts of development on the poor and tribal communities, Conservation movements: people's movements and activism, Indigenous knowledge systems and traditions of conservation.

Unit 3

Common goods and public goods, natural capital/ tragedy of commons, Cost benefit analysis of development projects, Environment Impact Assessment (EIA), Environment Management Plan (EMP), Green business, Eco-labeling, Problems and solutions with case studies.

Global and national state of housing and shelter, Urbanization, Effects of unplanned development case studies, Impacts of the building and road construction industry on the environment, Eco-homes/ Green buildings, Sustainable communities, Sustainable Cities.

Ethical issues related to resource consumption, Intergenerational ethics, Need for investigation and resolution of the root cause of unsustainability, Traditional value systems of India, Significance of holistic value-based education for true sustainability.

TEXTBOOKS/ REFERENCES:

1. R. Rajagopalan, Environmental Studies: From Crisis to Cure. Oxford University Press, 2011, 358 pages. ISBN: 9780198072089.

2. Daniel D. Chiras, Environmental Science. Jones & Bartlett Publishers, 01-Feb-2012, 669 pages. ISBN: 9781449645311.

3. Andy Jones, Michel Pimbert and Janice Jiggins, 2011. Virtuous Circles: Values, Systems, Sustainability. IIED and IUCN CEESP, London. URL:http://pubs.iied.org/pdfs/G03177.pdf

4. Annenberg Learner, The Habitable Planet, Annenberg Foundation 2015. URL: http:// www.learner.org/courses/envsci/unit/pdfs/textbook.pdf.

Evaluation Pattern – R.13 & R.16

18MAT181   **Mathematics Lab 1**   **(0-0-2-1)**

Course outcomes:

CO1: Ability to plot functions in software.

CO2 Understand to use maxima minima , mean value theorem maxima minima , mean   value theorem, Graphing with derivatives ,definite integrals and Riemann Sums in   software.

Co3: **Understand to use   Integration techniques** ,Sequences and Series in. **software.**

CO4: : **Understand to use**   Conic Sections and Parametric Equations, Hyperbolic Functions in. **software.**

- Introduction to Sage / Mathematica, plotting functions.

- Limits, Squeeze Theorem, Intermediate Value Theorem.

- Derivatives, Graphing with Derivatives, Asymptotes.

- Mean Value Theorem, Maxima and Minima

- Riemann Sums, Definite and Indefinite Integrals, Fundamental Theorem of Calculus.

- Basic Integration Techniques, Substitution.

- Integration Techniques: Logarithmic Functions, Inverse Trigonometric Functions and Trigonometric Substitution, Partial Fractions.

- Arc length, Surfaces of Revolution.

- Volumes, Work, Differential Equations.

- Improper Integrals, Comparison test for Integrals.

- Conic Sections and Parametric Equations, Hyperbolic Functions.

- Sequences and Series.

Textbook:

C.Arangala, K.A.Yokley, *Exploring Calculus: Labs and Projects with Mathematica,* CRC Press.

Evaluation Pattern – R.13 & R.16

Learning Outcomes:

SageMath is intended for professional-level real-world use, so for such students, working on improving SageMath is real-world experience, useful to the students after graduation. This lab component helps to develop the ability to plot functions in software. Understand to use maxima minima , mean value theorem maxima minima , mean value theorem, Graphing with derivatives ,definite integrals and Riemann Sums in software. Understand to use Integration techniques ,Sequences and Series in. software. : Understand to use Conic Sections and Parametric Equations, Hyperbolic Functions in. software.

| 18MAT182 | Mathematics Lab 2 | (0-0-2-1) |

Course outcomes:
Co1: Understand to use Vectors , planes in 3 D, Multivariate Functions, Limits, Continuity in software.

CO2: **Understand to use** Partial Derivatives, Differentiability, Directional Derivatives and Gradient inSoftware

CO3 **Understand to use** : Double Integrals in Cartesian and Polar Coordinates, Surface Area. Cylindrical and Spherical Coordinates, Triple Integrals, Change of Variables in Software

CO4: **Understand to use Green's theorem, stokes theorem, Divergence theorem in software.**

- Vectors, Lines and Planes in 3D, Cylinders and Quadric Surfaces.

