File Ref.No.70516/GA - IV - J3/2019/Admn

UNIVERSITY OF CALICUT

Abstract

General and Academic - Faculty of Science - Syllabus of MSc Mathematics with Data Science programme, under CBCSS PG Regulations 2019 with effect from 2020 Admission - Implemented- Orders Issued.

G & A - IV - J

U.O.No. 7731/2021/Admn Dated, Calicut University.P.O, 07.08.2021

Read:-1. U.O.No. 4487/2019/Admn dated 26.03.2019
2. U.O.No. 1935/2021/Admn Dated, Calicut University.P.O, 15.02.2021
3. Email from the Chairperson, Board of studies in Mathematics PG dtd 23.07.2021
4. Approval of the Dean, Faculty of Science dtd 30.07.2021
5. Orders of the VC in the file even no. dtd 04.08.2021

ORDER

1. The Regulations for Choice Based Credit and Semester System for Post Graduate (PG) Curriculum- 2019 (CBCSS PG Regulations 2019), for all PG Programmes under Affiliated Colleges and SDE/Private Registration with effect from 2019 Admission has been implemented in the University of Calicut vide paper read (1) above, and thesame has been modified, vide paper read (2) above.
2. The Chairperson, Board of Studies in Mathematics (PG), vide paper read (3) above, has forwarded the Scheme and Syllabus of M.Sc Mathematics with Data Science Programme in accordance with CBCSS PG Regulations 2019, w.e.f 2020 admission after circulating among the members of the Board of Studies in Mathematics (PG), Board of Studies in Statistics (PG) and Board of Studies in Computer Science (PG), as per Chapter 3(34) of Calicut University First Statute, 1976.
3. The Scheme and Syllabus of M.Sc Mathematics with Data Science programme has been approved by the Dean, Faculty of Science, vide paper read (4) above, and by the Vice Chancellor, subject to ratification by the Academic Council, vide paper read (5) above.
4. The Scheme and Syllabus of M.Sc Mathematics with Data Science programme (CBCSS) in tune with CBCSS PG Regulations 2019, is therefore implemented with effect from 2020 Admission onwards under affiliated colleges of the University, subject to ratification by the Academic Council.
5. Orders are issued accordingly (Syllabus appended).

Arsad M

Assistant Registrar

To

The Principals of all Affiliated Colleges.
Copy to: PS to VC/PA to PVC/ PA to Registrar/PA to CE/JCE I/JCE V/DR,DoA/DR, CDC/EX and EG Sections/GA I F/CHMK Library/Information Centres/SF/DF/FC

Forwarded / By Order

Section Officer

UNIVERSITY OF CALICUT

SYLLABUS FOR MSc MATHEMATICS WITH DATA SCIENCE(CBCSS) PG PROGRAMME

EFFECTIVE FROM 2020 ADMISSION ONWARDS

TOTAL CREDITS: 80

PROGRAMME OUTCOME:

Upon completing the M. Sc degree in the field of Mathematics and Data Science students should be

- **Acquired foundations in mathematical, statistical and computational techniques that are applied in Data Science.**
- **Able to develop mathematical and statistical models for modelling data sets.**
- **Able to do programs for computational works required for estimation/fitting of real data applications.**

SEMESTER 1 **Total Credits:20**

Course Code	Title of the Course	No. of credits	Work Load Hrs./Week	Core/ Audit Course
MTD 1 C 01	Algebra	4	5	Core
MTD 1 C 02	Linear Algebra	4	5	Core
MTD 1 C 03	Real Analysis	4	5	Core
MTD 1 C 04	Measure and Probability	4	5	Core
MTD 1 C 05	Statistical Inference and Computing using R	4	5	Core
MTD 1 A 01	Ability Enhancement Course	4	0	Audit Course

SEMESTER 2 **Total Credits:20**

Course Code	Title of the Course	No. of credits	Work Load Hrs./Week	Core/ Audit Course
MTD 2 C 06	Discrete Mathematics	4	5	Core
MTD 2 C 07	Number Theory	4	5	Core
MTD 2 C 08	Differential Equations	4	5	Core
MTD 2 C 09	Topology	4	5	Core
MTD 2 C 10	Regression Techniques and Time Series Analysis	4	5	Core
	Professional Competency Course	4	0	Audit Course

SEMESTER 3 **Total Credits:18**

Course Code	Title of the Course	No. of credits	Work Load Hrs./Week	Core/ Audit Course
MTD 3 C 11	Multivariable Calculus and Geometry	4	5	Core
MTD 3 C 12	Complex Analysis	4	5	Core
MTD 3 C 13	Functional Analysis	4	5	Core
MTD 3 C 14	Sampling Theory and Design & Analysis of Experiments	3	5	Core
	Elective I*	3	5	Elec.

SEMESTER 4 **Total Credits:22**

Course Code	Title of the Course	No. of credits	Work Load Hrs./Week	Core/ Audit Course
MTD 4 C 15	Multivariate Techniques and Data Science	3	4	Core
	Elective II**	3	5	Elec.
	Elective III**	3	5	Elec.
	Elective IV**	3	5	Elec.
MTD 4 P 01	Project	4	5	Core
MTD 4 L 01	Statistical Computing using R-(Practical)	2	2	
MTD 4 V 01	Viva Voce	4		Core

∗ This Elective is to be selected from list of elective courses in third semester.

∗∗ Elective II* is to be selected from group A, Elective III* from group B and Elective IV* from group C from the list of elective courses in fourth semester.

Statistical Computing using R is a practical course. Its objectives are to develop scientific and experimental skills of the students and to correlate the theoretical principles with applications in Data science. The practical is based on the following FOUR courses.

MTD 1 C 05: Statistical Inference and Computing using R
MTD 2 C 10: Regression Techniques and Time Series Analysis
MTD 3 C 14: Sampling Theory and Design & Analysis of Experiments
MTD 4 C 15 : Multivariate Techniques and Data Science

Practical is to be done by using R or Python. At least five statistical data oriented/supported problems should be done from each course. Practical Record shall be maintained by each student and the same shall be submitted for verification at the time of external examination.

The Board of Examiners (BoE) shall decide the pattern of question paper and the duration of the external examination. The external examination at each centre shall be conducted and evaluated on the same day jointly by two examiners – one external and one internal, appointed at the centre of the examination by the University on the recommendation of the Chairman, BoE. The question paper for the external examination at the centre will be set by the external examiner in consultation with the Chairman, BoE and the H/Ds of the centre. The questions are to be evenly distributed over the entire syllabus. Evaluation shall be done by assessing each candidate on the scientific and experimental skills, the efficiency of the algorithm/program implemented, the presentation and interpretation of the results. The valuation shall be done by the direct grading system and grades will be finalized on the same day.

There shall be External and Internal evaluation for Project Work and these shall be combined in the proportion of 4:1. However in the case of Comprehensive Viva-voce, there shall be only External Valuation.

No separate minimum is required for Internal evaluation for a pass, but a minimum P Grade is required for a pass in the external evaluation. However, a minimum P grade is required for pass in a course.

A student who fails to secure a minimum grade for a pass in a course will be permitted to write the examination along with the next batch.

List of Electives for 3rd Semester

Sl.No.	Course code	Title of the Course	Credits	Hours/ Week
1	MTD 3 E 01	Introduction to Analytics and AI	3	5
2	MTD 3 E 02	Machine Learnings Essentials	3	5
3	MTD 3 E 03	Natural Language Processing	3	5

List of Electives for 4th Semester

Sl.No.	Course code	Title of the Course	Credits	Hours/ Week
Group A				
1	MTD 4 E 04	Algebraic Graph Theory	3	5
2	MTD 4 E 05	Algebraic Topology	3	5
3	MTD 4 E 06	Cryptography	3	5
4	MTD 4 E 07	Measure and Integration	3	5
Group B				
5	MTD 4 E 08	Numerical Methods	3	5
6	MTD 4 E 09	Operations Research	3	5
7	MTD 4 E 10	Python for Data Analytics		
Group C				
8	MTD 4 E 11	Data Visualization	3	5
9	MTD 4 E 12	Deep Learning	3	5
10	MTD 4 E 13	Fundamentals of Bigdata	3	5

ABILITY ENHANCEMENT COURSE(AEC)

Successful fulfilment of any one of the following shall be considered as the completion of AEC**.**

(i) Internship, (ii) Class room seminar presentation, (iii) Publications, (iv) Case study analysis, (v) Paper presentation, (vi) Book reviews. A student can select any one of these as AEC.

Internship: Internship of duration 5 days under the guidance of a faculty in an institution/department other than the parent department. A certificate of the same should be obtained and submitted to the parent department.

Class room seminar: One seminar of duration one hour based on topics in mathematics and data science beyond the prescribed syllabus.

Publications: One paper published in conference proceedings/ Journals. A copy of the same should be submitted to the parent department.

Case study analysis: Report of the case study should be submitted to the parent department.

Paper presentation: Presentation of a paper in a regional/ national/ international seminar/conference. A copy of the certificate of presentation should be submitted to the parent department.

Book Reviews: Review of a book. Report of the review should be submitted to the parent department.

PROFESSIONAL COMPETENCY COURSE (PCC)

A student can select any one of the following as Professional Competency course:
1. Technical writing with LATEX.
2. Scientific Programming with Scilab.

PROJECT

The Project Report (Dissertation) should be self contained. It should contain table of contents, introduction, at least three chapters, bibliography and index. The main content may be of length not less than 30 pages in the A4 format with one and half line spacing. The project report should be prepared preferably in LaTeX. There must be a project presentation by the student followed by a viva voce. The components and weightage of External and Internal valuation of the Project are as follows:

Components	External(weightage)	Internal (weightage)
Relevance of the topic & statement of problem	4	1
Methodology & analysis	4	1
Quality of Report & Presentation	4	1
Viva Voce	8	2
Total weightage	20	5

The external project evaluation shall be done by a Board consisting of two External Examiners. The Grade Sheet is to be consolidated and must be signed by the External Examiners.

MTD4 V01 VIVA VOCE EXAMINATIONS

The Comprehensive Viva Voce is to be conducted by a Board consisting of two External Examiners. The viva voce must be based on the core papers of the entire programme. There should be questions from at least one course of each of the semesters I, II, and III. Total weightage of viva voce is 15. The same Board of two External Examiners shall conduct both the project evaluation and the comprehensive viva voce examination. The Board of Examiners shall evaluate at most 10 students per day.

EVALUATION AND GRADING OF OTHER COURSES

The evaluation scheme for each course shall contain two parts.

(a) **Internal Evaluation:** 20% Weightage

(b) **External Evaluation:** 80% Weightage

Both the Internal and the External evaluation shall be carried out using direct grading system as per the general guidelines of the University. Internal evaluation must consist of (i) 2 tests (ii) one assignment (iii) one seminar and (iv) attendance, with weightage 2 for tests (together) and weightage 1 for each other component.

Each of the two internal tests is to be a 10 weightage examination of duration one hour in direct grading. The average of the final grade points of the two tests can be used to obtain the final consolidated letter grade for tests (together) according to the following table.

