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

UNIVERSITY OF CALICUT

Abstract

General & Academic - CCSS PG Regulations 2019 - Faculty of Science- Scheme and Syllabus of M.Sc Mathematics Programme w.e.f 2020 Admission onwards - Incorporating Outcome Based Education - Implemented - Subject to ratification of Academic Council - Orders Issued.

G & A - IV - J

U.O.No. 5310/2021/Admn Dated, Calicut University.P.O, 15.05.2021

Read:-1) U.O.No. 8952/2019/Admn Dated 06.07.2019
2) U.O.No. 1339/2020/Admn Dated 31.01.2020
3) Item no.2 in the minutes of the meeting of Board of Studies in Mathematics PG, Dated 09.04.2021
4) Remarks of the Dean, Faculty of Science, Dated 08.05.2021.
5) Orders of the Vice Chancellor in the file of even no, Dated 10.05.2021

ORDER

1. The scheme and syllabus of M.Sc Mathematics Programme under CCSS PG Regulations 2019 in the Teaching Department of the University, w.e.f 2019 admission onwards has been implemented, vide paper read (1) above, and the same has been modified, vide paper read (2) above.
2. The Board of Studies in Mathematics PG has resolved to incorpate Outcome Based Education (OBE) in the scheme and syllabus of M.Sc Mathematics Programme under Teaching Department of the University, in tune with the new CCSS PG Regulations 2019 with effect from 2020 Admission onwards, vide paper read (3) above.
3. The Dean, Faculty of Science, vide paper read (4) above, has approved to implement the scheme and syllabus of M.Sc Mathematics Programme (CCSS-PG-2019) incorporating Outcome Based Education (OBE), in the syllabus forwarded by Chairperson, Board of studies in Mathematics PG, in tune with the new CCSS PG Regulations 2019 with effect from 2020 Admission onwards.
4. Considering the urgency, the Vice Chancellor has accorded sanction to implement the scheme and syllabus of M.Sc Mathematics Programme incorporating Outcome Based Education (OBE), in tune with the new CCSS PG Regulations under Teaching Departments of the University with effect from 2020 Admission onwards, subject to ratification by the Academic Council.
5. Scheme and syllabus of M.Sc Mathematics Programme (CCSS) incorporating Outcome Based Education (OBE) is therefore implemented with effect from 2020 Admission onwards under Teaching Department of the University, subject to ratification by the Academic Council.
6. Orders are issued accordingly. U.O.No.1339/2020/Admn Dated 31.01.2020, is modified to this extend. (Syllabus appended)

Arsad M

Assistant Registrar

To

The Head, Department of Mathematics
Copy to: PS to VC/PA to PVC/ PA to Registrar/PA to CE/JCE I/JCE V/DoA/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(CCSS) PROGRAMME

EFFECTIVE FROM 2020 ADMISSION ONWARDS

PROGRAMME OUTCOME:

Upon completing the M. Sc degree in the field of Mathematics, students have/capable of:

- **A solid understanding of graduate level algebra, analysis and topology.**
- **Using their mathematical knowledge to analyze certain problems in day to day life .**
- **Identifying unsolved yet relevant problems in a specific field.**
- **Undertaking original research on a particular topic.**
- **Communicate mathematics accurately and effectively in both written and oral form.**
- **Conducting scholarly or professional activities in an ethical manner.**

	Semester 1
	Semester 2
M.Sc.(Mathematics)	**Semester 3**
	Semester 4

Minimum Credits required for a pass

Core courses (other than project/dissertation)	48
Elective Courses	16
Project/Dissertation	8
Total	72

M.Sc.(Mathematics) Semester 1 **Total credits: 18**

Sl. No.	Course code.	Title of the Course	Credits	Hours/ Week	Core/ Elective
1	MAT1C01	Algebra – I	4	4L+1T	Core
2	MAT1C02	Linear Algebra	4	4L+1T	Core
3	MAT1C03	Real Analysis – I	4	4L+1T	Core
4	MAT1C04	Discrete Mathematics	3	3L+1T	Core
5	MAT1C05	Number Theory	3	3L+1T	Core
6	MAT1A01	Ability Enhancement Course[a]	2		Audit Course

M.Sc. (Mathematics) Semester 2 **Total credits: 18**

Sl. No.	Course code	Title of the Course	Credits	Hours/ Week	Core/ Elective
1	MAT2C06	Algebra – II	3	3L+1T	Core
2	MAT2C07	Real Analysis – II	4	4L+1T	Core
3	MAT2C08	Ordinary Differential Equations	3	3L+1T	Core
4	MAT2C09	Topology	4	4L+1T	Core
5	MAT2C10	Multivariable Calculus and Geometry	4	4L+1T	Core
6		Professional Competency Course[a]	2		Audit Course

M.Sc. (Mathematics) Semester 3 **Total credits: 16**

Sl. No.	Course code	Title of the Course	Credits	Hours/ Week	Core/ Elective
1	MAT3C11	Complex Analysis	4	4L+1T	Core
2	MAT3C12	Functional Analysis	4	4L+1T	Core
3	MAT3C13	PDE and Integral Equations	4	4L+1T	Core
4		Elective 1	4	4L+1T	Elective

M.Sc. (Mathematics) Semester 4 **Total credits: 20**

Sl. No.	Course code	Title of the Course	Credits	Hours/ Week	Core/ Elective
1	MAT4C14	Dissertation	8	8	Core
2		Elective 2 [b]			Elective
3		Elective 3[b]			Elective
4		Elective 4[b]			Elective
5		Elective 5[b]			Elective

[a] Evaluation of these courses will be as per the latest PG regulations.
[b]Total credit for Electives 2, 3, 4 and 5 is 12.

List of Electives for 3^{rd} Semester

Sl. No.	Course code	Title of the Course	Credits	Hours/ Week
1	MAT3E01	Advanced Topology	4	4L+1T
2	MAT3E02	Commutative Algebra	4	4L+1T
3	MAT3E03	Computer Oriented Numerical Analysis	4	4L+1T
4	MAT3E04	Linear Programming and its Applications	4	4L+1T
5	MAT3E05	Representation Theory of finite Groups	4	4L+1T

List of Electives for 4^{th} Semester

Sl. No.	Course code	Title of the Course	Credits	Hours/ Week
1	MAT4E01	Advanced Complex Analysis	3	3L+1T
2	MAT4E02	Advanced Functional Analysis	4	4L+1T
3^c	MAT4E03	Advanced Topics in Measure and Integration	4	4L+1T
4	MAT4E04	Algebraic Graph Theory	3	3L+1T
5	MAT4E05	Algebraic Topology	3	3L+1T
6	MAT4E06	Cryptography	3	3L+1T
7	MAT4E07	Differential Geometry	4	4L+1T
8	MAT4E08	Graph Theory	2	2L+1T
9^c	MAT4E09	Measure and Integration	3	3L+1T
10^c	MAT4E10	Non-Linear Programming	2	2L+1T
11^c	MAT4E11	Operations Research	3	3L+1T
12	MAT4E12	Wavelet Theory	4	4L+1T

1. ^{c} **MAT4E03: Advanced Topics in Measure and Integration (4 Credits) and MAT4E09:Measure and Integration (3 credits) cannot be offered simultaneously**
2. ^{c} **MAT4E10: Non-Linear Programming (2 Credits) and MAT4E11: Operations Research 3 credits) cannot be offered simultaneously**

ABILITY ENHANCEMENT COURSE(AEC)

Successful fulfilment of any one of the following shall be considered as the completion of AEC. (i) Internship, (ii) Classroom 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.