- Vector Valued Functions, Space curves, Arc Length and Curvature.

- Multivariate Functions, Limits, Continuity.

- Partial Derivatives, Differentiability, Directional Derivatives and Gradient.

- Tangent Plane, Extrema of Multivariate Functions, Lagrange Multiplier.

- Double Integrals in Cartesian and Polar Coordinates, Surface Area.

- Cylindrical and Spherical Coordinates, Triple Integrals, Change of Variables.

- Vector Differentiation, Line Integrals, Independence of Path.

- Green's theorem in Plane, Curl and Divergence.

- Surface Integrals.

- Stoke's Theorem.

- Divergence Theorem.

Resource:http://matrix.skku.ac.kr/Cal-Book/

Evaluation Pattern – R.13 & R.16

Learningoutcomes:

Mathematics laboratory is a place to enjoy mathematics through informal exploration. It is a place where anyone can generate problems and struggle to get a answer. It is a space to explore and design new mathematical activities. So, the maths lab should not be used to assess students' knowledge of mathematics.This components helps to use Vectors , planes in 3 D, Multivariate Functions, Limits, Continuity in software. Understand to use Partial Derivatives, Differentiability, Directional Derivatives and Gradient inSoftware. Understand to use : Double Integrals in Cartesian and Polar Coordinates, Surface Area. Cylindrical and Spherical Coordinates, Triple Integrals, Change of Variables in Software. Understand to use Green's theorem, stokes theorem, Divergence theorem in software.

18MAT283   **PRACTICAL/LAB. WORK USING R**   (0-0-2-1)

Course outcomes:

CO1:Install and use R for simple programming tasks.
CO 2. Extend the functionality of R by using add-on packages
CO 3. Extract data from files and other sources and perform various data manipulation tasks on them.
CO 4. Code statistical functions in R.
CO 5. Use R Graphics and Tables to visualize results of various statistical operations on data .
CO6. Apply the knowledge of R gained to data Analytics for real life applications.

List of Practical
- Graphical representation of data.
- Problems based on measures of central tendency.
- Problems based on measures of dispersion.
- Problems based on combined mean and variance and coefficient of variation
- Problems based on moments, skewness and kurtosis

- Fitting of binomial distributions for n and p = q = ½.
- Fitting of binomial distributions for given n and p.
- Fitting of binomial distributions after computing mean and variance.
- Fitting of Poisson distributions for given value of the parameter.
- Fitting of Poisson distributions after computing mean.
- Fitting of negative binomial.
- Fitting of suitable distribution.
- Application problems based on binomial distribution.
- Application problems based on Poisson distribution.
- Application problems based on negative binomial distribution.
- Problems based on area property of normal distribution
- To find the ordinate for a given area for normal distribution.
- Application based problems using normal distribution.
- Fitting of normal distribution when parameters are given
- Fitting of normal distribution when parameters are not given
- Fitting of polynomials, exponential curves.
- Karl Pearson correlation coefficient.
- Correlation coefficient for a bivariate frequency distribution.
- Lines of regression, angle between lines and estimated values of variables

Evaluation Pattern – R.13 & R.16

Learning outcomes: **Rlab** is an interactive, interpreted numerical computation program and its core programming language **Rlab** (the language) is very high level and is intended to provide fast prototyping and program development, as well as easy **data**-visualization, and processing. This lab helps to understand how to install and use R for simple programming tasks. Extend the functionality of R by using add-on packages. Extract data from files and other sources and perform various data manipulation tasks on them. Code statistical functions in R.Use R Graphics and Tables to visualize results of various statistical operations on data . Apply the knowledge of R gained to data Analytics for real life applications.

18MAT284   **Mathematics Lab 3**   **(0-0-2-1)**
Course outcomes

 Co1: Ability to find Matrix operations in software

 CO2: Ability to find solution of Equations in software

CO3: Ability to apply   linear transformations and vector spaces in software

 CO4:Ability to apply Diagonalization in software.