Average grade point (2 tests)	Grade for Tests	Grade Point for Tests
4.5 to 5	A+	5
3.75 to 4.49	A	4
3 to 3.74	B	3
2 to 2.99	C	2
Below 2	D	1
Absent	E	0

Internal Grade Calculation: Examples

Tests	Grade Point of Test 1	Grade Point of Test 2	Average Test Grade Point	Test Grade	Test Grade Point	Test Weightage	Test Weighted Grade Point
Student1	4.8	3.5	4.15	A	4	2	8
Student2	5	4.8	4.9	A+	5	2	10
Student3	2.3	4.7	3.5	B	3	2	6

Assignment	Assignment Grade	Assignment Grade Point	Assignment Weightage	Assignment Weighted Grade Point
Student1	A+	5	1	5
Student2	A	4	1	4
Student3	C	2	1	2

Seminar	Seminar Grade	Seminar Grade Point	Seminar Weightage	Seminar Weighted Grade Point
Student 1	B	3	1	3
Student 2	A+	5	1	5
Student 3	D	1	1	1

Attendance	Attendance Grade	Attendance Grade Point	Attendance Weightage	Attendance Weighted Grade Point
Student 1	A+	5	1	5
Student 2	A+	5	1	5
Student 3	C	2	1	5

Consolidation	Total Weighted Grade Point	Total Weightage	Total Internal Grade Point	Final Internal Grade
Student 1	21	5	21/5 = 4.2	A+
Student 2	24	5	24/5 = 4.8	O
Student 3	11	5	11/5 = 2.2	F

Question Paper Pattern for the written examinations

For each course there will be an external examination of duration 3 hours. The valuation will be done by Direct Grading System. Each question paper will consist of 8 short answer questions each of weightage 1, 9 paragraph type questions each of weightage 2, and 4 essay type questions each of weightage 5. All short answer questions are to be answered while 6 paragraph type questions and 2 essay type questions are to be answered with a total weightage of 30. The questions are to be evenly distributed over the entire syllabus(see the model question paper). More specifically, each question paper consists of three parts viz Part A, Part B and Part C . Part A will consist of 8 short answer type questions each of weightage 1 of which at least 2 questions should be from each unit. Part B has 3 units based on the 3 modules of each course. From each module there will be three questions of which two should be answered. Part C will consist of four essay type questions each of weightage 5 of which 2 should be answered. These questions should cover the entire syllabus of the course.

DETAILED SYLLABI

SEMESTER 1

MTD 1 C 01: ALGEBRA
No. of Credits: 4
No. Of hours of Lectures/week: 5

Course Outcome: Upon the successful completion of the course students will:

- Learn direct product of groups and factor group computation.
- Understand the notion of group action on a set.
- Understand the notion of free groups.
- Understand the concepts rings and ideals.
- Learn basic properties of field extensions.

TEXT: JOHN B. FRALEIGH; A FIRST COURSE IN ABSTRACT ALGEBRA(7th Edition) Pearson Education Inc., 2003.

Module 1

Direct products and finitely generated abelian groups; Factor groups; Factor group computations and simple groups; Group action on a set; Applications of G-sets to counting.

[Chapter II: section-11; Chapter III: sections- 14, 15, 16,17]

Module 2

Sylow theorems; Applications of Sylow theory; Free Groups; Rings of polynomials; Factorization of polynomials over a field; Homomorphisms and Factor rings.
[Chapter VII: section- 36,37,39; Chapter IV: sections-22, 23; Chapter V: section- 26]

Module 3

Prime and maximal ideals; Introduction to extension fields; Algebraic extensions; Geometric constructions; Finite fields;
[Chapter V: section- 26; Chapter VI: sections-29,31,32,33]

References

[1] N. Bourbaki: Elements of Mathematics: Algebra I, Springer; 1998.
[2] Dummit and Foote: Abstract algebra(3rd edn.); Wiley India; 2011.
[3] P.A. Grillet: Abstract algebra(2nd edn.); Springer; 2007
[4] I.N. Herstein: Topics in Algebra(2nd Edn); John Wiley & Sons, 2006.
[7] T.Y. Lam: Exercises in classical ring theory(2nd edn); Springer; 2003.
[8] C. Lanski: Concepts in Abstract Algebra; American Mathematical Society; 2010.
[9] N.H. Mc Coy: Introduction to modern algebra, Literary Licensing, LLC; 2012.

SEMESTER 1

MTD 1 C 02: LINEAR ALGEBRA
No. of Credits: 4
No. Of hours of Lectures/week: 5

Course Outcome: Upon the successful completion of the course students will:

- Learn basic properties of vector spaces.
- Understand the relation between linear transformations and matrices.
- Understand the concept of diagonalizable and triangulable operators and various fundamental results of these operators.
- Understand Primary decomposition Theorem.
- Learn basic properties inner product spaces.

TEXT 1 : HOFFMAN K. and KUNZE R., LINEAR ALGEBRA(2ndEdn.), Prentice Hall of India, 1991.

Module 1

Vector Spaces & Linear Transformations
[Chapter 2 Sections 2.1 - 2.4; Chapter 3, Sections 3.1 to 3.3 from the text 1]

Module 2

Linear Transformations (continued) and Elementary Canonical Forms
[Chapter 3 Sections 3.4 - 3.7; Chapter 6, Sections 6.1 to 6.4 from the text 1]

Module 3

Elementary Canonical Forms (continued), Inner Product Spaces
[Chapter 6, Sections 6.6 & 6.7; Chapter 8, Sections 8.1 & 8.2 from the text]

References

[1] P. R. Halmos: Finite Dimensional Vector spaces; Narosa Publishing House, New Delhi; 1980.
[2] A. K. Hazra: Matrix: Algebra, Calculus and generalised inverse- Part I; Cambridge International Science Publishing; 2007.
[3] I. N. Herstein: Topics in Algebra; Wiley Eastern Ltd Reprint; 1991.
[4] S. Kumaresan: Linear Algebra-A Geometric Approach; Prentice Hall of India; 2000.
[5] R. R. Stoll and E.T.Wong: Linear Algebra; Academic Press International Edn; 1968.
[6] G. Strang: linear algebra and its applications(4th edn.); Cengage Learning; 2006.

SEMESTER 1

MTD 1 C 03: REAL ANALYSIS
No. of Credits: 4
No. Of hours of Lectures/week: 5

Course Outcome: Upon the successful completion of the course students will:

- Learn the topology of the real line
- Understand the notions of Continuity, Differentiation and Integration of real functions.
- Learn Uniform convergence of sequence of functions, equicontinuity of family of functions and Weierstrass theorems

TEXT: RUDIN W., PRINCIPLES OF MATHEMATICAL ANALYSIS(3rd Edn.), Mc. Graw-Hill, 1986.

Module 1

Basic Topololgy Finite, Countable and Uncountable sets Metric Spaces, Compact Sets, Perfect Sets, Connected Sets. Continuity - Limits of function, Continuous functions, Continuity and compactness, continuity and connectedness, Discontinuities, Monotonic functions, Infinite limits and Limits at Infinity
[Chapter 2 & Chapter 4].

Module 2

Differentiation The derivative of a real function, Mean Value theorems, The continuity of Derivatives, L Hospitals Rule, Derivatives of Higher Order, Taylors Theorem, Differentiation of Vector valued functions. The Riemann Stieltjes Integral, - Definition and Existence of the integral, properties of the integral, Integration and Differentiation
[Chapter 5 & Chapter 6 up to and including 6.22].

Module 3

The Riemann Stieltjes Integral (Continued) - Integration of Vector vector-valued Functions, Rectifiable curves. Sequences and Series of Functions - Discussion of Main problem, Uniform convergence, Uniform convergence and continuity, Uniform convergence and Integration, Uniform convergence and Differentiation. Equicontinuous Families of Functions, The Stone Weierstrass Theorem
[Chapters 6 (from 6.23 to 6.27) & Chapter 7 (up to and including 7.27 only)].

References

[1] H. Amann and J. Escher: Analysis-I; Birkhuser; 2006.
[2] T. M. Apostol: Mathematical Analysis (2nd Edn.); Narosa; 2002.
[3] R. G. Bartle: Elements of Real Analysis (2nd Edn.); Wiley International Edn.; 1976.
[4] R. G. Bartle and D.R. Sherbert: Introduction to Real Analysis; John Wiley Bros; 1982. [
[5] J. V. Deshpande: Mathematical Analysis and Applications- an Introduction; Alpha Science International; 2004.
[6] C. C. Pugh: Real Mathematical Analysis, Springer; 2010.
[7] K. A. Ross: Elementary Analysis- The Theory of Calculus(2nd edn.); Springer.

SEMESTER 1

MTD 1 C O4: MEASURE AND PROBABILITY
No. of Credits: 4
No. of hours of Lectures/week: 5

Course Outcome: Upon the successful completion of the course students will:

- Learn the concept of measures and measurable functions
- Learn Lebesgue integration and its various properties
- Learn the concept of random variables starting from axiomatic definition of probability upto limit theorem of probability.
- Understand probability distribution and distribution function and their properties.

TEXT 1: H. L.Royden ,P. M. FitzpatrickH.L. REAL ANAYLSIS (4th Edn.), Prentice Hall of India, 2000.
TEXT 2: BHAT B R, MODERN PROBABILITY THEORY, AN INTRODUCTORY TEXT BOOK, 3rd Edn. Wiely Eastern Ltd.

Module 1

Sigma Algebra , Borel sets Section 1.4 : Proposition13 Lebesgue Measure [Chapter 2 : Sections 2.1, 2.2 ,2.3 ,2.4 ,2.5 ,2.6,2.7 upto preposition19. Lebesgue Measurable Functions Chapter 3 : Sections 3.1, 3.2 , 3.3. of TEXT 1]

Module 2

Lebesgue Integration; Lebesgue Integration: Further Topics[Chapter 4 : Sections 4.1, 4.2, 4.3, 4.4, 4.5 , 4.6 ,Chapter 5 : Sections: 5.1, 5.2 ,5.3. of TEXT 1]

Module 3

Probability space, Limit of sequence of events, Monotone and continuity properties of probability measure, Addition Theorem Independence of finite number of events, sequence of events tail events and tail – field Borel Cantelli Theorem, Borel zero-one law, Conditional Probability and Bayes Theorem. Random variables its probability Distribution and distribution Function properties, Discrete and continuous type random variables, Discrete probability distributions(Poisson,Binomial,Geometric and Negative binomial distribution) and continuous probability distributions (Uniform, Exponential, gamma, normal and beta distributions), Mathematical expectation, Moments of Random variables. [Unit 0; Unit 2 Sections 2.1& 2.2; Unit 3; Unit 4: Section 4.1; Unit 5; Sections 5.1, 5.2 &5.3(a, b); Unit 9:Sections 9.1& 9.3 of TEXT 2**]**

References

[1] K B. Athreya and S N Lahiri:,Measure theory,Hindustan Book Agency,New Delhi,(2006).
[2] R G Bartle:, The Elements of Integration and LebsgueMesure , Wiley(1995).
[3] S K Berberian: ,measure theory and Integration,The Mc Millan Company,New York,(1965).
[4] L M Graves: ,The Theory of Functions of Real Variable Tata McGraw-Hill Book Co(1978)
[5] P R Halmos: , Measure Theory, GTM ,Springer Verlag
[6] W Rudin:, Real and Complex Analysis,Tata McGraw Hill,New Delhi,2006
[7] I K Rana:,An Introduction to Measure and Integration, Narosa Publishing Company,New York.
[8] Terence Tao: ,An Introduction to Measure Theory,Graduate Studies in Mathematics,Vol 126AMS.