Classroom seminar: One seminar of duration one hour based on topics in mathematics beyond the prescribed syllabus.

Publications: One paper published in conference proceedings/ Journals. A copy of the same shouldbe 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 depart-.

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.
3. Scientific Programming with Python.

Internal Assessment

For each course except audit courses, **20 marks** are internal- **Test: 8; Seminar: 5; Assignment/ Viva voce: 4; Attendance: 3.**

QUESTION PAPER PATTERN
(Except for Computer Oriented Numerical Analysis)

4-Credit Courses (Time: 3 Hours)

	Question type and Marks	Total No. of questions	No. of questions to be answered	Total Marks
Part A	Short answer type **2** marks each	**8** 2 questions from each Unit	Answer **all** questions	**16**
Part B	Paragraph type **4** marks each	**6** at least 1 question from each Unit	Answer **any 4** questions	**16**
Part C *****	Essay type **12** marks each	**4** 1 question from each Unit. Each question has two parts A and B, of 12 marks each	Answer **either A or B** of each of the 4 questions	**48**
			Total marks	**80**

3-Credit Courses (Time: 3 Hours)

	Question type and Marks	Total No. of questions	No. of questions to be answered	Total Marks
Part A	Short answer type **2** marks each	**6** 2 questions from each Unit	Answer **all** questions	**12**
Part B	Paragraph type **4** marks each	**8** at least 1 question from each Unit	Answer **any 5** questions	**20**
Part C *****	Essay type **16** marks each	**3** 1 question from each Unit. Each question has two partsA and B, of 16 marks each	Answer **either A or B** of each of the 3 questions	**48**
			Total marks	**80**

2-Credit Courses (Time: 1.5 Hours) ** *Notice that the Examination is of* **one and a half hours** *duration, but for* **80** *marks. So that a question of 4(8 or 24) marks in these papers must be equivalent to a question of 2(resp. 4 or 12) marks in a 3 hours-duration paper of 80 marks.*

	Question type and Marks	Total No. of questions	No. of questions to be answered	Total Marks
Part A	Short answer type **4** marks each	**4** 2 questions from each Unit	Answer **all** questions	**16**
Part B	Paragraph type **8** marks each	**3** at least 1 question from each Unit	Answer **any 2** questions	**16**
Part C *****	Essay type **24** marks each	**2** 1 question from each Unit. Each question has two partsA and B, of 24 marks each	Answer **either A or B** of each of the 2 questions	**48**
			Total marks	**80**

***** It is desirable to have two or more subquestions in each question

For Computer Oriented Numerical Analysis

The examination will have two parts, a written and a practical examination of one and half duration each.

For Written Examination:

The question paper is of **40 marks** and of **one and half hours** duration. The paper has two parts, Part A and Part B.

Part A is of 16 marks consisting of 4 short answer questions, one question from each unit and each question carries 4 marks. The questions are to be evenly distributed over the entire syllabus. Part A is Compulsory. Part B is of 24 marks and has 4 UNITS. In each UNIT, there will be two questions A and B, of which one is to be answered. Each question carries 6 marks.

For Practical Examination:

The practical examination, of **one and half hours** duration, will carry a maximum of **40 marks** of which 15 marks for Part A, 20 marks for part B and 5 marks for record.

A candidate appearing for the practical examination should submit his/her record to the examiners. The candidate is to choose two problems from part A and three problems from part B by lots. Let him/her do any one of the problems got selected from each section on a computer. The examiners have to give data to check the program and verify the result. A print out of the two programs along with the solutions as obtained from the computer should be submitted by the candidate to the examiners.These print outs are to be treated as the answer sheets of the practical examination.

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:

The valuation shall be jointly done by the supervisor of the project in the department and an External Expert from the approved panel, based on a well-defined scheme of valuation framed by them. The break-up for the valuation is given below.

Sl. No.	Particulars	Weightage (%)
1	Review of Literature and Formulation of the Research Problem/Objective	20
2	Methods and Description of the techniques used	15
3	Analysis and Discussion of results	30
4	Presentation of the report, organization, linguistics style, references etc.	15
5	Viva Voce examination based on the Project work/Dissertation	20
	Total	**100**

Detailed Syllabi

MAT1C01: ALGEBRA - I
No. of Credits: 4

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

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

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

Unit I

Direct products & finitely generated Abelian Groups; Plane Isometries (Omit the proof of theorem12.5); Factor Groups; Factor-Group Computations and Simple Groups

[Sections: 11; 12(Omit the proof of theorem 12.5); 14; 15]

Unit II

Group Action on a set; Applications of G-sets to counting; Field of quotients of an Integral Domain[Sections: 16; 17; 21]

Unit III

Rings of Polynomials; Factorization of polynomials over a field; Homomorphisms and factor rings; Prime and Maximal Ideals

[Sections: 22; 23; 26; 27]

Unit IV

Introduction to extension fields; Vector Spaces (Theorem 30.23 only); Algebraic extensions (omitProof of the Existence of an Algebraic Closure); Geometric constructions; Finite fields

[Sections: 29; 30(Theorem 30.23 only); 31(omit Proof of the Existence of an Algebraic Closure);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.

[5] **T.W. Hungerford**: Algebra; Springer Verlag GTM 73(4th Printing); 1987

[6] **N. Jacobson**: Basic Algebra-Vol. I; Hindustan Publishing Corporation(India), Delhi; 1991

[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

[10] **S. M. Ross**: Topics in Finite and Discrete Mathematics; Cambridge; 2000

[11] **J. Rotman**: An Introduction to the Theory of Groups(4th edn.); Springer, 1999.

MAT1C02: LINEAR ALGEBRA
No. of Credits: 4

TEXT: HOFFMAN K. and KUNZE R., LINEAR ALGEBRA(2nd Edn.), Prentice-Hall of India, 1991.