- Matrices 1

- Matrices 2

- Gaussian Elimination 1

- Gaussian Elimination 2

- Vector Spaces 1

- Vector Spaces 2

- Linear Transformations 1

- Linear Transformations 2

- Eigen Values and Eigen Vectors

- Characteristic Polynomial and Minimal Polynomial

- Diagonalization

Resource: http://joshua.smcvt.edu/linearalgebra/lab.pdf

Evaluation Pattern – R.13 & R.16

Learning Outcomes:

SageMath is intended for professional-level real-world use, so for such students, working on improving SageMath is real-world experience, useful to the students after graduation. This lab component helps to develop the ability to find Matrix operations in software. Ability to find solution of Equations in software. Ability to apply linear transformations and vector spaces in software. Ability to apply Diagonalization in software.

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18MAT285   **Python Lab for Numerical Methods**   **0 0 2 1**
Course outcomes

CO1: Ability to to find solution of Equations using Bisection, Newton Raphson etc methods in Software
CO2: Ability to to find solution of system of equations using Gauss's Methods
CO3: : Ability to to find solution of Deferential Equations and Integral equations

1. Bisection and False position Methods.
2. Newton Raphson and Secant Methods.
3. Gaussian Elimination, Gauss Jordan method, LU Factorisation.
4. Iterative Methods for Solving Linear Equations.
5. Polynomial Approximation and Interpolation Methods 1
6. Polynomial Approximation and Interpolation Methods 2
7. Numerical Differentiation.
8. Numerical Integration 1.
9. Numerical Integration 2.
10. Ordinary Differential Equations.

Evaluation Pattern – R.13 & R.16

Learning outcomes;

Python For The Lab is a collection of resources to help you start using Python for developing solutions in your lab. From analyzing data collected with your experiments to writing software to control your setup. Don't miss out any updates. Join a community of over 1000 Python developers. : It is used to find solution of Equations using Bisection, Newton Raphson etc methods in Software Ability to find solution of system of equations using Gauss's Methods Ability to to find solution of Deferential Equations and Integral equations

18MAT286   **Computing Using R**   **0-0-2-1**

Course Outcome
CO1:Ability to find significance level and testing of hypothesis in software R
CO2: Ability to find regression equations and analyze the data in R
CO3:Ability to understand and analyze Multiple Regression and test using R- software.
CO4: Apply the knowledge of R gained to data Analytics in Estimation theory and Analysis of variance

List of Practical
- Testing of significance and confidence intervals for single proportion and difference of two proportion
- Testing of significance and confidence intervals for single mean and difference of two means and paired tests.
- Testing of significance and confidence intervals for difference of two standard deviations.
- Exact Sample Tests based on Chi-Square Distribution.
- Testing if the population variance has a specific value and its confidence intervals.
- Testing of goodness of fit.
- Testing of independence of attributes.
- Testing based on 2 X 2 contingency table without and with Yates' corrections.
- Testing of significance and confidence intervals of an observed sample correlation coefficient.
- Testing and confidence intervals of equality of two population variances
- Simple Linear Regression
- Multiple Regression
- Tests for Linear Hypothesis
- Bias in regression estimates
- Lack of fit

- Orthogonal Polynomials
- Analysis of Variance of a one way classified data
- Analysis of Variance of a two way classified data with one observation per cell
- Analysis of Covariance of a one way classified data
- Analysis of Covariance of a two way classified data.