SEMESTER 1

MTD 1 C 05: STATISTICAL INFERENCE AND COMPUTING USING R
No. of Credits: 4
No. of hours of Lectures/week: 5

Course Outcome: At the end of the course students will be able to

- Understand the notion of point estimation of the parameters and properties of the good estimator
- Learn the approaches methods of point estimation
- Understand the concept of interval estimation
- Understand the concept of testing of hypothesis
- Understand and apply large sample and small sample tests using r in real data contexts.
- Understand the use of non parametric tests using r in real data contexts.

TEXT 1 Rohatgi, V. K and Saleh, A. K. MdE (2001) An introduction to Probability and Statistics, John Wiley and Sons, Inc.

TEXT 2 Dalgaard, P (2008) Introductory Statistics with R, Second Edition, Springer.

Module 1: Estimation of Parameters

(Based on TEXT 1)
Point estimation, properties of good estimators, method of estimation: Method of moments, Least square, Conditional least square, Maximum likelihood estimation (MLE), Interval estimation, Bayesian inference-Bayesian estimation.

Module 2: Testing of Hypothesis

(Based on TEXT 1)
Fundamental notions of hypothesis testing (section 9.2) Testing of hypothesis, Research hypothesis and statistical hypothesis, Null hypothesis, Alternative hypothesis, Types of errors, p value, Neyman-Pearson Lemma (section 9.3), MP test, UMP test-construction and illustration, chi square tests (section 10.3), t-tests (section 10.4), F-tests (section 10.5),
MP test, UMP test-construction and illustration, test for mean, test for variance, tests for proportion, chi-square test for goodness of fit and independence, Non parametric tests- some single sample problems, sign test, Wilcoxon signed rank test, Kruskall-Wallis test, Kolmogrov-Smirnov test, tests of independence: chi-square test of independence (section 13.5)

Module 3: Statistical inference using R

(Based on TEXT 2)
Introduction to the statistical software R, Data objects in R, Creating vectors, Creating matrices, Manipulating data, Accessing elements of a vector or matrix, Lists, Addition, Multiplication, Subtraction, Transpose, Inverse of matrices. Read a file. Boolean operators. R-Graphics- Histogram, Box-plot, Stem and leaf plot, Scatter plot, Plot options; Multiple plots in a single graphic window, Adjusting graphical parameters. Looping- For loop, repeat loop, while loop, if command, if else command, Summary statistics for a single group, Summary statistics by groups (chapter 1 and 4 of Text 2),One- and two-sample tests (chapter 5 and chapter 7 of text book 2), Analysis of variance and the Kruskal–Wallis test (chapter 7 of text 2).

References

[1] Casella G. and Berger, R.L. (2002): Statistical Inference, Second Edition Duxbury, Australia.

[2] Srivastava M and Srivstava, N (2009): Statistical Inference: Testing of Hypothesis, Eastern Economy Edition, PHI Learning Pvt. Ltd., New Delhi.

[3] Zuur, A . F, Ieno, E. N and E. Meesters(2009):"A Beginner's Guide to R". Springer,

[4] Crawley . M. J (2005):"Statistics: An Introduction using R", Wiley.

SEMESTER 2

MTD 2 C 06: DISCRETE MATHEMATICS
No. of Credits: 4
No. of hours of Lectures/week: 5

Course Outcome: Upon the successful completion of the course students will:

- Understand the fundamentals of Graphs.
- Learn the structure of graphs and familiarize the basic concepts used to analyze different problems in different areas of different branches.
- Acquire a basic knowledge of formal languages, grammars and automata.
- Learn the equivalence of deterministic and non-deterministic finite accepters.

TEXT 1: J. A. BONDY& U. S. R. MURTY, GRAPH THEORY, Springer., 2008.

TEXT 2: PETER LINZ, AN INTRODUCTION TO FORMAL LANGUAGES AND AUTOMATA (3rd Edn.), Narosa Publishing House, New Delhi, 2003.

Module 1

Graphs: Graphs and their representation, Isomorphisms and Automorphisms, Constructing graphs from other graphs. Sub graphs: Sub Graphs and Super graphs, Spanning and induced Subgraphs, Modifying Graphs; Edge Cuts and Bonds. Connected Graphs: Walks and Connection, Cut Edges, Euler Tours.
[Chapter 1: Sections1.1, 1.2, 1.4(Omit Proof Technique: Counting in Two Ways and Labelled Graphs), Chapter 2: Sections 2.1(Omit maximality and minimality, Acyclic Graphs, Di Graphs and Proof Technique: The Pigeonhole Principle), 2.2(Omit proof Techniques: Induction and Contradiction; and Weighted Graphs and Subgraphs), 2.3 and2.5(Omit Cuts in Directed Graphs),Chapter 3: Sections 3.1(Omit Proof Technique: Eigen Values), 3.2 and 3.3of TEXT 1]

Module 2

Trees: Forests and Trees, Spanning Trees, Nonseparable Graphs: Cut Vertices, Separations and Blocks, Connectivity: Vertex Connectivity, Edge Connectivity, Planar Graphs, Plane and Planar Graphs, Duality, Euler's formula. The Four Colour Problems: Colourings of Planar Maps. Stable Sets and Cliques ,Vertex Colouring: Chromatic Number, Critical Graphs.
[Chapter 4: Sections 4.1(Omit Rooted Trees and Branchings, Proof Thechnique; Ordering Vertices) and 4.2. Chapter 5: Sections 5.1, 5.2(Omit proof Technique: Splitting of Edges) .Chapter 9: Sections 9.1, 9.3 (Omit Essential Edge Connectivity, Connectivity in Digraphs), Chapter 10: Sections 10.1, 10. 2(Omit Vector Spaces and Duality) and 10.3, Chapter 11 Section 11.1, Chapter 12: Section 12.1(Omit Stable sets in Digraphs and Kernels), Chapter 14: Sections 14.1(Omit A Greedy Colouring Heuristic, Colouring of digraphs and the Path Partition Conjecture) and 14.2of TEXT 1]

Module 3

Automata and Formal Languages: Introduction to the theory of Computation: Three basic concepts, some applications, Finite Automata: Deterministic finite accepters, Non deterministic accepters, Equivalence of deterministic and nondeterministic finite accepters . [Chapter 1: sections 1.2 & 1.3; Chapter 2: sections 2.1, 2.2 & 2.3 of TEXT 2]

References

[1] J. A. Clark: A first look at Graph Theory; World Scientific; 1991.
[2] C. J. Dale: An Introduction to Data base systems(3rd Edn.); Addison Wesley Pub Co., Reading Mass; 1981.
[3] R. Diestel: Graph Theory(4th Edn.); Springer-Verlag; 2010

[4] R. P. Grimaldi: Discrete and Combinatorial Mathematics- an applied introduction(5th edn.); Pearson; 2007.
[5] F. Harary: Graph Theory; Narosa Pub. House, New Delhi; 1992.
[6] D. J. Hunter: Essentials of Discrete Mathematics (3rd edn.); Jones and Bartlett Publishers; 2015.
[7] A. V. Kelarev: Graph Algebras and Automata; CRC Press; 2003
[8] C. L. Liu : Elements of Discrete Mathematics(2nd Edn.); Mc Graw Hill International Edns. Singapore; 1985.
[9] L. Lovsz, J. Pelikn and K. Vesztergombi: Discrete Mathematics: Elementary and beyond; Springer; 2003.
[10] W. T. Tutte: Graph Theory; Cambridge University Press; 2001
[11] D. B. West: Introduction to graph theory; Prentice Hall; 2000.
[12] R. J. Wilson : Introduction to Graph Theory; Longman Scientific and Technical Essex(co-published with John Wiley and sons NY); 1985.

SEMESTER 2

MTD 2 C O7: NUMBER THEORY
No. of Credits: 4
No. of hours of Lectures/week: 5

Course Outcome: Upon the successful completion of the course students will:

- Be able to effectively express the concepts and results of number theory.
- Learn basic theory of arithmetical functions and Dirichlet multiplication, averages of some arithmetical functions.
- Understand distribution of prime numbers and prime number theorem.
- Learn the concept of quadratic residue and Quadratic reciprocity laws.
- Get a basic knowledge in Cryptography.

TEXT 1 : APOSTOL T.M., INTRODUCTION TO ANALYTIC NUMBER THEORY, Narosa Publishing House, New Delhi, 1990.

TEXT 2: KOBLITZ NEAL A., COURSE IN NUMBER THEROY AND CRYPTOGRAPHY, SpringerVerlag, NewYork, 1987.

Module 1

Arithmetical functions and Dirichlet multiplication; Averages of arithmetical functions [Chapter 2: sections 2.1 to 2.14, 2.18, 2.19; Chapter 3: sections 3.1 to 3.4, 3.9 to 3.12 of Text 1]

Module 2

Some elementary theorems on the distribution of prime numbers [Chapter 4: Sections 4.1 to 4.10 of Text 1]

Module 3

Quadratic residues and quadratic reciprocity law [Chapter 9: sections 9.1 to 9.8 of Text 1]
Cryptography, Public key [Chapters 3 ; Chapter 4 sections 1 and 2 of Text 2.]

References

[1] A. Beautelspacher: Cryptology; Mathematical Association of America (Incorporated); 1994
[2] H. Davenport: The higher arithmetic (6th Edn.); Cambridge Univ.Press; 1992
[3] G. H. Hardy and E.M. Wright: Introduction to the theory of numbers; Oxford International Edn; 1985
[4] A. Hurwitz & N. Kritiko: Lectures on Number Theory; Springer Verlag ,Universitext; 1986
[5] T. Koshy: Elementary Number Theory with Applications; Harcourt / Academic Press; 2002
[6] D. Redmond: Number Theory; Monographs & Texts in Mathematics No: 220; Marcel Dekker Inc.; 1994
[7] P. Ribenboim: The little book of Big Primes; Springer-Verlag, New York; 1991
[8] K.H. Rosen: Elementary Number Theory and its applications (3rd Edn.); Addison Wesley Pub Co.; 1993
[9] W. Stallings: Cryptography and Network Security-Principles and Practices; PHI; 2004
[10] D.R. Stinson: Cryptography- Theory and Practice (2nd Edn.); Chapman & Hall / CRC (214. Simon Sing : The Code Book The Fourth Estate London); 1999
[11] J. Stopple: A Primer of Analytic Number Theory-From Pythagorus to Riemann; Cambridge Univ Press; 2003
[12] S.Y. Yan: Number Theroy for Computing(2nd Edn.); Springer-Verlag; 2002.