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

Unit I

Vector Spaces; Linear Transformations
[Chapter 2: Sections 2.1 to 2.4; Chapter 3: Section 3.1]

Unit II

Linear Transformations (continued)
[Chapter 3: Sections 3.2 to 3.7]

Unit III

Linear Transformations (continued); Elementary Canonical Forms
[Chapter 6: Sections 6.1 to 6.4]

Unit IV

Elementary Canonical Forms (continued); Inner Product Spaces
[Chapter 6: Sections 6.6 to 6.7; Chapter 8: Sections 8.1, 8.2]

References

[1] **P. R. Halmos**: Finite Dimensional Vector spaces; Narosa Pub House, New Delhi; 1980

[2] **A. K. Hazra**: Matrix: Algebra, Calculus and generalised inverse- Part I; Cambridge InternationalScience 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] **S. Lang**: Linear Algebra; Addison Wesley Pub.Co.Reading, Mass; 1972

[6] **S. Maclane and G. Bikhrkhoff**: Algebra; Macmillan Pub Co NY; 1967

[7] **N. H. McCoy and R. Thomas**: Algebra; Allyn Bacon Inc NY; 1977

[8] **R. R. Stoll and E.T.Wong**: Linear Algebra; Academic Press International Edn; 1968

[9] **G. Strang**: Linear Algebra and Its Applications(4th edn.); Thomson Learning, Inc. 2006

MAT1C03: REAL ANALYSIS - I
No. of Credits: 4

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(3*rd* Edn.), Mc. Graw-Hill, 1986.

Unit I

Basic Topology - Metric Spaces, Compact Sets, Perfect Sets, Connected sets
[Chapter 2 (omit Finite, Countable and Uncountable sets)]

Unit II

Continuity - Limits of function, Continuous functions, Continuity and compactness, continuity and connectedness, Discontinuities, Monotonic functions, Infinite limits and Limits at Infinity.
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
[Chapter 4 & Chapter 5]

Unit III

The Riemann Stieltjes Integral, - Definition and Existence of the integral, properties of the integral, Integration and Differentiation, Integration of Vector valued- Functions, Rectifiable curves. Sequences and Series of Functions - Discussion of Main problem, Uniform convergence[Chapter 6 & Chapter 7: 7.1 to 7.10]

Unit IV

Sequences and Series of Functions - Uniform convergence and continuity, Uniform convergence and Integration, Uniform convergence and differentiation, Equicontinuous Families of Functions, The Stone-Weiestrass Theorem[Chapter 7: 7.11 to 7.33]

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 and D.R. Sherbert**: Introduction to Real Analysis; John Wiley Bros; 1982

[4] **J. V. Deshpande**: Mathematical Analysis and Applications- an Introduction; Alpha Science International; 2004

[5] **V. Ganapathy Iyer**: Mathematical analysis; Tata McGrawHill; 2003

[6] **R. A. Gordon**: Real Analysis- a first course(2nd Edn.); Pearson; 2009

[7] **A. N. Kolmogorov and S. V. Fomin**: Introductory Real Analysis; Dover Publications Inc;1998

[8] **S. Lang**: Under Graduate Analysis(2nd Edn.);Springer-Verlag; 1997

[9] **C. C. Pugh**: Real Mathematical Analysis, Springer; 2010

[10] **K. A. Ross**: Elementary Analysis- The Theory of Calculus(2nd edn.); Springer; 2013

[11] **A. H. Smith and Jr. W.A. Albrecht**: Fundamental concepts of analysis; Prentice Hall ofIndia; 1966

[12] **V. A. Zorich**: Mathematical Analysis-I; Springer; 2008

MAT1C04DISCRETE MATHEMATICS
No. of Credits: 3

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

- Understand the fundamentals of Graphs
- Learn the structure of graphs and familarize the basic concepts used to analyse different problems in different branches such as chemistry, computer science etc.
- Acquire a basic knowledge of formal languages, grammars and automata.
- Learn the equivalence of deterministic and non deterministic finite accepters.
- Learn the concepts of partial order relation and total order relation.
- Acquire a knowledge of Boolean algebras and Boolean function and understand how these concepts arise in certain real life problems.

TEXT:

1. **R. BALAKRISHNAN and K. RANGANATHAN, A TEXT BOOK OF GRAPHTHEORY, Springer-Verlag New York, Inc., 2000.**
2. **K. D JOSHI, FOUNDATIONS OF DISCRETE MATHEMATICS**, New Age International(P) Limited, New Delhi, 1989.
3. **PETER LINZ, AN INTRODUCTION TO FORMAL LANGUAGES AND AUTOMATA (2*nd* Edn.), Narosa Publishing House, New Delhi, 1997.**

Unit I

Graphs Basic concepts, sub graphs, Paths, Connectedness, Automorphisms, Connectivity, Trees, Eulerian graphs, Hamiltonian graphs, Planarity

[Chapter 1: Sections 1.0 to 1.4 (up to and including 1.4.10), 1.5 (up to and including 1.5.3); Chapter 3: Sections 3.1 (up to and including 3.1.10), 3.2 (up to and including 3.2.4); Chapter 4: Section 4.1 (up to and including 4.1.7); Chapter 6: Sections 6.1 (up to and including 6.1.2), 6.2 (up to and including 6.2.4); Chapter 8 sections 8.1 (up to and including 8.1.7), 8.2 (up to and including 8.2.5), 8.3 from Text 1]

Unit II

Sets with Additional Structures: Order Relations; Boolean Algebras: Definition and Properties, Boolean functions

[Chapter 3: Section 3 (upto and including 3.11); Chapter 4: Sections 4.1 and 4.2 from text 2]

Unit III

Automata and Formal languages Languages, Grammars, Automata, Applications, DFA, NDFA, Equivalence of DFA & NDFA

[Chapters 1 sections 1.2 and 1.3; chapter 2 sections 2.1, 2.2 and 2.3 from Text 3]

References

[1] **J. C. Abbot**: Sets, lattices and Boolean Algebras; Allyn and Bacon, Boston; 1969

[2] **J. A. Bondy, U.S.R. Murty**: Graph Theory; Springer; 2000

[3] **Colman and Busby**: Discrete Mathematical Structures; Prentice Hall of India; 1985

[4] **R. Diestel**: Graph Theory(4th Edn.); Springer-Verlag; 2010

[5] **S. R. Givant and P. Halmos**: Introduction to boolean algebras; Springer; 2009

[6] **F. Harary**: Graph Theory; Narosa Pub. House, New Delhi; 1992

[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] **D. B. West**: Introduction to graph theory; Prentice Hall; 2000

MAT1C05: NUMBER THEORY
No. of Credits: 3

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. and
- 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.**
2. **KOBLITZ NEAL, A COURSE IN NUMBER THEROY AND CRYPTOGRAPHY, Springer-Verlag, NewYork, Inc. 1994.**

Unit I

Arithmetical functions and Dirichlet multiplication; Quadratic residues and quadratic reciprocity law

[Chapter 2 sections 2.1 to 2.14, 2.18, 2.19; Chapter 9 sections 9.1 to 9.8 of Text 1]

Unit II

Averages of arithmetical functions; Some elementary theorems on the distribution of prime numbers[Chapter 3 sections 3.1 to 3.4, 3.9 to 3.12; Chapter 4 Sections 4.1 to 4.10 of Text 1]

[Chapter 3 sections 3.1 to 3.4, 3.9 to 3.12; Chapter 4 Sections 4.1 to 4.10 of Text 1]

Unit III

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 InternationalEdn; 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 DekkerInc.; 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 PubCo.; 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; 1999

[11] **J. Stopple**: A Primer of Analytic Number Theory-From Pythagorus to Riemann; CambridgeUniv Press; 2003

[12] **S.Y. Yan**: Number Theroy for Computing(2nd Edn.); Springer-Verlag; 2002

SEMESTER 2

MAT2C06: ALGEBRA - II
No. of Credits: 3

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

- Be able to apply Sylow's theorem effectively in various contexts.
- Learn automorphisms of fields.
- Get a basic knowledge in Galois Theory.
- Learn how to apply Galois Theory in various contexts.

