Integrated MSc in Mathematics with minor in Data Sciences

Regulation 2018
Syllabus

Programme Outcomes (PO):

PO1. Knowledge in Mathematical Science: Understand the basic concepts, fundamental principles and the scientific theories related to mathematical sciences.

PO2. Abstract thinking: Ability to absorb and understand the abstract concepts that lead to various advanced theories in mathematical sciences.

PO3. Modelling and solving: Ability in modelling and solving problems by identifying and employing the appropriate existing theories and methods.

PO4. 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.

PO5. 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.

PO6. 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.

PO7. Environment and sustainability: Understand the significance of preserving the environment towards sustainable development.

PO8. 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.

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10. **Communication**: Develop various communication skills such as reading, listening, and speaking which will help in expressing ideas and views clearly and effectively.

PO11. **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.

PO12. **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.

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:

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

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:
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, Saptatalas 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 (Six 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.

18CUL101 CULTURAL EDUCATION I 2002

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:

<table>
<thead>
<tr>
<th>CO1</th>
<th>Gain a positive appreciation of Indian culture, traditions, customs and practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Understand the foundational concepts of Indian civilization like purusharthas, law of karma, etc, which contributes towards personality growth.</td>
</tr>
<tr>
<td>CO3</td>
<td>Understand the cultural ethos of Amrita Vishwa Vidyapeetham, and Amma’s life and vision of holistic education</td>
</tr>
<tr>
<td>CO4</td>
<td>Imbibe spirit of living in harmony with nature</td>
</tr>
<tr>
<td>CO5</td>
<td>Get guidelines for healthy and happy living from the great spiritual masters</td>
</tr>
</tbody>
</table>

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)

18CUL111 CULTURAL EDUCATION II 2002

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)
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) Harishankarparsaiyi- 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)
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. Shivaparakash

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
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 (Mehta 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
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), Poonthanan.

Unit 2

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

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.

Unit 1
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

Unit 3
Memoirs from Modern Poets: Theeppathi, Balachandran Chullikkadu-literary contributions of his time.

Unit 4
Part of an autobiography/travelogue: Kannerum Kinavum, Chapter: Valarnnu Varunnoratmavu, V.T. Bhattacharipadu-Socio-cultural literature-historical importance.

Unit 5

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)

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**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.

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**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. PrakriyaBhashyam written 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. Namalinganusanam by Amarasimha published by Travancore Sanskrit series
7. SubhashitaRatnaBhandakara by Kashinath Sharma, published by Nirayasagarpress

18SSK201 LIFE SKILLS I 1 0 2 2

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:**

**REFERENCES:**
4. *Nova GRE, KAPAL GRE, Barrons GRE books*;
5. *Quantitative Aptitude, The Institute of Chartered Accountants of India*.
7. *The BBC and British Council online resources*
8. *Owl Purdue University online teaching resources*
9. *www.the grammarbook.com online teaching resources*
10. *www.englishpage.com online teaching resources and other useful websites*.

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


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:
4. The Hard Truth about Soft Skills, by Amazon Publication.

REFERENCES:
1. Quantitative Aptitude, by R S Aggarwal, S Chand Publ.
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:
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;
5. Quick Arithmetics, by Ashish Agarwal, S Chand Publ.;
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.

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

Textbook:

References:
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.

**Unit 1**
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:


References:


18PHY105 Introduction to Mechanics 3104

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 non-conservative 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 isolated 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, rotational 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 angle (linear) approximation, connection with uniform circular motion, average kinetic and potential energies, friction and damping, damped and forced oscillations, resonance, power absorption, Q-value, superposition principle.

Introduction to wave motion (selected topics and simple exercises only): propagation of disturbance, 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


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


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:


References:

Course Outcome:

CO1: Understand the basic concepts of vector valued functions, limits, derivatives and its 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 Seperable 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


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:


References:


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-Coefficient 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:


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

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
Textbook:

References:

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**

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:

References:

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 coordinates.