SEMESTER 2

MTD 2 C 08: DIFFERENTIAL EQUATIONS
No. of Credits: 4
No. of hours of Lectures/week: 5

Course Outcome: Upon the successful completion of the course students will:

- Learn the existence of uniqueness of solutions for a system of first order ODEs.
- Learn many solution techniques such as separation of variables, variation of parameter power series method, Frobenious method etc.
- Get an idea of how to analyse the behaviour of solutions such as stability, asymptotic stability etc.
- Learn a technique to solve first order first order PDE and analyse the solution to get information about the parameters involved in the model.
- Learn explicit representations of solutions of important classes of PDE Laplace equation and wave equation for initial value problems.

TEXT 1 : Shepley L. Ross, Differential equations(third edition), Wiley student edition, 2018.

TEXT 2: T.Amaranath, An elementary Course in Partial Differential Equations, Narosa

Second Ed. 2003.

Module 1

The fundamental theorem of existence and uniqueness theorem, Dependence of solution on initial conditions, existence and uniqueness theorem for systems and higher order equations. Power series solution about an ordinary point, solutions about singular points, the method of Frobenious, Bessel's equations and Bessel's functions.[Chapter 10 (sections 10.2, 10.3 and 10.4)and Chapter 6(sections 6.1, 6.2 and 6.3) of text 1]

Module 2

Phase Plane, paths, and critical points, Critical points and paths of linear systems, Critical points and paths of nonlinear equations, limit circles and periodic solutions[Chapter 13(sections 13.1, 13.2, 13.3 and 13.4)of Text 1]

Module 3

First Order PDE - Curves and Surfaces, Genesis of first order PDE, Classifications of integrals-Linear equation of first order- Pfaffian Differential Equations- Compatible systems- Charpits equations, Jacobi's method. Second order PDE - Classification of second order PDE - One dimensional wave equations-Vibration of finite string - Vibration of semi-infinite string - Vibrations of infinite string, Laplace equations - Boundary value problem, Maximum and minimum principles. [Chapter 1(Section 1.1 to 1.8)and Chapter 2(Sections 2.1, 2.2, 2.3.1, 2.3.2, 2.3.3, 2.4.1, 2.4.2) of Text 2]

References

[1] Sneddon, Elements of Partial Differential Equations (MC Graw-Hill)

[2] Phoolan Prasad, Renuka Raveendran, Partial Differential Equations (Wiley Eastern)

[3] Zahir Ahsan, Differential Equations and their Applications (Prentice Hall 1999)

[4] Earl A Coddington, Norman Levinson, Theory of Ordinary Differential Equations (Tata Mc Graw Hill)

[5] G.Birkoff and G.C Rota, Ordinary Differential Equations (Wiley and Sons- 3rd Edn (1978)).

[6] M.Ram Mohan Rao, Ordinary Differential Equations and Applications.

[7] Hamdy A. Taha: Operations Research- An Introduction(4th Edn.); Macmillan Pub Co. Delhi; 1989

SEMESTER 2

MTD 2 C 09: TOPOLOGY
No. of Credits: 4
No. of hours of Lectures/week: 5

Course Outcome: Upon the successful completion of the course students will:

- Be proficient in abstract notion of a toplogical space, where continuous function are defined in terms of open set not in the traditional $\varepsilon - \delta$ definition used in analysis).
- Realize Intermediate value theorem is a statement about connectedness, Bolzano weierstrass theorem is a theorem about compactness and so on.
- Learn the concept of quotient topology.
- Learn five properties such as T_0, T_1, T_2, T_3 and T_4 of a topological space X which express how rich the open sets is. More precisely, each of them tells us how tightly a closed subset can be wrapped in an open set.

TEXT : JOSHI, K.D., INTRODUCTION TO GENERAL TOPOLOGY (Revised Edn.), New Age International(P) Ltd., New Delhi, 1983.

Module 1

A Quick Revision of Chapter 1,2 and 3. Topological Spaces, Basic Concepts [Chapter 4 and Chapter 5 Sections 1, Section 2 (excluding 2.11 and 2.12) and Section 3 only]

Module 2

Making Functions Continuous, Quotient Spaces, Spaces with Special Properties [Chapter 5 Section 4 and Chapter 6]

Module 3

Separation Axioms: Hierarchy of Separation Axioms, Compactness and Separation Axioms, The Urysohn Characterization of Normality, Tietze Characterisation of Normality. [Chapter 7: Sections 1 to 3 and Section 4 (up to and including 4.6)]

References

[1] M.A. Armstrong: Basic Topology; Springer- Verlag New York; 1983
[2] J. Dugundji: Topology; Prentice Hall of India; 1975
[3] M. Gemignani: Elementary Topology; Addison Wesley Pub Co Reading Mass; 1971
[4] M.G. Murdeshwar: General Topology(2nd Edn.); Wiley Eastern Ltd; 1990
[5] G.F. Simmons: Introduction to Topology and Modern Analysis; McGraw-Hill International Student Edn.; 1963
[6] S. Willard: General Topology; Addison Wesley Pub Co., Reading Mass; 1976

SEMESTER 2

MTD 2 C 10: REGRESSION TECHNIQUES AND TIME SERIES ANALYSIS

No. of Credits: 4

No. of hours of Lectures/week: 5

Course outcome: At the end of the course students will be able to

- Develop the understanding of linear regression model
- Develop the ability to fit regression models for the real data.
- Develop the understanding of time series models
- Develop the ability to fit time series models for the real data.

TEXT 1: Douglas C. Montgomery, Elizabeth A. Peck, G. Geoffrey Vining, Introduction to Linear Regression Analysis, Fifth Ed., Wiley India Pvt. Ltd., 2012.

TEXT 2: Douglas C. Montgomery, Cheryl L. Jennings, Murat Kulahci, Introduction to Time Series Analysis and Forecasting, Second Ed., Wiley, 2016.

TEXT 3: William W. S Wei (2006) , Time series analysis Univariate and Multivariate Methods, second edition, Pearson Education Inc.

Module 1: Regression Analysis

Regression and uses of regression, simple regression and multiple linear regression model, (section 2.2, section 3.2 of Text 1).
Least Squares Estimation in Linear Regression Models and properties of estimates, Statistical Inference in Linear Regression, Prediction of New Observations, Model Adequacy Checking, Variable Selection Methods in Regression, Generalized and Weighted Least Squares, Regression Models for General Time Series Data, Econometric Models (Chapter 3 of Text 2)
(*Illustrations and analysis of real data using R-programming is compulsory (Use Text book 1))*

Module 2: Exploratory Time series Analysis

Some Examples of Time Series, Time Series Plots, Plotting Smoothed Data, Stationary Time Series, Autocovariance and Autocorrelation Functions, First-Order Exponential Smoothing, Modelling Time Series Data, Second-Order Exponential Smoothing, Higher-Order Exponential Smoothing, Forecasting, Exponential Smoothing for Seasonal Data. (Chapter 4 of Text 2)
(Illustrations and analysis of real data using R-programming is compulsory (Use Text book 2).)

Module 3: Linear Time series Models

Time series as a realization of Stochastic process, Autocorrelation and partial autocorrelation functions, white noise process, Estimation of mean, autocovariances and autocorrelations, (section 2.5), stationary time series models: Autoregressive (AR(1),Ar(2),AR(p)) process, Moving average process (MA(1),MA(2), MA(q)) processes, stationarity and invertibility conditions of AR and MA processes (section 3.1 and 3.2). Dual relationship between AR (p) and MA (q) processes (section 3.3). ARMA (p,q) process (section 3.4), ARIMA Models (section 4.2), Non-stationarity in mean and autocovariance, variance stabilizing transformation, Forecasting (section 5.2), steps of model identification, Estimation of parameters(section 7.1and 7.2), Diagnostic checking (section 7.5) , seasonal ARIMA models. (Module 3 is based on the Text book 3)
Time series analysis of real data using R-programming is compulsory. (Text 2)

References

[1] George E. P. Box, Gwilym M. Jenkins, Gregory C. Reinsel, Greta M. Ljung, Time Series Analysis: Forecasting and Control, Fifth Ed., Wiley, 2016.

[2] Brockwell, P. J., & Davis, R. A., Introduction to time series and forecasting, Third Ed., Springer, 2016.

[3] Terence C. Mills, Applied Time Series Analysis: A Practical Guide to Modelling and Forecasting, Academic Press, 2019.

SEMESTER 2

MTD 2 A 02: TECHNICAL WRITING WITH LATEX (PCC)
No. of Credits: 4

1. Installation of the software LATEX
2. Understanding LATEX compilation
3. Basic Syntex, Writing equations, Matrix, Tables
4. Page Layout : Titles, Abstract, Chapters, Sections, Equation references, citation.
5. List making environments
6. Table of contents, Generating new commands
7. Figure handling, numbering, List of figures, List of tables, Generating bibliography and index
8. Beamer presentation
9. Pstricks: drawing simple pictures, Function plotting, drawing pictures with nodes
10. Tikz:drawing simple pictures, Function plotting, drawing pictures with nodes

References

[1] L. Lamport: A Document Preparation System, User's Guide and Reference Manual, Addison-Wesley, New York, second edition, 1994.
[2] M.R.C. van Dongen:LATEX and Friends, Springer-Verlag Berlin Heidelberg 2012.
[3] Stefan Kottwitz: LATEX Cookbook, Packt Publishing 2015.
[4] David F. Griffths and Desmond J. Higham: Learning LATEX (second edition), Siam 2016.
[5] George Gratzer: Practical LATEX, Springer 2015.
[6] W. Snow: TEX for the Beginner. Addison-Wesley, Reading, 1992
[7] D. E. Knuth:The TEX Book. Addison-Wesley, Reading, second edition, 1986
[8] M. Goossens, F. Mittelbach, and A. Samarin :The LATEXCompanion. AddisonWesley, Reading, MA, second edition, 2000.

SEMESTER 2

MTD 2 A 03: PROGRAMMING WITH SCILAB (PCC)

No. of Credits: 4

- Installation of the softwareScilab.
- Basic syntax, Mathematical Operators, Predefined constants, Built in functions.
- Complex numbers, Polynomials, Vectors, Matrix. Handling these data structures using built in functions
- Programming
  (a) Functions
  (b) Loops
  (c) Conditional statements
  (d) Handling .sci files

5. Installation of additional packages e.g. "optimization"
6. Graphics handling
   (a) 2D, 3D
   (b) Generating .jpg files
   (c) Function plotting
   (d) Data plotting
7. Applications
   (a) Numerical Linear Algebra (Solving linear equations, eigenvalues etc.)
   (b) Numerical Analysis : iterative methods
   (c) ODE: plotting solution curves

References

[1] Claude Gomez, Carey Bunks Jean-Philippe Chancelier Fran ois Delebecque Mauriee Goursat Ramine Nikoukhah Serge Steer : Engineering and Scientific Computing with Scilab, Springer-Science, LLC, 1998.