TEXT: JOHN B. FRALEIGH, A FIRST COURSE IN ABSTRACT ALGEBRA(7^{th} Edn.), Pearson Education Inc., 2003.

Unit I

Isomorphism Theorems; Series of groups(Omit the subsection 'The Schreier Theorem'); Sylow Theorems; Applications of Sylow Theorems; Free groups

[Sections: 34; 35(Omit the subsection 'The Schreier Theorem'); 36; 37; 39]

Unit II

Automorphisms of fields; The Isomorphism Extension Theorem; Splitting fields; Separable extensions

[Sections: 48; 49; 50; 51]

Unit III

Galois Theory; Illustrations of Galois theory. Cyclotomic extensions, Insolvability of the Quintic

[Sections: 53; 54; 55; 56]

References

[1] **N. Bourbaki**: Elements of Mathematics: Algebra I, Springer; 1998

[2] **Dummit and Foote**: Abstract algebra(3rd edn.); Wiley India; 2011

[3] **M.H. Fenrick**: Introduction to the Galois correspondence(2nd edn.); Birkhuser; 1998

[4] **P.A. Grillet**: Abstract algebra(2nd edn.); Springer; 2007

[5] **I.N. Herstein**: Topics in Algebra(2nd Edn); John Wiley & Sons, 2006.

[6] **T.W. Hungerford**: Algebra; Springer Verlag GTM 73(4th Printing); 1987

[7] **C. Lanski**: Concepts in Abstract Algebra; American Mathematical Society; 2010

[8] **R. Lidl and G. Pilz:** Applied abstract algebra(2nd edn.); Springer; 1998

[9] **N.H. Mc Coy**: Introduction to modern algebra, Literary Licensing, LLC; 2012

[10] **J. Rotman**: An Introduction to the Theory of Groups(4th edn.); Springer; 1999

[11] **I. Stewart**: Galois theory(3rd edn.); Chapman & Hall/CRC; 2003

MAT2C07: REAL ANALYSIS - II
No. of Credits: 4

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

- Learn why and for what the theory of measure was introduced
- Learn the concept of measures and measurable functions
- Learn Lebesgue integration and its various properties
- Learn how to generalize the concept of measure theory.
- Learn that a measure may take negative values.

TEXT: H.L. ROYDEN, REAL ANALYSIS (3rd Edn.), Prentice Hall of India, 2000.

Unit I

Algebras of Sets; Lebesgue Measure – Introduction, Outer measure, Measurable sets and Lebesgue measure, A non- measurable set, Measurable functions, Littlewood's three principles

[Chapter 1: Section 4; Chapter 3: Sections 1, 2, 3, 4, 5, 6]

Unit II

The Lebesgue Integral – The Riemann integral, The Lebesgue integral of a bounded function overa set of finite measure, The integral of a nonnegative function, The general Lebesgue integral

[Chapter 4: Sections 1, 2, 3, 4]

Unit III

Differentiation and Integration – Differentiation of monotone functions, Functions of bounded variation, Differentiation of an integral, Absolute continuity

[Chapter 5: Sections 1, 2, 3, 4]

Unit IV

General Measure and Integration theory: Measure and Integration – Measure spaces, Measurable functions, Integration, General convergence theorems, Signed measures, The Radon-Nikodym theorem; Measure and Outer Measure – Outer measure and measurability, The extension theorem,
Product measures

[Chapter 11: Sections 1, 2, 3, 4, 5, 6; Chapter 12: Sections 1, 2, 3, 4]

References

[1] **G. De Barra**: Measure theory and Integration(2nd Edn); Woodhead Publishing; 2003

[2] **L.M. Graves**: The theory of functions of a real variable; Tata McGraw-Hill Book Co.; 1978

[3] **P. R. Halmos**: Measure Theory; Springer-Verlag; 1950

[4] **Hewitt and K. Stromberg**: Real and Abstract Analysis; Springer-Verlag GTM 25; 1975

[5] **M.H. Protter and C.B. Moray**: A first course in Real Analysis; Springer-Verlag UTM; 1977

[6] **I.K. Rana**: An Introduction to Measure and Integration; Narosa Publishing House, Delhi; 1997

[7] **W. Rudin**: Real and complex analysis(3rd Edn.); McGraw-Hill; 1987

MAT2C08: ORDINARY DIFFERENTIAL EQUATIONS
No. of Credits: 3

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, Frobeniious method etc.
- Learn method of solving system of first order differential calculus equations.
- Get an idea of how to analyze the behavior of solutions such as stability, asymptotic stability etc.
- Get a basic knowledge of Calculus of variation.

TEXT: SIMMONS, G.F., DIFFERENTIAL EQUATIONS WITH APPLICATIONSAND HISTORICAL NOTES, New Delhi, 1974.

Unit I

The Existence and Uniqueness of Solutions; Second order linear equations(a quick review); PowerSeries Solutions and Special functions

[Chapter 11: Sections 55, 56, 57; (Chapter 3: Sections 14 to 19 -a quick review); Chapter 5: Sections 26, 27, 28, 29]

Unit II

Power Series Solutions and Special functions (continued); Some special functions of MathematicalPhysics; The Calculus of Variations; The Existence and Uniqueness of Solutions

[Chapter 5: Sections 30, 31 (omit appendices A, B, C, D, E); Chapter 6: Sections 32, 33, 34, 35 (omit appendices A, B, C); Chapter 9: Sections 47, 48, 49 (omit appendices A, B)]

Unit III

Systems of First Order Equations; Non linear Equations

[Chapter 7 : Sections 37, 38; Chapter 8 : Sections 40, 41, 42, 43, 44]

References

[1] **G. Birkhoff and G.C. Rota**: Ordinary Differential Equations(3rd Edn.); Edn. Wiley & Sons;1978

[2] **W.E. Boyce and R.C. Diprima**: Elementary Differential Equations and boundary value prob-lems(2nd Edn.); John Wiley & Sons, NY; 1969

[3] **A. Chakrabarti**: Elements of Ordinary Differential Equations and special functions; Wiley East-ern Ltd., New Delhi; 1990

[4] **E.A. Coddington**: An Introduction to Ordinary Differential Equtions; Printice Hall of India, New Delhi; 1974

[5] **R.Courant and D. Hilbert**: Methods of Mathematical Physics- vol I; Wiley Eastern Reprint;1975

[6] **P. Hartman**: Ordinary Differential Equations; John Wiley & Sons; 1964

[7] **L.S. Pontriyagin** : A course in Ordinary Differential Equations Hindustan Pub. Corporation, Delhi; 1967

[8] **I. Sneddon**: Elements of Partial Differential Equations; McGraw-Hill International Edn.; 1957

MAT2C09: TOPOLOGY
No. of Credits: 4

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 sets 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.