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:


References:


**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**

Unit 2


Unit 3


Unit 4


Unit 5


Textbook:

References:


Semester 4

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

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. (9.2-9.11 of 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:

References:
18MAT218 Real Analysis 1 (3-1-0-4)

Course Outcome:

CO1: Understanding the set theoretic statements and the completeness property of $\mathbb{R}$.
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 $\mathbb{R}$.

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


Textbook:

S. Kumaresan and Ajit Kumar, A Basic Course in Real Analysis, CRC Press.
References:
Terence Tao, Analysis I, Hindustan Book Agency.
Terence Tao, Analysis II, Hindustan Book Agency.

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

Unit 4
Unit 5


Textbook:

References:

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


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:

References:

Semester 5
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 2
Elementary functions, exponential and Logarithmic functions, Branches of logarithm, Trigonometric and Hyperbolic functions.

Unit 3

Unit 4

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:

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

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:

References:


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

Unit 2

Unit 3

Unit 4

Unit 5

Text Books:

References:
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: Understand 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.

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


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, Invariant 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:


References:


**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

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

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:


References:

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


**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**


**Unit 2**


**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:


References:


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

**Course 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
• 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.

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 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.
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 unsupervised 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**


**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.


References:


**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).

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 using Principal 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.
7. Ridge Regression and the Lasso.
8. Principal Components Regression, Partial Least Squares.
9. Non Linear Modelling, Polynomial Regression and Step Functions, Splines, GAMS.

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 software:

**CO4:** Ability to apply Neural Network Optimization 1 and 2 using software:

**CO5:** Ability to understand applications of Recurrent and Convolution Neural Networks in R:
1. Support Vector Classifier, Support Vector Machine, ROC Curves, SVM with Multiple Classes.
2. Principal 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.
9. Recurrent Neural Networks.
10. LSTM and memory architectures.

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 forthcoming 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:


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


References:


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


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

Textbook:

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

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** Develop 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

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

Textbooks:

References:

**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 T² and its distribution, Uses of T² statistic, the distribution of T² 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

Text Books:

References:

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 environment), 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

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 $L^p$ Spaces, Convex Functions, Jensen’s Inequality, The Inequalities of Holder and Minkowski, Completeness of $L^p(\mu)$. (6.1-6.5 of Text)

Unit 5

Textbook:

References:


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

**18MAT517 Stochastic Processes**

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**

**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:

References:

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 \( \mathbb{R}^n \) 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


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:


References:


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-Schmidt 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


Textbook:


References:

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


G.F. Sim

Semester9

18MA T633  Algebraic Topology  

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 $S^n$.

**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 $S^1$, Examples of Fundamental Groups.

**Unit 5**
Covering Spaces – Definition and examples, basic properties of Covering Spaces, Classification of Covering Spaces, Universal Covering Spaces.

Textbook:

References:

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**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.

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**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:

References:


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**


Textbooks:


**References:**


**Semester9:**

18CSA581 PRACTICALS/ 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**

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

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

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 versa and
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.

2. 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
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

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:

Kahani

a) Kafan - Premchand,

b) Rajasthan ki Ek Gaav kee theerthyatra - Beeshmasahni

c) Raychandrabhai :By Mahathma Gandhi - Sathya ke prayog

d) Rajani - Mannu Bhandari

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:

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 in Software

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/

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

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

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

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

1. Bisection and False position Methods.
4. Iterative Methods for Solving Linear Equations.
5. Polynomial Approximation and Interpolation Methods 1
6. Polynomial Approximation and Interpolation Methods 2

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.

18MAT382 Practical/Lab to Be Performed On A Computer Using Matlab/Python

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 on Cauchy, 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

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

(0-0-2-1)
Course outcomes
CO:1 Ability to solve Linear Programming Problem using Graphical Method using software.
CO2: Ability 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.
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

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

Textbook:

References:
D.B. West, *Introduction to Graph Theory*, PHI.
Frank Harary, *Graph Theory*, PHI.

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 differential 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:

References:

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,Ω), 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:

References:
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 operations.

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:

References:
G.H Hardy and E.M Wright *Introduction to the Theory of Numbers*, Oxford Press.

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.

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.

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

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