[2] Sandeep Nagar: Introduction to Scilab For Engineers and Scientists, A press, 2017.

SEMESTER 3

MTD 3 C 11: MULTIVARIABLE CALCULUS AND GEOMETRY
No. of Credits: 4
No. of hours of Lectures/week: 5

Course Outcome: Upon the successful completion of the course students will:

- Be proficient in differentiation of functions of several variables.
- Understand curves in plane and inspace.
- Get a deep knowledge in Curvature, torsion, Serret-Frenet formulae
- Learn Fundamental theorem of curves in plane and space.
- Learn the concept of Surfaces in three dimension, smooth surfaces, surfaces of revolution
- Learn explicitly tangent and normal to the surfaces.
- Get a thorough understanding of oriented surfaces, first and second fundamental forms surfaces, gaussian curvature and geodesic curvature and so on.

TEXT 1 : RUDIN W., PRINCIPLES OF MATHEMATICAL ANALYSIS, (3rd Edn.), Mc. Graw Hill, 1986.

TEXT 2: ANDREW PRESSLEY, ELEMENTARY DIFFERENTIAL GEOMETRY(2nd Edn.), Springer-Verlag, 2010.

Module 1

Functions of Several Variables Linear Transformations, Differentiation, The Contraction Principle, The Inverse Function Theorem, the Implicit Function Theorem. [Chapter 9 – Sections 1–29, 33–37 from Text -1]

Module 2

What is a curve? Arc-length, Reparametrization, Closed curves, Level curves versus parametrized curves. Curvature, Plane curves, Space curves What is a surface, Smooth surfaces, Smooth maps, Tangents and derivatives, Normals and orientability. [Chapter 1 Sections 1– 5, Chapter 2 Sections 1 – 3, Chapter 4 Sections 1 – 5 from Text - 2]

Module 3

Level surfaces, Applications of the inverse function theorem, Lengths of curves on surfaces, Equiareal maps and a theorem of Archimedes, The second fundamental form, The Gauss and Weingarten maps, Normal and geodesic curvatures. Gaussian and mean curvatures, Principal curvatures of a surface. [Chapter 5 Sections 1 & 6, Chapter 6 Sections 1 and 4(up to and including 6.4.3) Chapter 7 Sections 1 – 3, Chapter 8 Sections 1 – 2 from Text - 2]

References

[1] M. P. do Carmo: Differential Geometry of Curves and Surfaces;
[2] W. Klingenberg: A course in Differential Geometry;
[3] J. R. Munkres: Analysis on Manifolds; Westview Press; 1997
[4] C. C. Pugh: Real Mathematical Analysis, Springer; 2010
[5] M. Spivak: A Comprehensive Introduction to Differential Geometry-Vol. I; Publish or Perish, Boston; 1970
[6] M. Spivak: Calculus on Manifolds; Westview Press; 1971
[7] V.A. Zorich: Mathematical Analysis-I; Springer; 2008

SEMESTER 3

MTD 3 C 12: COMPLEX ANALYSIS
No. of Credits: 4
No. of hours of Lectures/week: 5

Course Outcome: Upon the successful completion of the course students will:

- Learn the concept of (complex) differentiation and integration of functions defined on the complex plane and their properties.
- Be thorough in power series representation of analytic functions, different versions of Cauchy's Theorem.
- Get an idea of singularities of analytic functions and their classifications.
- Learn different version of maximum modulus theorem.

TEXT : JOHN B. CONWAY, FUNCTIONS OF ONE COMPLEX VARIABLE(2nd Edn.); Springer International Student Edition; 1992

Module 1

The extended plane and its spherical representation, Power series, Analytic functions, Analytic functions as mappings, Mobius transformations, Riemann-Stieltijes integrals [Chapt. I Section 6;,Chapt. III Sections 1, 2 and 3; Chapter IV Section 1]

Module 2

Power series representation of analytic functions, Zeros of an analytic function, The index of a closed curve, Cauchy's Theorem and Integral Formula, The homotopic version of Cauchys Theorem and simple connectivity[Chapt .IV Secttions 2-6]

Module 3

Counting zeros; the Open Mapping Theorem and Goursats Theorem. The classification of singularities, Residues, The Argument Principle and The Maximum Principle, Schwarz's Lemma.[Chapt. IV Sections 7, 8 Chapt. V; Chapter VI Sections 1, 2.]

References

[1] H. Cartan: Elementary Theory of analytic functions of one or several variables; Addison - Wesley Pub. Co.; 1973.
[2] T.W. Gamelin: Complex Analysis; Springer-Verlag, NY Inc.; 2001.
[3] T.O. Moore and E.H. Hadlock: Complex Analysis, Series in Pure Mathematics Vol. 9; World Scientific; 1991.
[4] L. Pennisi: Elements of Complex Variables(2nd Edn.); Holf, Rinehart & Winston; 1976.
[5] R. Remmert: Theory of Complex Functions; UTM , Springer-Verlag, NY; 1991.
[6] W. Rudin: Real and Complex Analysis(3rd Edn.); Mc Graw - Hill International Editions; 1987.
[7] H. Sliverman: Complex Variables; Houghton Mifflin Co. Boston; 1975.

SEMESTER 3

MTD 3 C 13: FUNCTIONAL ANALYSIS
No. of Credits: 4
No. of hours of Lectures/week: 5

Course Outcome: Upon the successful completion of the course students will:

- Learn the concept of normed linear spaces and various properties of operators defined on them.

TEXT : B.V.LIMAYE, FUNCTIONAL ANALYSIS(2nd Edn.), New Age International Ltd Publishers, New Delhi, 1996.

Module 1

Metric Spaces and Continuous Functions, Lebesgue Measure and Integration; Normed Spaces Continuity of Linear Maps [Chapter I: Section 3(3.1 to 3.4, 3.11 to 3.13(without proof), Section 4(4.5 to 4.7, 4.8 to 4.11(without proof); Chapter II: Section 5,6 from the text]

Module 2

Hahn -Banach Theorems, Hahn -Banach Theorems, Banach Spaces.[Chapter II: Sections 7(7.1 to 7.12. omit proof of 7.12), section 8; from the text]

Module 3

Closed Graph and Open Mapping Theorems, Bounded Inverse Theorem [Chapter III: Chapter III: section 9(upto and including 9.3) Section 10, Section 11(upto and including 11.3) from the Text]

References

[1] G. Bachman and L. Narici: Functional Analysis; Academic Press, NY; 1970.
[2] J. B. Conway: Functional Analysis; Narosa Pub House, New Delhi; 1978.
[3] J. Dieudonne: Foundations of Modern analysis; Academic Press; 1969.
[4] W. Dunford and J. Schwartz: Linear Operators - Part 1: General Theory; John Wiley & Sons; 1958
[5] Kolmogorov and S.V. Fomin: Elements of the Theory of Functions and Functional Analysis (English translation); Graylock Press, Rochaster NY; 1972
[6] E. Kreyszig: Introductory Functional Analysis with applications; John Wiley & Sons; 1978
[7] F. Riesz and B. Nagy: Functional analysis; Frederick Unger NY; 1955
[8] W. Rudin: Functional Analysis; TMH edition; 1978
[9] W. Rudin: Real and Complex Analysis(3rd Edn.); McGraw-Hill; 1987

SEMESTER 3

MTD 3 C 14: SAMPLING THEORY AND DESIGN & ANALYSIS OF EXPERIMENTS

No. of Credits: 3
No. of hours of Lectures/week : 5

Course outcome: At the end of the course the students will be able to

- Understand concept and usefulness of sampling.
- Understand different methods of sample selection.
- Understand Basic Principles of design and analysis of experiments
- Develop the ability to apply different designs in real situations.

TEXT 1 Singh, D and Chowdhary, F.S. (1999): Theory and Analysis of Sample Survey Designs, Wiley Eastern (New Age International), New Delhi.

TEXT 2 Douglas C. Montgomery, Design and Analysis of Experiments, 9h Edition, John Whiley and Sons, 2017.

Module 1: Sampling Theory

(Based on Text Book 1)
probability sampling and non probability sampling, sampling and non sampling errors, bias, variance and MSE , simple random sampling with and without replacement - estimation of population mean, total and proportions, estimation of sample size - Properties of the estimators, variance and standard error of the estimators, confidence intervals determination of the sample size. Stratified random sampling, estimation of the population mean, total and proportion, properties of estimators, various methods of allocation of a sample, comparison of the precisions of estimators under proportional allocation, optimum allocation and SRS. Systematic sampling – Linear and Circular, estimation of the mean and its variance, intraclass correlation coefficient , comparison of systematic sampling, SRS and stratified random sampling for a population with a linear trend.

Module 2: Basics of Experimental Design

(Based on Text Book 2)
Basic Principles of Experimental design, Strategy of Experimentation - Applications of Experimental Design – Basic Principles – Guidelines for designing experiments, Basic Designs: Completely Randomized Design (CRD), Randomized Block Design (RBD) and Latin Square Design (LSD) – Analysis ,

Module 3: Analysis of Covariance and Factorial Designs

(Based on Text Book 2
Analysis of Co-variance , Multiple Comparisons – Multiple Range Tests - Analysis of Covariance , Factorial experiments ,Factorial experiments – 2^2, 2^3 and 3^2, 3^3 experiments and their analysis - Fractional replication in Factorial Experiments.

Reference

[1] Cochran W.G (1992): Sampling Techniques, Wiley Eastern, New York.
[2] M.N. Murthy (1977) Sampling Theory and Methods, Statistical Publishing Society, 4).
[3] Sampath S. C. (2001) Sampling Theory and Methods, Alpha Science International Ltd., India
[4] Das M.N. and Giri N.C., Design and Analysis of Experiments, 3rd Edition, New Age International (P) Ltd 2017
[5] John Lawson, Design and Analysis of Experiments with R, 1st Edition, CRC Press, 2015.

3rd SEMESTER ELECTIVES-DETAILED SYLLABI

SEMESTER 3

MTD 3 E 01: INTRODUCTION TO ANALYTICS AND AI

No. of Credits: 3
No. of hours of Lectures/week : 5

Course outcome: At the end of the course the students will be able to

- Understand the role of analytics and AI in business
- Identify the transformation in banking industry with the development of AI and analytics
- Understand the AI and Analytics enabled Health care, life science, shopping and exponential technologies

Module 1

Analytics and AI Strategy for Business Transfer: Re-engineering Business to think AI and Analytics – Robust Data Monetization Strategy – Accelerated Decision-making with Real-Time Analytics – Analytics as a Service Model – Analytics-Led Enterprise Transformation.

Banking Industry Transformed by Analytics and AI: Redefining Banking Industry – AI powered Financial services – Fraud Mitigation through AI – Reorienting Customer Retention and Risk Management – Advantage of AI in Fintech Companies – AI-Driven Transformations in Insurance – Adopting Digital Based Insurance Model.