Unit I

Definition of a Topological Space, Examples of Topological Spaces; Bases and Subbases, Subspaces[Chapter 4 from the text]

Unit II

Closed Sets and Closure, Neighborhoods, Interior and Accumulation Points, Continuity and Related Concepts
[Chapter 5: Sections 1,2,3 from the text]

Unit III

Making Functions Continuous, Quotient Spaces, Smallness Conditions on a Space, Connectedness[Chapter 5: Section 4; Chapter 6: Sections 1, 2 from the text]

Unit IV

Hierarchy of Separation Axioms, Cartesian Products of families of sets, The Product Topology
[Chapter 7: Section 1; Chapter 8: Sections 1, 2 from the text]

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 InternationalStudent Edn.; 1963

[6] **S. Willard**: General Topology; Addison Wesley Pub Co., Reading Mass; 1976

MAT2C10: MULTIVARIABLE CALCULUS AND GEOMETRY
No. of Credits: 4

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 in space.
- Get a deep knowledge of 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.**
2. **ANDREW PRESSLEY, ELEMENTARY DIFFERENTIAL GEOMETRY(2nd Edn.), Springer-Verlag, 2010.**

Unit I

Functions of Several Variable: Linear Transformations, Differentiation, The Contraction Principle, The Inverse Function Theorem, The Implicit Function Theorem

[Chapter 9: Sections 1-29 from text 1]

Unit II

Curves in the plane and in space: What is a Curve?, Arc Length, Reparametrization, Closed curves, Level Curves versus parametrized curves; How much does a curve curve?: Curvature, Plane curves, Space Curves

[Chapter 1: Sections 1-5; Chapter 2: Sections 1-3 from text 2]

Unit III

Surfaces in three dimension: What is a surface?, Smooth surfaces, Smooth maps, Tangents and derivatives, Normals and orientability; Level surfaces, Ruled surfaces and surfaces of revolution, Applications of the inverse function theorem; Lengths of curves on surfaces, Equiareal maps and a theoremof Archimedes

[Chapter 4: Section 1-5; Chapter 5: Sections 1, 3 and 6; Chapter 6: Section 1 and 4(upto and including 6.4.2) from text 2]

Unit IV

Curvature of surfaces: The Second Fundamental form, The Gauss and Weingarten maps, Normaland geodesic curvatures; Gaussian, mean and Principal curvatures: Gaussian and mean curvatures, Principal curvatures of a surface

[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] **K. Tapp**: Differential Geometry of Curves and Surfaces; Undergraduate Texts in Mathematics, Springer; 2016

[8] **V.A. Zorich**: Mathematical Analysis-I; Springer; 2008

SEMESTER 2 (PCC)

MAT2A02: TECHNICAL WRITING WITH LaTeX (PCC)
No. of Credits: 2

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 LaTeX Companion. Addison-Wesley, Reading, MA, second edition, 2000.

[9] **M. Goossens and S. Rahtz**: The LaTeX Web Companion: Integrating TEX, HTML, and XML. Addison-Wesley Series on Tools and Techniques for Computer Typesetting. Addison-Wesley, Reading, MA, 1999.

[10] **M. Goossens, S. Rahtz, and F. Mittelbach**: The LaTeXGraphics Companion: Illustrating Documents with TeX and PostScript. Addison-Wesley Series on Tools and Techniques for Computer Typesetting.

[11] Addison-Wesley, New York, 1997

MAT2A03: SCIENTIFIC PROGRAMMING WITH SCILAB (PCC)

No. of Credits: 2

1. Installation of the software Scilab.
2. Basic syntax, Mathematical Operators, Predefined constants, Built in functions.
3. Complex numbers, Polynomials, Vectors, Matrix. Handling these data structures using built infunctions
4. 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 Franois 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, Apress, 2017

Semester 2(PCC)

MAT2A04: SCIENTIFIC PROGRAMMING WITH PYTHON(PCC)
No. of Credits: 2

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1. Literal Constants, Numbers, Strings, Variables, Identifier, Data types
2. Operators, Operator Precedence, Expressions
3. Control flow: If, while, for, break, continue statements
4. Functions: Defining a function, function parameters, local variables, default arguments, keywords, return statement, Doc-strings
5. Modules: using system modules, import statements, creating modules
6. Data Structures: Lists, tuples, sequences.
7. Writing a python script
8. Files: Input and output using file and pickle module
9. Exceptions: Errors, Try-except statement, raising exceptions, try-finally statement
10. Roots of Nonlinear Equations: Evaluation of Polynomials, Bisection method, Newton-Raphson Method, Complex roots by Bairstow method.
11. Direct Solution of Linear Equations: Solution by elimination, Gauss Elimination method, Gauss Elimination with Pivoting, Triangular Factorisation method
12. Iterative Solution of Linear Equations: Jacobi Iteration method, Gauss-Seidel method.
13. Curve Fitting-Interpolation: Lagrange Interpolation Polynomial, Newton Interpolation Polynomial, Divided Difference Table, Interpolation with Equidistant points.
14. Numerical Differentiation: Differentiating Continuous functions, Differentiating Tabulated functions.
15. Numerical Integration: Trapezoidal Rule, Simpsons 1/3 rule.
16. Numerical Solution of Ordinary Differential Equations: Eulers Method, Rung-Kutta (Order 4)
17. Eigenvalue problems: Polynomial Method, Power method.

References

[1] **Swaroop C H:**, A Byte of Python.

[2] **Amit Saha:** ,Doing Math with Python, No Starch Press, 2015.

[3] **SD Conte and Carl De Boor:** Elementary Numerical Analysis (An algorithmic approach) 3rd edition, McGraw-Hill, New Delhi

[4] **K. Sankara Rao:** Numerical Methods for Scientists and Engineers Prentice Hall of India, New Delhi.

[5] **Carl E Froberg:** Introduction to Numerical Analysis, Addison Wesley Pub Co, 2nd Edition

[6] **Knuth D.E.:** The Art of Computer Programming: Fundamental Algorithms(VolumeI), Addison Wesley, Narosa Publication, New Delhi.

[7] Python Programming, wikibooks contributors Programming Python, Mark Lutz,

[8] Python 3 Object Oriented Programming, Dusty Philips, PACKT Open source Publishing

[9] Python Programming Fundamentals, Kent D Lee, Springer

[10] Learning to Program Using Python, Cody Jackson, Kindle Edition

[11] Online reading http://pythonbooks.revolunet.com/

Semester 3

MAT3C11: COMPLEX ANALYSIS
No. of Credits: 4

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 versions of maximum modulus theorem.