Evaluation Pattern – R.13 & R.16

Learning outcomes

R (programming language) R is a programming language and free software environment for statistical computing and graphics supported by the R Foundation for Statistical Computing. The R language is widely used among statisticians and data miners for developing statistical software and data analysis. Tis lab component helps in developing the ability to find significance level and testing of hypothesis in software R. Ability to find regression equations and analyze the data in R Ability to understand and analyze Multiple Regression and test using R- software. Apply the knowledge of R gained to data Analytics in Estimation theory and Analysis of variance

18MAT382 Practical/Lab to Be Performed On A Computer Using Matlab/Python
0-0-2-1

Course Outcome:
CO1: Ability to test whether the given function is concave/ convex
CO2: : Ability to test whether the given Matrix is positive definite/negative definite/semi positive   definite/ semi negative definite
CO3: Ability to find solutions of optimization problems.
 CO4: Ability to find optimal solution of two variable problems based onCauchy, Newton   method etc. the methods

1. To determine local/Relative optima of a given unconstrained problem.
2. Test whether the given function is concave/convex.
3. Test whether the given matrix is positive definite/negative definite/semi positive definite/ semi negative definite
4. Solution of optimization problems using Karush-Kuhn-Tucker conditions
1. Find optimal solution of single variable functions using

(i)Exhaustive search methods,
(ii)Bounding phase method
(iii) Region elimination method interval halving,
(iv) Fibonacci search
(v) Golden section search
(vi) Point estimation-successive quadratic search
(vii) Gradient based methods
2. Find optimal solution of two variable problems based on the methods
(i)Hook-Jeeves pattern search method
(ii)gradient based methods-steepest descent
(iii)Cauchy's steepest descent method
(iv)Newton's method
(v)conjugate gradient method-constrained optimization

Evaluation Pattern – R.13 & R.16

Learning outcomes

Using MATLAB with Python. MATLAB® provides a flexible, two-way integration with many programming languages, including Python. This allows different teams to work together and use MATLAB algorithms within production software and IT system.   This components helps to Ability to test whether the given function is concave/ convex.. Ability to test whether the given Matrix is positive definite/negative definite/semi positive definite/ semi negative definite Ability to find solutions of optimization problems. Ability to find optimal solution of two variable problems based on Cauchy, Newton method etc. the methods.

18MAT383   Practical/Lab to be performed on a computer using OR/Statistical packages

(0-0-2-1)
Course outcomes
CO:1Ability to solve . Linear Programming Problem using Graphical Method using software.
 CO2: **1Ability to solve** Solution of LPP with simplex method. Using software.
CO3: Illustration of following special cases in LPP using Simplex method Unrestricted variables
        Unbounded solution Infeasible solution Alternative or multiple solutions Using software
CO4; Ability to solve Problems based on Dual simplex method.&Transportation Problem   software

1. To solve Linear Programming Problem using Graphical Method with
(i) Unbounded solution
(ii) Infeasible solution
(iii) Alternative or multiple solutions.
2. Solution of LPP with simplex method.
3. Problem solving using Charnes-M method.
4. Problem solving using Two Phase method.
5. Illustration of following special cases in LPP using Simplex method
(i) Unrestricted variables
(ii) Unbounded solution
(iii) Infeasible solution
(iv) Alternative or multiple solutions.
7. Problems based on Dual simplex method.
8. Solution of Transportation Problem.
9. Solution of Assignment Problem.
10. Solution of Travelling Salesman Problem.
11. Solution of Dynamic programming problems

12. Solution of game problems

Evaluation Pattern – R.13 & R.16

Learning Outcomes:

Statistical packages like R, SAS, SPSS, and STATISTICA are not as easy to *use* as specialized card sort programs when analyzing card sort data.We can use a range of software packages to analyse data - from Access or Excel to dedicated packages, such as SPSS, Stata and R for statistical analysis of quantitative data, Nvivo for qualitative (textual and audio-visual) data analysis (QDA), or ArcGIS for analysing geospatial data. Ability to solve linear Programming Problem using Graphical Method using software.Ability to solve Solution of LPP with simplex method. Using software. Illustration of following special cases in LPP using Simplex method Unrestricted variables Unbounded solution Infeasible solution Alternative or multiple solutions Using software. Ability to solve Problems based on Dual simplex method.&Transportation Problem software

Electives

18MAT660   **Graph Theory**   **(3-0-0-3)**

Course outcomes

   CO-1: Understand the basic concepts of graphs and trees.
   CO-2: Understand and apply the concepts of graph connectivity and shortest path problems.
   CO-3: Understand and apply the concepts of matching problems in job assignments.
   CO-4: Understand the concepts of vertex and edge colorings.
   CO-5: Understand the concepts of planar graphs and dual graphs.