Module 2

Redefining Healthcare and Life Sciences: AI adoption in Healthcare – Real-world Evidence Based Analytics improving Treatment outcomes – Leveraging Patient and Drug similarity Analytics – AI : A Boon to the Life Science Industry – Analytics and Genomics.

Analytics and AI in Retail: AI-powered shopping experience – Emergence of Smart Consumers – Recommendation Engines for Personalizing Experiences – Evolution of Smart Retailers – Omnichannel Experiences – Fluid Supply Chain Transformation.

Module 3

Exponential Technologies underpinned by Analytics and AI: Beating Cyberattacks with Analytics – Connected Car Technology reshaping Automotive Industry – IoT Analytics – Cryptocurrency Analytics – Chatbots – Redefining the Talent Landscape.

References:

[1]. Sameer Dhanrajani, “AI and Analytics”, Wiley, 2018.

[2]. Stuart Russel and Peter Norvig, “Artificial Intelligence – A Modern Approach”, Pearson Education Press, 2011.

[3]. Kevin Knight, Elaine Rich, B. Nair, “Artificial Intelligence”, McGraw Hill, 2008.

[4]. George F. Luger, “Artificial Intelligence”, Pearson Education, 2001.

[5]. Nils J. Nilsson, “Artificial Intelligence: A new Synthesis”, Morgan Kaffman, 2002.

SEMESTER 3

MTD 3 E 02: MACHINE LEARNING ESSENTIALS

No. of Credits: 3
No. of hours of Lectures/week : 5

Course outcome: At the end of the course the students will:

- Have a strong foundation for machine learning
- Understand and learn the differences between supervised and unsupervised learning
- Learn the reinforcement learning

Module 1

Introduction: Machine Learning Foundations – Overview – Design of a Learning System – Types of Machine Learning – Supervised Learning and Unsupervised Learning – Mathematical Foundations of Machine Learning – Applications of Machine Learning.
Supervised Learning - I: Simple Linear Regression – Multiple Linear Regression – Polynomial Regression – Ridge Regression – Lasso Regression – Evaluating Regression Models – Model Selection – Bagging – Ensemble Methods.

Module 2

Supervised Learning - II: Classification – Logistic Regression – Decision Tree Regression and Classification – Random Forest Regression and Classification – Support Vector Machine Regression and Classification - Evaluating Classification Models
Unsupervised Learning: Clustering – K-Means Clustering – Density-Based Clustering – Dimensionality Reduction – Collaborative Filtering.

Module 3

Association Rule Learning and Reinforcement Learning: Association Rule Learning – Apriori – Eclat – Reinforcement Learning – Upper Confidence Bound – Thompson Sampling – Q-Learning.

References:

[1]. Christopher Bishop, “Pattern Recognition and Machine Learning” Springer, 2007.
[2]. Kevin P. Murphy, “Machine Learning: A Probabilistic Perspective”, MIT Press, 2012.
[3]. Ethem Alpaydin, “Introduction to Machine Learning”, MIT Press, Third Edition, 2014.
[4]. Tom Mitchell, "Machine Learning", McGraw-Hill, 1997.
[5]. Stanford Lectures of Prof. Andrew Ng.
[6]. NPTEL Lectures of Prof. B.Ravindran.

SEMESTER 3

MTD 3 E 03: NATURAL LANGUAGE PROCESSING

No. of Credits: 3

No. of hours of Lectures/week: 5

Course Outcome: Upon the successful completion of the course students will:

- Identify the features and challenges of Indian languages
- Understand the morphology and parts of speech related processing of Indian languages
- Get an overview of the Probabilistic models for natural language processing

Module 1

Introduction: Overview - Origins and challenges of NLP- Theory of Language -Features of Indian Languages – Issues in Font –Models and Algorithms- NLP Applications.

MORPHOLOGY AND PARTS-OF-SPEECH: Phonology – Computational Phonology - Words and Morphemes – Segmentation – Categorization and Lemmatisation – Word Form Recognition – Valency - Agreement - Regular Expressions – Finite State Automata – Morphology- Morphological issues of Indian Languages – Transliteration.

Module 2

PROBABILISTIC MODELS: Probabilistic Models of Pronunciation and Spelling – Weighted Automata – N- Grams – Corpus Analysis – Smoothing – Entropy - Parts-of-Speech – Taggers – Rule based – Hidden Markov Models – Speech Recognition.

SYNTAX: Basic Concepts of Syntax – Parsing Techniques – General Grammar rules for Indian Languages – Context Free Grammar – Parsing with Context Free Grammars – Top Down Parser – Earley Algorithm – Features and Unification - Lexicalised and Probabilistic Parsing.

Module 3

SEMANTICS AND PRAGMATICS: Representing Meaning – Computational Representation – Meaning Structure of Language – Semantic Analysis – Lexical Semantics – WordNet – Pragmatics – Discourse – Reference Resolution – Text Coherence – Dialogue Conversational Agents.

References:

[1] Daniel Jurafskey and James H. Martin “Speech and Language Processing”, Prentice Hall, 2009.

[2] Christopher D.Manning and Hinrich Schutze, “Foundation of Statistical Natural Language Processing", MIT Press, 1999.

[3] Ronald Hausser, “Foundations of Computational Linguistics”, Springer-Verleg, 1999.

[4] James Allen, “Natural Language Understanding”, Benjamin/Cummings Publishing Co. 1995.

SEMESTER 4

MTD 4 C 15: MULTIVARIATE TECHNIQUES AND DATA SCIENCE
No. of Credits: 3
No. of hours of Lectures/week : 4

Course outcome: At the end of the course the students will be able to

- Understand concept and context of multivariate techniques
- Demonstrate the knowledge and skill of use of multivariate normal distribution.
- Develop the ability to perform multivariate analysis of classification, principal component, cluster and factor analysis.
- Understand the concept of Multi dimensional scaling, Structure Equation Models.

TEXT 1 Anderson T.W., An Introduction to Multivariate Statistical Analysis, John Wiley & sons, 3rd Edition, 2009.

TEXT 2 Everitt B, Hothorn T, 2011. An Introduction to Applied Multivariate Analysis with R, Springer.

Module: 1

MULTIVARIATE NORMAL DISTRIBUTION Introduction to Multivariate Normal Distribution, Probability Density function of Multivariate Normal Distribution, The Distribution of Linear Combinations of Normally Distributed Variates; Independence of Variates; . Conditional Distributions and Marginal Distributions, The Characteristic Function; Moments, Maximum Likelihood Estimators of Mean Vector and the Covariance Matrix , The Distribution of the Sample Mean Vector; Inference Concerning the Mean When the Covariance Matrix is Known, Correlation coefficient of Bivariate Sample, Partial Correlation Coefficient and Multple Correlation Coefficient (Text Book 1: 2.2, 2.3, 2.4, 2.5 , 2.6, 3.2 , 3.3, 4.2, 4.3, &4,4) (For the computations of multivariate techniques using R that involved in the module, Text Book 2can be used)

Module: 2

CLASSIFICATION The Problem of Classification, Standards of Good Classification, Procedures of Classifil:atiun into one of Two Populations with Known Probability Distributions, Classification into One of Two Known Multivariate Normal Populations, Classification into One of Two Multivariate Normal Populations When the Parameters are estimated, Probabilities of Misclassification, Classification into One of Several Populations, Classification into One of Several Multivariate Normal Populations, (Text Book 1: 6.2 , 6.3, 6.4, 6.5, 6.6, 6.7 & 6.8) (For the computations of multivariate techniques using R that involved in the module, Text Book 2can be used)

Module: 3

PRINCIPAL COMPONENTS AND FACTOR ANALYSIS Definition of Principal Components in the Population, Maximum Likelihood Estimators of the Principal Components and Their Variances, Computation of the Maximum Likelihood Estimates of the Principal Components.Factor Model, Maximum Likelihood Estimators for Random Orthogonal Factors, Estimation for Fixed Factors, Factor Interpretation and Transformation, Estimation of Factor Scores. Concept and Applications of – (Cluster Analysis, Multi dimensional scaling, Structure Equation Models) (Text Book 1 : 11.2, 11.3& 11.4, 14.2, 14.3, 14.4, 14.5, 14.6,) (For the computations of multivariate techniques using R that involved in the module, Text Book 2can be used)

References

[1] Richard A. Johnson and Dean W. Wichern, Applied Multivariate Statistical Analysis, Prentice hall India, 7th Edition, 2019.

[2] Daniel Zelterman, Applied Multivariate Statistics with R , Springer

[3] Joseph F. Hair, Jr., William C. Black, Barry J. Babin, Rolph E. Anderson and Ronald L. Tatham, Multivariate Data Analysis, 7th Edition, Pearson Education India, 2014.

SEMESTER 4

MTD 4 E 04: ALGEBRAIC GRAPH THEORY

No. of Credits: 3
No. of hours of Lectures/week : 5

TEXT : CHRIS GODSIL,GORDON ROYLE ALGEBRAIC GRAPH THEORY, Springer - Verlag, NY, 2001

Course Outcome: Upon the successful completion of the course students will:

- Understand that theory of permutation groups may be used to study the graphs.
- Acquire a knowledge of various family of graphs.
- Learn mappings between graphs homomorphisms, isomorphisms and automorphisms.
- Develop basic properties of transitive graphs.

Module 1

Graphs: Graphs, Subgraphs, Auotomorphisms, Homomorphisms, Circulant Graphs, Johnson Graphs, Line Graphs and Planar Graphs [Chapter 1: Sections 1.1 to 1.8 from the text]

Module 2

Groups: Permutation Groups, Counting, Asymmetric Graphs, Orbits on Pairs, Primitivity, Primitivity and Connectivity [Chapter 2: Sections 2.1 to 2.6 from the text]

Module 3

Transitive Graphs: Vertex Transitive Graphs, Edge Transitive Graphs, Edge Connectivity, Vertex Connectivity and Matching [Chapter 3: Sections 3.1 to 3.5 from the text]

References

[1] L.W. Beineke, R.J. Wilson and P.J. Cameron: Topics in Algebraic Graph Theory; Cambridge University Press; 2005
[2] N.L. Biggs and A.T. White: Permutation Groups and Combinatorial Structures; Cambridge University Press; 1979
[3] J.A. Bondy and U.S.R. Murthy: Graph Theory with Applications; Springer; 2008.

SEMESTER 4

MTD 4 E 05: ALGEBRAIC TOPOLOGY

No. of Credits: 3

No. of hours of Lectures/week : 5

Course Outcome: Upon the successful completion of the course students will:

- Learn how basic geometric structures may be studied by transforming them into algebraic questions.
- Learn that there can associate a group called fundamental group to every topological space.
- Learn to prove fundamental theorem of algebra by calculating the fundamental group of algebra..
- Learn that two objects that can be deformed into one another will have the same homology group.
- Learn Brouwer fixed point theorem and related results.

TEXT : FRED H. CROOM, BASIC CONCEPTS OF ALGEBRAIC TOPOLOGY, UTM, Springer - Verlag, NY, 1978.