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

Unit I

The extended plane and its spherical representation, Power series, Analytic functions, Analytic functions as mappings, Mobius transformations

[Chapt. I Section 6;,Chapt. III Sections 1, 2 and 3]

Unit II

Riemann-Stieltijes integrals, Power series representation of analytic functions, Zeros of an analytic function, The index of a closed curve

[Chapt. IV: Sections 1, 2, 3, 4]

Unit III

Cauchy's Theorem and Integral Formula, The homotopic version of Cauchy's Theorem and simple connectivity(Omit proof of third version of Cauchy's theorem), Counting zeros; the Open Mapping Theorem and Goursats Theorem

[Chapt. IV: Sections 5, 6(Omit proof of third version of Cauchy's theorem), 7 and 8]

Unit IV

The classification of singularities, Residues, The Argument Principle and The Maximum Principle[Chapt.V: Sections 1, 2 and 3; Chapt. VI: Sections 1 and 2]

References

[1] **L.V. Ahlfors**: Complex Analysis(3rd Edn.); Mc Graw Hill International Student Edition; 1979

[2] **H. Cartan**: Elementary Theory of analytic functions of one or several variables; Addison - WesleyPub. Co.; 1973

[3] **T.W. Gamelin**: Complex Analysis; Springer-Verlag, NY Inc.; 2001

[4] **T.O. Moore and E.H. Hadlock**: Complex Analysis, Series in Pure Mathematics-Vol. 9; WorldScientific; 1991

[5] **L. Pennisi**: Elements of Complex Variables(2nd Edn.); Holf, Rinehart & Winston; 1976

[6] **R. Remmert**: Theory of Complex Functions; UTM , Springer-Verlag, NY; 1991

[7] **W. Rudin**: Real and Complex Analysis(3rd Edn.); Mc Graw - Hill International Editions; 1987

[8] **H. Sliverman**: Complex Variables; Houghton Mifflin Co. Boston; 1975

MAT3C12: FUNCTIONAL ANALYSIS
No. of Credits: 4

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

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

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

Unit I

Metric Spaces and Continuous Functions, Lebesgue Measure and Integration; Normed Spaces [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 from the text]

Unit II

Continuity of Linear Maps, Hahn -Banach Theorems
[Chapter II: Section 6; Sections 7(upto and including 7.6) from the text]

Unit III

Hahn -Banach Theorems, Banach Spaces; Uniform Boundedness Principle
[Chapter II: Sections 7(7.7 to 7.12. omit proof of 7.12), section 8; Chapter III: section 9(upto andincluding 9.1) from the text]

Unit IV

Uniform Boundedness Principle(contd.), Closed Graph and Open Mapping Theorems, BoundedInverse Theorem
[Chapter III: Section 9(9.2 to 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

MAT3C13: PDE AND INTEGRAL EQUATIONS

No. of Credits:4

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

- Learn a technique to solve first order PDE and analyse the solution to get information about the parameters involved in the model.
- Learn explicit representations of solutions of three important classes of PDE Heat equations Laplace equation and wave equation for initial value problems.
- Get an idea about Integral equations
- Learn the relation between Integral and differential Equations

TEXT 1: AN INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATIONS, YEHUDA PINCHOVER AND JACOB RUBINSTEIN, Cambridge University Press

TEXT 2: HILDEBRAND, F.B., METHODS OF APPLIED MATHEMATICS (2nd Edn.), Prentice-Hall of India, New Delhi, 1972.

Unit I

First-order equations: Introduction, Quasilinear equations, The method of characteristics, Examples of the characteristics method, The existence and uniqueness theorem, The Lagrange method, Conservation laws and shock waves, The eikonal equation, General nonlinear equations, Exercises. [Chapter 2 from Text 1]

Unit II

Second-order linear equations in two indenpendent variables:, Classification, Canonical form of hyperbolic equations, Canonical form of parabolic equations, Canonical form of elliptic equations

The one-dimensional wave equation: Introduction, Canonical form and general solution, The Cauchy problem and d'Alemberts formula, Domain of dependence and region of influence, The Cauchy problem for the nonhomogeneous wave equation[Chapter 3 and 4 from Text 1]

Unit III

The method of separation of variables: Introduction, Heat equation: homogeneous boundary condition, Separation of variables for the wave equation, Separation of variables for nonhomogeneous equations, The energy method and uniqueness, Further applications of the heat equation.

Elliptic equations: Introduction, Basic properties of elliptic problems, The maximum principle, Ap- plications of the maximum principle, Greens identities, The maximum principle for the heat equation, Separation of variables for elliptic problems, Poissons formula.[Chapter 5 and 7 from Text 1]

Unit IV

Integral Equations: Introduction, Relations between differential and integral equations, The Green'sfunctions, Fredholom equations with separable kernels, Illustrative examples, Hilbert- Schmidt Theory, Iterative methods for solving Equations of the second kind. The Newmann Series, Fredholm Theory [Sections 3.1 3.3, 3.6 3.11 from the Text 2]

References

[1] **Amaranath T.**:Partial Differential Equations, Narosa, New Delhi, 1997.

[2] **A. Chakrabarti**: Elements of ordinary Differential Equations and special functions; Wiley Eastern Ltd, New Delhi; 1990

[3] **E.A. Coddington**: An Introduction to Ordinary Differential Equations Printice Hall of India, NewDelhi; 1974

[4] **R. Courant and D.Hilbert**: Methods of Mathematical Physics-Vol I; Wiley Eastern Reprint;1975

[5] **P. Hartman**: Ordinary Differential Equations; John Wiley & Sons; 1964

[6] **F. John**: Partial Differential Equations; Narosa Pub. House New Delhi; 1986

[7] **Phoolan Prasad Renuka Ravindran**: Partial Differential Equations; Wiley Eastern Ltd, NewDelhi; 1985

[8] **L.S. Pontriyagin**: A course in ordinary Differential Equations; Hindustan Pub. Corporation,Delhi; 1967

[9] **I. Sneddon**: Elements of Partial Differential Equations; McGraw-Hill International Edn.; 1957

MAT3E01: ADVANCED TOPOLOGY
No. of Credits: 4

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

- Learn separation axioms and know how the topology behaves if it satisfies different separation axioms.
- Understand the notion of various connectedness in topological spaces.
- Learn generalization of certain well-known results in analysis to topological spaces.
- Learn to form new topological spaces from a given collection of topological spaces.
- Learn the notion of nets and filters and how to use these concepts to prove certain results in an efficient way where the notion of sequence fails to apply.
- Understand that every metric space can be embedded as a dense subspace of a complete metric space.

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

Unit I

Separation Axioms: Compactness and Separation Axioms, The Urysohn Characterization of Normality, Tietze Characterisation of Normality

[Chapter 7: Sections 2, 3 & 4]

Unit II

Local Connectedness and paths, Products and Co products: Productive Properties, Countably Productive Properties

[Chapter 6: Section 3; Chapter 8: Sections 3 & 4(up to 4.4 only)]

Unit III

Nets and Filters: Definition and Convergence of Nets, Topology and Convergence of Nets, Filtersand their Convergence

[Chapter 10: Sections 1, 2 & 3]

Unit IV

Complete Metric spaces: Complete Metrics, Consequences of Completeness, Completions of aMetric

[Chapter 12: Sections 1, 2 & 4)

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 InternationalStudent Edn.; 1963

[6] **S. Willard**: General Topology; Addison Wesley Pub Co., Reading Mass; 1976.