Unit 1
Graphs and Subgraphs, Isomorphism, matrices associated with graphs, degree of a graph, connected graphs, shortest path algorithm,Trees, cut edges and cut vertices, spanning trees, minimum spanning trees.
Unit 2
Graph connectivity, k-connected graphs and blocks, Euler graphs, Euler's theorem, Fleury's algorithm for Eulerian trails, Hamilton cycles, Chinese-postman-problem, Traveling Salesman problem.
Unit 3
Matchings, maximal matchings,Coverings and minimal coverings, Berge's theorem, Hall's theorem, Tutte's perfect matching theorem, Job assignment problem, Independent Sets and Cliques.
Unit 4
Vertex colorings, greedy algorithm and its consequences, Brooks' theorem. Edge-colorings, Vizing's theorem on edge-colorings.
Unit 5
Planar Graphs, Euler formula. Dual graphs. Kuratowaski's Characterization, Planarity testing algorithm.
Textbook:
J.A. Bondy and U.S.R. Murty, *Graph Theory and Applications*, Springer.
References:
D.B. West, *Introduction to Graph Theory*, PHI.
Frank Harary, *Graph Theory*, PHI.

Evaluation Pattern – R.13 & R.16

18MAT667   **Differential Geometry**   **(3-0-0-3)**

Course outcomes
 CO1: Explain the concepts and language of differential geometry and its role in modern mathematics.
CO2:Analyse and solve complex problems using appropriate techniques from differentia geometry

CO3: Develop the ability to compute quantities of geometric interest such as curvature, as well as develop a facility to compute in various specialized systems, such as semi geodesic coordinates or ones representing asymptotic lines or principal curvatures.
CO4:Familiarise the method of the moving frame and overdetermined systems of differential equations as they arise in surface theory.
CO5:Apply differential geometry to specific research problems in mathematics and other fields.

Unit 1

Graphs and level sets, Vector fields, Tangent Spaces. (Chapter 1,2,3)

Unit 2

Surfaces, Vector fields on Surfaces, Orientation, The Gauss map. (Chapter 4,5 6)

Unit 3

Geodesics, Parallel Transport. (Chapter 7,8)

Unit 4

The Weingarten map, Curvature of Plane curves. (Chapter 9,10)

Unit 5

Arc length and Line integrals, Curvature of surfaces. (Chapter 11,12 of Text, except the proofs of Theorem 1, Theorem 2 of Chapter 11 and Theorem 1 of Chapter 12)

Textbook:

J.A. Thorpe, *Elementary Topics in Differential Geometry,* Springer.

References:

I.M. Singer and J.A Thorpe,*Lecture notes on Elementary Topology and Geometry,* Springer.

Evaluation Pattern – R.13 & R.16

18MAT668   **Advanced Complex Analysis**   **(3-0-0-3)**

Course outcomes

CO1:Understand Compactness and Convergence in the space of Analytic functions.

 CO2:Ability to understand Riemann Mapping Theorem, Wierstrass Factorization Theorem

CO3: Ability to understand The Gamma function, Riemann Zeta function, Runge's Theorem,

CO4:Understand analytic continuation and Riemann surfaces, Schwarz Reflection Principle.
CO5: Understand the Analytic Continuation along a path &Basic properties of Harmonic functions.

Unit 1

Compactness and Convergence in the space of Analytic functions, The space $C(G,\Omega)$, Space of Analytic functions.

Unit 2

Riemann Mapping Theorem, Wierstrass Factorization Theorem, Factorization of sine function.

Unit 3

The Gamma function, Riemann Zeta function, Runge's Theorem, Simple connectedness.

Unit 4

Mittag-Leffler's Theorem, Analytic continuation and Riemann surfaces, Schwarz Reflection Principle.

Unit 5

Analytic Continuation along a path, Monodromy Theorem, Basic properties of Harmonic functions.