Module I

Geometric Complexes and Polyhedra: Introduction. Examples, Geometric Complexes and Polyhedra, Orientation of geometric complexes; Simplicial Homology Groups: Chains, cycles, Boundaries and homology groups, Examples of homology groups, The structure of homology groups [Chapter 1: Sections 1.1 to 1.4; Chapter 2: Sections 2.1 to 2.3 from the text]

Module 2

Simplicial Homology Groups(Contd.): The Euler Poincare's Theorem, Pseudomanifolds and the homology groups of S n; Simplicial Approximation: Introduction, Simplicial approximation, Induced homomorphisms on the Homology groups, The Brouwer fixed point theorem and related results [Chapter 2: Sections 2.4, 2.5; Chapter 3: Sections 3.1 to 3.4 from the text]

Module 3

The Fundamental Group: Introduction, Homotopic Paths and the Fundamental Group, The Covering Homotopy Property for S 1 , Examples of Fundamental Groups [Chapter 4: Sections 4.1 to 4.4 from the text]

References

[1] Eilenberg S, Steenrod N.: Foundations of Algebraic Topology; Princeton Univ. Press; 1952 .
[2] S.T. Hu: Homology Theory; Holden-Day; 1965.
[3] Massey W.S.: Algebraic Topology: An Introduction; Springer Verlag NY; 1977.
[4] C.T.C. Wall: A Geometric Introduction to Topology; Addison-Wesley Pub. Co. Reading Mass; 1972.

SEMESTER 4

MTD 4 E 06: CRYPTOGRAPHY
No. of Credits: 3
No. of hours of Lectures/week : 5

Course Outcome: Upon the successful completion of the course students will:

- Understand the fundamentals of cryptography and cryptanalysis.
- Acquire a knowledge of Claude Shanon's ideas to cryptography, including the concepts of perfect secrecy and the use of information theory to cryptography.
- Learn to use substitution -permutation networks as a mathematical model to introduce many of the concepts of modern block cipher design and analysis including differential and linear cryptoanalysis.
- Familiarize different cryptographic hash functions and their application to the construction of message authentication codes.
-

TEXT : Douglas R. Stinson, Cryptography Theory and Practice, Chapman & Hall, 2nd Edition.

Module 1

Classical Cryptography: Some Simple Cryptosystems, Shift Cipher, Substitution Cipher, Affine Cipher, Vigenere Cipher, Hill Cipher, Permutation Cipher, Stream Ciphers. Cryptanalysis of the Affine, Substitution, Vigenere, Hill and LFSR Stream Cipher

Module 2

Shannons Theory:- Elementary Probability Theory, Perfect Secrecy, Entropy, Huffman Encodings, Properties of Entropy, Spurious Keys and Unicity Distance, Product Cryptosystem.

Module 3

Block Ciphers: Substitution Permutation Networks, Linear Cryptanalysis, Differential Cryptanalysis , Data Encryption Standard (DES), Advanced Encryption Standard (AES). Cryptographic Hash Functions: Hash Functions and Data integrity, Security of Hash Functions, iterated hash functionsMD5, SHA 1, Message Authentication Codes, Unconditionally Secure MAC s. [Chapter 1 : Section 1.1(1.1.1 to 1.1.7), Section 1.2 (1.2.1 to 1.2.5) ; Chapter 2 : Sections 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7 ; Chapter 3 : Sections 3.1, 3.2, 3.3(3.3.1 to 3.3.3), Sect.3.4, Sect. 3.5(3.5.1,3.5.2), Sect.3.6(3.6.1, 3.6.2); Chapter 4 : Sections 4.1, 4.2(4.2.1 to 4.2.3), Section 4.3 (4.3.1, 4.3.2), Section 4.4(4.4.1, 4.4.2), Section 4.5 (4.5.1, 4.5.2)]

References

[1] Jeffrey Hoffstein: Jill Pipher, Joseph H. Silverman, An Introduction to Mathematical Cryptography, Springer International Edition.
[2] H. Deffs& H. Knebl: Introduction to Cryptography, Springer Verlag, 2002.
[3] Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone: Handbook of Applied Cryptography, CRC Press, 1996.
[4] William Stallings: Cryptography and Network Security Principles and Practice, Third Edition, Prentice-hall India, 2003.

SEMESTER 4

MTD 4 E 07: MEASURE AND INTEGRATION

No. of Credits: 3

No. of hours of Lectures/week : 5

Course Outcome: Upon the successful completion of the course students will:

- Get an insight in modern theory of integration as a tool in advanced analysis and in statistics.
- Learn how to interact topolgy and measures.
- Understand the concept of regularity properties of measures.
- Understand the notion real measure, complex measure, total variation of complex measure and some powerful results in this area.

TEXT : WALTER RUDIN, REAL AND COMPLEX ANALYSIS(3rd Edn.), Mc.GrawHill International Edn., New Delhi, 1987.

Module 1

Abstract Integration: The concept of measurability, Simple Functions, Elementary Properties of measures, Arithmetic in $[0, \infty]$, Integration of positive functions, Integration of complex functions, The role played by sets of measure zero [Chapter 1: 1.8 to 1.41 from the text]

Module 2

Positive Borel Measures: Topological preliminaries(upto 2.13 - a quick review), The Riesz Representation Theorem, Regularity properties of Borel measures, Lebesgue measure, Continuity properties of measurable functions [Chapter 2: All sections(2.1 to 2.13 - a quick review)]

Module 3

Complex Measures: Total variation, Absolute continuity, Consequences of the Radon-Nikodym theorem, Bounded linear functionals on LP, The Riesz representation Theorem [Chapter 6 : All sections from the text]

References

[1] L. M. Graves: The theory of functions of a real variable; Tata McGraw-Hill Book Co.; 1978.
[2] Hewitt and K. Stromberg: Real and Abstract Analysis; Springer-Verlag GTM 25; 1975.
[3] M. H. Protter and C.B. Moray: A first course in Real Analysis; Springer-Verlag UTM; 1977.
[4] I. K. Rana: An Introduction to Measure and Integration; Narosa Publishing House, Delhi; 1997
[5] S. C. Saxena and S.M. Shah: Introduction to Real Variable Theory; Intext Educational Publishers, San Francisco; 1972.

SEMESTER 4

MTD 4 E 08: NUMERICAL METHODS

No. of Credits: 3

No. of hours of Lectures/week : 5

Course Outcome: Upon the successful completion of the course students will:

- Students should gain an understanding of common numerical methods.
- Students should know how to apply numerical methods to various mathematical problems.
- Students should have an improved ability to derive and program numerical methods.

Text Book: Kendall E. Atkinson, AN INTRODUCTION TO NUMERICAL ANALYSIS Second Edition JohnWiley&Sons,1988.

Module 1

Computer Representation of Numbers, Definitions and Sources of Error, Propagation of Errors, Errors in Summation, Stability in Numerical Analysis, The Bisection Method , Newton's Method, The Secant Method , Muller's Method, A General Theory for One-Point Iteration Methods , Aitken Extrapolation for Linearly Convergent Sequences, The Numerical Evaluation of Multiple Roots , Brent's Rootfinding Algorithm , Roots of Polynomials, Systems of Nonlinear Equations, Newton's Method for Nonlinear Systems.
[Sections:1.2 to 1.6, 2.1 to 2.11]

Module 2

The Trapezoidal Rule and Simpson's Rule , Newton-Cotes Integration Formulas , Gaussian Quadrature, Asymptotic Error Formulas and Their Applications, Automatic Numerical Integration ,Singular Integrals, Numerical Differentiation, Existence, Uniqueness, and Stability Theory, Euler's Method , Multistep Methods, The Midpoint Method, The Trapezoidal Method, A Low-Order Predictor-Corrector Algorithm, Derivation of Higher Order Multistep Methods, Convergence and Stability Theory for Multistep Methods, Stiff Differential Equations and the Method of Lines, Single-Step and Runge-Kutta Methods,Boundary Value Problems
[Sections : 5.1 to 5.7, 6.1 to 6.11]

Module 3

Gaussian Elimination, Pivoting and Scaling in Gaussian Elimination, Variants of Gaussian Elimination, Error Analysis, The Residual Correction Method, Iteration Methods, Error Prediction and Acceleration, The Numerical Solution of Poisson's Equation, The Conjugate Gradient Method, Eigenvalue Location, Error, and Stability Results, The Power Method , Orthogonal Transformations Using Householder Matrices, The Eigenvalues of a Symmetric Tridiagonal Matrix, The QR Method, The Calculation of Eigenvectors and Inverse Iteration, Least Squares Solution of Linear Systems.
[sections 8.1 to 8.9, 9.1 to 9.7]

References

[1] Brian Bradie, *A Friendly Introduction to Numerical Analysis*, Prentice Hall (2006), ISBN: 0-13-013054-0

[2] Richard L. Burden and J. Douglas Faires. *Numerical Analysis*. Brooks/Cole, Australia ; Pacific Grove, CA, 7th ed edition, 2001. ISBN 978-0-534-38216-2.

[3] E. Ward Cheney and David R. Kincaid. *Numerical Mathematics and Computing*. Cengage Learning, May 2012. ISBN 978-1-133-10371-4.

[4] Arieh Iserles. *A First Course in the Numerical Analysis of Differential Equations*. Cambridge University Press, January 1996. ISBN 978-0-521-55655-2.

[5] C. T. Kelley. *Iterative Methods for Linear and Nonlinear Equations*. SIAM, January 1995. ISBN 978-0-89871-352-7.

[6] Alfio Quarteroni, Riccardo Sacco, and Fausto Saleri. *Numerical Mathematics*. Springer, January 2017. ISBN 978-0-387-22750-4.

SEMESTER 4

MTD 4 E 09: OPERATIONS RESEARCH

No. of Credits: 3

No. of hours of Lectures/week: 5

Course Outcome: Upon the successful completion of the course students will:

- Learn how to formulate and solve problems as networks and graphs.
- learn how to develop linear programming (LP) models for shortest path, maximum flow, minimal spanning tree, critical path, minimum cost flow, and transshipment problems.
- Learn how to construct linear integer programming models and discuss the solution techniques.
- Learn how to solve the integer programming models using branch-and-bound method.

TEXT : K.V. MITAL; C. MOHAN., OPTIMIZATION METHODS IN OPERATIONS RESEARCH AND SYSTEMS ANALYSIS(3rd. Edn.), New Age International(P) Ltd., 1996.