MAT3E02: COMMUTATIVE ALGEBRA
No. of Credits: 4

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

- Learn basic properties of commutative rings, ideals and modules over commutative rings,
- Learn uniqueness theorem for a decomposable ideal.
- Learn integrally closed domain and valuation ring.
- Understand the basic theory of Noetherian and Artin Rings

TEXT : ATIYAH M.F. and MACDONALD I. G., INTRODUCTION TO COMMUTATIVE ALGEBRA, Addison Wesley, NY, 1969.

Unit I

Rings and Ideals; Modules
[Chapt, I; Chapt II (up to and including 'Operations on Submodules')]

Unit II

Modules; Rings and Modules of Fractions

[Chapter II (from 'Direct Sum and Product'); Chapt III]

Unit III

Primary Decomposition; Integral Dependence and Valuations
[Chapt. IV; Chapt. V]

Unit IV Chain Conditions; Noetherian Rings; Artin Rings [Chapt. VI; Chapt. VII; Chapt. VIII]

References

[1] **N. Bourbaki**: Commutative Algebra; Paris - Hermann; 1961

[2] **D. Burton**: A First Course in Rings and Ideals; Addison - Wesley; 1970

[3] **N. S. Gopalakrishnan**: Commutative Algebra; Oxonian Press; 1984

[4] **T.W. Hungerford**: Algebra; Springer Verlag GTM 73(4th Printing); 1987

[5] **D. G. Northcott**: Ideal Theory; Cambridge University Press; 1953

[6] **O. Zariski, P. Samuel**: Commutative Algebra- Vols. I & II; Van Nostrand, Princeton; 1960

MAT3E03: COMPUTER ORIENTED NUMERICAL ANALYSIS
No. of Credits: 4

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

- Learn C++ programming language.
- Be familiar with numerical solutions of algebraic equations, numerical integration and differentiation, numerical interpolation and approximation of functions.
- Implement programming techniques to solve numerical problems in C++ programming language.

TEXT:

1. **ROBERT LAFORE, OBJECT ORIENTED PROGRAMMING IN C++ (3rd Edn.),Galgotia Publications (Pvt. Ltd.), Ansari Road, New Delhi, 2007.**
2. **V. RAJARAMAN, COMPUTER ORIENTED NUMERICAL METHODS, Prentice Hall of India, New Delhi.**

THEORY

Unit I

The following chapters of Text 1 Chapter 2: C++ Programming Basics Chapter 3 : Loops andDecisions Chapter 4 : Structures

Unit II

The following chapters of Text 1

Chapter 5: Functions Chapter 6 : Objects and Classes (Sections: A Simple class, C++ Objects as Physical Objects, C++ Objects as data Types and Constructors Only) Chapter 7 : Arrays: (Sections: Array Fundamentals, Function Declared with array Arguments Only)

Unit III

The following chapters of Text 2

Algorithms, Solutions of Algebraic Equations and Interpolation

[Chapters 1, Chapter 3: Sections 3.1 to 3.5 and chapters 4 and 5]

Unit IV

The following chapters of Text 2

Differentiation, Integration and Solutions of Differential equations[Chapters 8: Sections 8.1 to 8.7 and Chapter 9: Sections 9.1 to 9.5]

PRACTICALS

The following programs in C++ have to be done on a computer and a record of algorithm, print out of the program and print out of solution as shown by the computer for each program should be maintained. These should be bound together and submitted to the examiners at the time of practicalexamination.

PROGRAMS

Part A

1. Lagrange Interpolation
2. Newton's Interpolation
3. Newton-Raphson Method
4. Bisection Method
5. Simpson's rule of Integration
6. Trapezoidal rule of integration

Part B

1. Euler's method

2. Runge-Kotta method of order 2
3. Runge - Kutta method of order 4
4. Gauss elimination with pivoting
5. Gauss - Seidal iteration

References

[1] **S.D. Conte and Carl De Boor**: Elementary Numerical Analysis-an Algorithmic Approach(3rdEdn.); Mc Graw Hill book company, New Delhi, 2007

[2] **K. Sankara Rao**: Numerical Methods for Scientists and Engineers; Prentice hall of India, NewDelhi, 2007

[3] **Carl E. Froberg**: Introduction to Numerical Analysis(2nd Edn.); Addison Wesley Pub. Co., 1974

[4] **A Ralston**: A First Course in Numerical Analysis; Mc Graw Hill Book Company, 1978

[5] **John H Mathews**: Numerical Methods for Mathematics, Science and Engg; Prentice Hall ofIndia, New Delhi, 1992

[6] **Kunthe D.E**: The Art of Computer Programming-VOL I: Fundamental Algorithms; AddisonWesley Narosa, New Delhi, 1997

[7] **Herbert Schildt**: C++: The Complete Reference(3rd Edn.); Mc Graw-Hill Pub. Co. Ltd., NewDelhi, 1982

[8] **Yashavant P. Kanetkar**: Let Us C++; BPB Publications, New Delhi, 2003

[9] **E. Balagurusami**: Object Oriented Programming with C++; Tata Mc. Graw - Hill PublishingCo. Ltd., New Delhi, 2013

[10] **Schaum Series**: Programming in C++; Tata Mc Graw-Hill Publishing Co. Ltd., New Delhi,2000

MAT3E04: LINEAR PROGRAMMING AND ITS APPLICATIONS
No. of Credits: 4

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

- Learn graphical method and the simplex algorithm for solving a linear programming problem.
- Learn more optimization techniques for solving the linear programming models-transportation problem and integer programming problem.
- Learn optimization techniques for solving some network related problems.
- Learn sensitivity analysis and parametric programming, which describes how various changes in the problem affect its solution.

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

(Pre requisites: A basic course in calculus and Linear Algebra)

Unit I

Convex Functions; Linear Programming
[Chapter 2: Sections 11, 12; Chapter 3: Sections 1 to 15(Omit proof of theorem 4 in section 7), 17 from the text]

Unit II

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

Unit III

Flow and Potential in Networks; Integer Programming
[Chapter 5: Sections 1 to 7; Chapter 6: Sections 1 to 9 from the text]

Unit IV

Additional Topics in Linear Programming
[Chapter 7: Sections 1 to 15 from the text]

References

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

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

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

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

[5] **S.S.Rao**: Optimization - Theory and applications(2nd Edn.), Wiley Eastern(P) Ltd, New Delhi;

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

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

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

MAT3E05: REPRESENTATION THEORY OF FINITE GROUPS
No. of Credits: 4

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

- Acquire the basics of classical representation theory of finite groups.
- Understand character theory and orthogonal relations.
- Acquire a knowledge of the theory of induced characters.