Textbook:

John B Conway, *Functions of One Complex Variable,* Springer.

References:

L.V. Ahlfors, *Complex Analysis*, Mc-Graw Hill.

Evaluation Pattern – R.13 & R.16

18MAT669   **Analytic Number Theory**   **(3-0-0-3)**

Course outcomes

Co.1: Understand integers with divisibility properties and realize the group structure in integers using modular operaions.
Co.2: Apply division algorithm and factorization techniques in Cryptography.
Co.3: Study arithmetic functions and its applications in Number Theory
Co.4: Understand quadratic residue, primitive roots and solve Diophantine equations

CO 5 : Familiarize the methods and apply in situational problems of applications like cryptography

Unit 1
Greatest Common Divisor, Fundamental Theorem of Arithmetic, Euclidean Algorithm. (Chapter 1)
Unit 2
Mobius function, Euler totient function, Mangoldt and Liouville's function, Divisor function, Dirichlet Product, Multiplicative functions, Generalized Convolutions, Formal power Series. (2.1 to 2.17)
Unit 3
Definition and Properties of Congruences, Linear Congruences, Euler-Fermat Theorem, Lagrange's Theorem, Chinese Remainder Theorem and its applications. (5.1 to 5.10)
Unit 4
Finite Abelian Groups and Their Characters, The Character Group, Orthogonality Relations, Dirichlet Characters, The L function for a character.(6.1 to 6.10)
Unit 5
Dirichlet's Theorem on Primes in Arithmetic Progressions, Distribution of primes in Arithmetic Progressions.(7.1 to 7.9)
Textbook:
 Tom Apostol, *Introduction to Analytical Number Theory,* Springer.
References:
G.H Hardy and E.M Wright ,*Introduction to the Theory of Numbers,* Oxford Press.
Evaluation Pattern – R.13 & R.16

18CSA678   **Advanced topics in Deep learning**   **(3-0-0-3)**

Course outcomes

CO1: To understand the fundamentals of deep learning

CO2: To know the main techniques in deep learning and the main research in this field.

CO3: Be able to design and implement deep neural network systems,

CO4: Be able to autonomously extend the knowledge acquired during the study course by reading and understanding scientific and technical documentation.

CO5 Identify new application requirements in the field of computer vision.

Unit 1

Introduction to Tensorflow, Installing and learning its basics, Recap of Neural networks, Convolution neural networks(CNN) and Recurrent Neural Networks (RNN)

Unit 2

Autoencoder and Decoders, Introduction to Generative Adversarial networks (GANs)

Unit 3

Introduction to Speech Processing, important neural network architectures used in them

Unit 4

Introduction to Natural Language processing (NLP), Important neural network architectures used in them

Textbooks:

Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press.

Evaluation Pattern – R.13 & R.16

18CSA679   **Advanced topics in Machine learning**   **(3-0-0-3)**

Course outcomes

CO1:Understand to apply Logistic regressions.

CO2: Linear discriminant analysis, Nonlinear methods, Isomap, Local linear embedding

CO3: Able to apply Regression trees, Classification trees, comparison of trees and linear models,

 Unit 1

Support Vector Machines: Hyperplane, Maximum Margin Classifier, Support Vector Classifiers, Support Vector Machines, One vs One Classification and One vs All Classification, Relationship to Logistic Regression.

Unit 2

Dimensionality reduction, linear methods including PCA, Linear discriminant analysis, Nonlinear methods, Isomap, Local linear embedding, nonlinear PCA, t-SNE

Unit 3

Regression trees, Classification trees, comparison of trees and linear models, Bagging, Random Forests, Boosting.

Unit 4Bayes Theorem, Prior, Likelihood function, Maximum likelihood estimation, Undirected graphical models, Hidden Markov Models.

Textbooks:

G. James, R. Tibshirani, An Introduction to Statistical Learning: with applications in R, Springer.

T. Hastie, R. Tibshirani, Elements of Statistical Learning: Data mining, Inference and Predicton, Springer.

References:

Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press.

Evaluation Pattern – R.13 & R.16