Module 1

Convex Functions; Linear Programming [Chapter 2 : Sections 11 to 12 ; Chapter 3 : Sections 1 to 15, 17 from the text]

Module 2

Linear Programming (contd.); Transportation Problem [Chapter 3 : Sections 18 to 20, 22; Chapter 4 Sections 1 to 11, 13 from the text]

Module 3

Integer Programming; Sensitivity Analysis [Chapter 6 : Sections 1 to 9; Chapter 7 Sections 1 to 10 from the text] Flow and Potential in Networks; Theory of Games [Chapter 5 : Sections 1 to 4, 6 7; Chapter 12 : all Sections]

References

[1] R.L. Ackoff and M.W. Sasioni: Fundamentals of Operations Research; Wiley Eastern Ltd. New Delhi; 1991

[2] C.S. Beightler, D.T. Philiphs and D.J. Wilde: Foundations of optimization(2nd Edn.); Prentice Hall of India, Delhi; 1979

[3] G. Hadley: Linear Programming; Addison-Wesley Pub Co Reading, Mass; 1975

[4] G. Hadley: Non-linear and Dynamic Programming; Wiley Eastern Pub Co. Reading, Mass; 1964

[5] H.S. Kasana and K.D. Kumar: Introductory Operations Research-Theory and Applications; Springer-Verlag; 2003

[6] R. Panneerselvam: Operations Research; PHI, New Delhi(Fifth printing); 2004

[7] A. Ravindran, D.T. Philips and J.J. Solberg: Operations Research-Principles and Practices(2nd Edn.); John Wiley & Sons; 2000

[8] G. Strang: Linear Algebra and Its Applications(4th Edn.); Cengage Learning; 2006

[9] Hamdy A. Taha: Operations Research- An Introduction(4th Edn.); Macmillan Pub Co. Delhi; 1989

SEMESTER 4

MTD 4 E 10: PYTHON FOR DATA ANALYTICS

No. of Credits: 3
No. of hours of Lectures/week : 5

Course outcome: At the end of the course the students will be able to

- Understand the importance of Python as a tool for data analytics.
- Learn the basic concepts of Python.
- Understand the different functions available in Python for data analytics and visualization.

Module 1

Python Concepts and Data Structures: Interpreter – Program Execution – Statements – Expressions – Flow Controls – Functions – Numeric Data Types – Sequences – Strings – Tuples – Lists – Dictionaries.

OOP in Python: Class Definition – Constructors – Object Creation – Inheritance – Overloading – Text Files and Binary Files – Reading and Writing.

Module 2

Data Wrangling: Combining and Merging Data Sets – Reshaping and Pivoting – Data Transformation – String manipulations – Regular Expressions.

Data Aggregation and Group Operations: GroupBy Mechanics – Data Aggregation – GroupWise Operations – Transformations – Pivot Tables – Cross Tabulations – Date and Time data types.

Module 3

Unit – V: Visualization in Python: Matplotlib Package – Plotting Graph - Controlling Graphs – Adding Text – More Graph Types – Getting and Setting Values – Patches.

(Illustrations and analysis of real data using Python -programming is compulsory)

References:

[1]. Mark Lutz, “Programming Python”, O'Reilly Media, 4th edition, 2010.

[2]. Joel Grus, “Data Science from scratch”, O'Reilly, 2015.

[3]. Tim Hall and J-P Stacey, “Python for Absolute Beginners”, Apress, 1st edition, 2009.

[4]. Magnus Lie Hetland, “Beginning Python: From Novice to Professional”, Apress, Second Edition, 2005.

[5]. Shai Vaingast, “Beginning Python Visualization Crafting Visual Transformation Scripts”, Apress, 2nd edition, 2014.

[6]. Wes Mc Kinney, “Python for Data Analysis”, O'Reilly Media, 2012.

PYTHON FOR DATA ANALYTICS - LIST OF EXERCISES:

1. Editing and executing Programs involving Flow Controls.

2. Editing and executing Programs involving Functions.

3. Program in String Manipulations

4. Creating and manipulating a Tuple

5. Creating and manipulating a List

6. Creating and manipulating a Dictionary

7. Object Creation and Usage

8. Program involving Inheritance

9. Program involving Overloading

10. Reading and Writing with Text Files and Binary Files

11. Combining and Merging Data Sets

12. Program involving Regular Expressions

13. Data Aggregation and GroupWise Operations

SEMESTER 4

MTD 4 E 11: DATA VISUALIZATION

No. of Credits: 3

No. of hours of Lectures/week: 5

Course Outcome: Upon the successful completion of the course students will:

- Get an idea of representing complex data in various type of data sources
- Understand the methodologies related to visualization of data sets
- Learn to use data visualization tools

Module 1

Introduction: Definition – Methodology – Seven Stages of Data Visualization - Data Visualization Tools. Visualizing Data: Mapping Data onto Aesthetics – Visualizing Amounts - Visualizing Distributions: Histograms and Density Plots – Visualizing Propositions: – Visualizing Associations: Among Two or More Quantitative Variables – Visualizing Time Series and Other Functions of an Independent Variable – Trends – Visualizing Geospatial Data

Interactive Data visualization: Introduction to D3 - Fundamental Technology: The Web – HTML – DOM – CSS – JavaScript – SVG. D3 Setup – Generating Page Elements – Binding Data - Drawing with data – Scales: Domains and Ranges – Normalization – Creating a Scale – Scaling the Scatter Plot – Other Methods and Other Scales. Axes – Modernizing the Chart – Update the Data – Transition – Updates – Interactivity.

Module 2

D3 based reusable chart Library: Setup and Deployment – Generate Chart – Customize Chart: Additional Axis – Show Axis Label – Change Chart Type – Format Values – Size – Color – Padding – Tooltip. Use APIs: Load and Unload – Show and Hide – Focus – Transform – Groups – Grid – Regions – Flow – Revert – Toggle –Legend – Sub chart – Zoom – Resize. Customize Style. Building Real time and Live Updating animated graphs with C3.

Introduction to Tableau: Environment Setup – Navigation – File & Data Types. TA SOURCE: Custom Data View – Extracting Data – Fields Operations – Editing Meta Data – Data Joining – Data Blending. Worksheets.

Module 3

Charts in Tableau: Bar Chart – Line Chart – Pie Chart – Scatter Plot – Bubble Chart –Gantt Chart – Histograms - Waterfall Charts. Dashboard – Formatting – Forecasting – Trend Lines.

References:

[1] Ben Fry, “Visualizing Data: Exploring and Explaining Data with the Processing Environment”,O'Reilly, 1st Edition, 2008

[2] Scott Murray, “Interactive data visualization for the web: An Introduction to Designing with D3”, O'Reilly, 2nd Edition, 2017

[3] Joshua N. Milligan, “Learning Tableau 2019: Tools for Business Intelligence, data prep, and visual analytics”, Packt Publishing Limited, 2019.

[4] Claus O. Wilke, “Fundamentals of Data Visualization: A Primer on Making Informative and Compelling Figures”, O.Reilly, 2019.

SEMESTER 4

MTD 4 E 12 : DEEP LEARNING

No. of Credits: 3

No. of hours of Lectures/week: 5

Course Outcome: Upon the successful completion of the course students will:

- Understand the concepts of Artificial Neural Network
- Learn the CNN and RNN
- Develop an idea on Computer vision and related algorithms

Module 1

Artificial Neural Networks: The Neuron – Activation Function – Gradient Descent – Stochastic Gradient Descent – Back Propagation – Business Problem.

Convolutional Neural Networks: Convolution Operation – ReLU layer – Pooling – Flattening – Full Conversion Layer – Softmax and Cross-Entropy.

Module 2

Recurrent Neural Networks: RNN intuition – Tackling Vanishing Gradient Problem – Long Short-Term Memory – Building a RNN – Evaluating the RNN – Improving the RNN – Tuning the RNN.

Boltzmann Machines: Introduction to Boltzmann Machine – Energy-Based Models – Restricted Boltzmann Machine – Contrastive Divergence – Deep Belief Networks – Deep Boltzmann Machine.

Module 3

Computer Vision: Viola-Jones Algorithm – Haar-like Features – Integral Image – Training Classifiers – Adaptive Boosting – Cascading – Face Detection with Open CV.

References:

[1]. Ian Goodfellow, “Deep Learning”, MIT Press, 2017.

[2]. Josh Patterson, “Deep Learning: A Practitioner’s Approach”, PACKT, 2017.

[3]. Dipayan Dev, “Deep Learning with Hadoop”, PACKT, 2017.

[4]. Francois Challot, “Deep learning with Python”, Manning, 2017.

[5]. Hugo Larochelle’s Video Lectures.

DEEP LEARNING - LIST OF EXERCISES:

1. Setting up the Spyder IDE Environment and Executing a Python Program

2. Installing Keras, Tensorflow and Pytorch libraries and making use of them

3. Artificial Neural Networks

4. Convolutional Neural Networks

5. Image Transformations 6. Image Gradients and Edge Detection

7. Image Contours

8. Image Segmentation

9. Harris Corner Detection

10. Face Detection using Haar Cascades

11. Chatbot Creation

SEMESTER 4

MTD 4 E 13: FUNDAMENTALS OF BIG DATA

No. of Credits: 3

No. of hours of Lectures/week: 5

Course Outcome: Upon the successful completion of the course students will:

- Get an idea of bigdata management and analytics solutions
- Understand the advances of NoSQL/MongoDB over relational databases
- Learn to use bigdata analytic tools.

Module 1

Introduction to Big Data - definition and importance of Big Data – four dimensions of Big Data - volume, velocity, variety, veracity – importance of big data - structured data, unstructured data - - distributed computing and Big Data. Big Data management - operational databases - relational databases - on relational databases - NoSQL - key-value pair databases – document databases - columnar databases - graph databases - spatial databases.
Big Data analysis - basic analytics - operationalized analytics – modifying business intelligence products to handle Big Data - Big Data analytics examples - Analytics solutions - text analytics - exploring unstructured data - understanding text analytics - analysis and extraction techniques - the extracted information - text analytics tools for Big Data.

Module 2

NoSQL databases - types - Advantages over Relational Databases - MongoDB - introduction - MongoDB philosophy - the data model – designing the database - collections - documents - data types - the -id Field - indexes - viewing available databases and collections - opening a database - inserting data - querying for data - retrieving documents – aggregation commands - grouping results - conditional operators, removing elements from an array - atomic operations.
Hadoop - history - components - HDFS - MapReduce Basics – origins of MapReduce – map function - reduce function - putting them together - Hadoop common components - application development in Hadoop - Pig and Pig Latin - Load - Transform - Dump and Store - Hive – Jaql.

Module 3

Understanding MapReduce - key/value pairs - the Hadoop Java API for MapReduce - the Mapper class - the Reducer class - the Driver class - writing simple MapReduce programs - Hadoop-provided mapper and reducer implementations - Hadoop-specific data types. Implementing WordCount using streaming - analyzing a large dataset - summarizing the UFO data - summarizing the shape data - a relational view on data with Hive - creating a table for the UFO data – inserting the UFO data - redefining the table with the correct column separator - creating a table from an existing file - SQL views.

References:

[1]. Hurwitz, Alan Nugent, Fern Halper and Marcia Kaufman, Big Data for Dummies.

[2]. Eelco Plugge, Peter Membrey and Tim Hawkins, The Definitive Guide to MongoDB: The NOSQL Database for Cloud and Desktop Computing, 1st Edition, Apress.

[3]. Chris Elaton, Derk Deroos, Tom Deutsch, George Lapis and Pual Zikopoulos, Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data, 1st Edition, Garry Turkington, Hadoop Beginner's Guide, Packt Publishing Ltd.