TEXT: WALTER LEDERMANN, INTRODUCTION TO GROUP CHARACTERS (2nd Edn.), Cambridge University Press, 1987

Unit I

Introduction, G-modules, Characters, Reducibility, Permutation Representations, Complete reducibility [Chapt. I: Section 1.1-1.6]

Unit II

Schur's lemma, The Commutant (endomorphism) algebra, Orthogonality relations, The GroupAlgebra, The Character Table

[Chapt. I: Section 1.7-1.8; Chapt. II: 2.1-2.3]

Unit III

Finite Abelian Groups, The Lifting Process, Linear Characters, Induced Representations, Reciprocity Law.

[Chapt. II: Section 2.4-2.6; Chapt. III: 3.1-3.2]

Unit IV

The Alternating Group A_5, Normal subgroups, Transitive groups, The symmetric group, Induced characters of S_n

[Chapt. III: Section 3.3-3.4; Chapt. IV: 4.1-4.3]

References

[1] **C. W. Kurtis and I. Reiner**: Representation Theory of Finite Groups and Associative Algebras. Hohn Wiley & Sons, New York; 1962

[2] **Faulton**: The Representation Theory of Finite Groups; Lecture Notes in Mathematics, No. 682; Springer; 1978

[3] **C. Musli**: Representations of Finite Groups; Hindustan Book Agency, New Delhi; 1993

[4] **I. Schur**: Theory of Group Characters; Academic Press, London; 1977

[5] **J. P. Serre**: Linear Representaion of Finite Groups; Graduate Text in Mathematics- Vol. 42;Springer; 1977

MAT4E01: ADVANCED COMPLEX ANALYSIS
No. of Credits: 3

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

- Get a deep knowledge about the space of continuous functions from an open set in the complex plane to a region of the complex plane.
- Learn a technique to extend the domain over which a complex analytic function is defined.
- Understand that there is a unique conformal map f of the unit disk onto a simply connected domain of the extended complex plane such that f(0) and arg f′(0) take given values
- Express some functions as infinite series or products.

TEXT: JOHN B. CONWAY, FUNCTIONS OF ONE COMPLEX VARIABLE(2nd Edn.), Springer International Student Edition, 1973.

Unit I

The Space of continuous functions $C(G, \Omega)$, Spaces of Analytic functions, Spaces of meromorphic functions

[Chapt. VII: Sections 1, 2, and 3]

Unit II

The Riemann Mapping theorem, Weierstrass Factorization Theorem and Factorization of the sinefunction

[Chapt. VII: Sections 4, 5 and 6]

Unit III

Runge's Theroem, Simple connectedness and Mittag-Leffler's Theorem

[Chapt. VIII: Section 1, 2 and 3]

References

[1] **L.V. Ahlfors**: Complex Analysis(3rd Edn.); Mc Graw Hill International Student Edition; 1979

[2] **H. Cartan**: Elementary Theory of analytic functions of one or several variables; Addison - WesleyPub. Co.; 1973

[3] **T.W. Gamelin**: Complex Analysis; Springer-Verlag, NY Inc.; 2001

[4] **T.O. Moore and E.H. Hadlock**: Complex Analysis, Series in Pure Mathematics-Vol. 9; WorldScientific; 1991

[5] **L. Pennisi**: Elements of Complex Variables(2nd Edn.); Holf, Rinehart & Winston; 1976

[6] **R. Remmert**: Theory of Complex Functions; UTM , Springer-Verlag, NY; 1991

[7] **W. Rudin**: Real and Complex Analysis(3rd Edn.); Mc Graw - Hill International Editions: 1987

[8] **H. Sliverman**: Complex Variables; Houghton Mifflin Co. Boston; 1975

[9] **Liang - Shin Hahn and Bernard Epstein**: Classical Complex Analysis; Jones and BartlettPublishers; 1996

MAT4E02: ADVANCED FUNCTIONAL ANALYSIS
No. of Credits: 4

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

- Understand the concept of the spectrum of bounded operators and how much it will be helpful in solving certain differential equations.
- Get an idea about different types of convergence of sequences in normed spaces and their relations.
- Understand that there is a nice class of operators called compact linear operators stronger than continuous linear operators on a normed space and understand the behavior of spectrum of such operators.
- Understand that there is a surjective isometry between a Hilbert space and its dual.

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

Unit I

Spectrum of a Bounded Operator; Duals and Transposes; Weak Convergence
[Chapter III: Section 12; Chapter IV: Section 13(up to and including 13.4), Section 15(up to and including 15.2(c) from the text]

Unit II

Reflexivity; Compact Linear Maps; Spectrum of a compact operator; Inner product Spaces [Chapter IV: Section 16 (16.1 to 16.2, 16.4(a) and (b), 16.5(without proof); Chapter V: Section 17(up to and including 17.3), Section 18(18.1 to 18.5, 18.7(a)); Chapter VI: Section 21 from the text]

Unit III

Orthonormal sets, Approximation and Optimization, Projection and Riesz Representation Theorems; Bounded Operators and Adjoints
[Chapter VI: Section 22 (omit 22.3(b), 22.8(c), (d) and (e)), Section 23 (up to and including 23.3,omit proof of 23.3), Section 24 (up to and including 24.6); Chapter VII: Section 25(omit 25.4(b)) from the text]

Unit IV

Normal, Unitary and Self- adjoint Operators; Spectrum and Numerical Range; Compact Self adjoint Operators
[Chapter VII: Section 26(up to Fourier - Plancherel Transform), Section 27(omit 27.6), 28(omit 28.3(b), 28.7, 28.8(b)) from the text]

References

[1] **George Bachman and Lawrence Narici**: Functional Analysis; Academic Press, NY; 1970.

[2] **Kolmogorov and Fomin S.V.**: Elements of the Theory of Functions and Functional Analysis; English translation, Graylock Press, Rochaster NY; 1972.

[3] **W.Dunford and J.Schwartz**: Linear Operators -Part 1 General Theory; John Wiley and Sons;1958.

[4] **E.Kreyszig**: Introductory Functional Analysis with Applications; John Wiley and Sons; 1978.

[5] **J.B.Conway**: Functional Analysis; Narosa Pub House New Delhi; 1978.

[6] **Walter Rudin**: Functional Analysis; TMH Edition; 1978.

[7] **J.Dieudonne**: Foundations of Modern analysis; Academic Press; 1969.

MAT4E03: ADVANCED TOPICS IN MEASURE AND INTEGRATION
No. of Credits: 4

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

- Learn how a measure will be helpful to generalize the concept of an integral.
- Learn how a smallest sigma algebra containing all open sets be constructed on a topological space which ensures the measurability of all continuous function and how a measure called Borel measure is defined on this sigma algebra which ensures the integrability of a huge class of continuous functions.
- Understand the regularity properties Borel measures.
- Realize a measure may take real values even complex values.
- Learn to characterize bounded linear functionals on L^p.
- Learn product measure and their completion.

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

(Prerequisites: A basic Course in Real Analysis)

Unit I

Abstract Integration: The concept of measurability, Simple Functions, Elementary Properties of measures, Arithmetic in [0, ∞],

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]

Unit II

Positive Boral Measures: Topological preliminaries(up to 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)]

Unit III

Complex Measures: Total variation, Absolute continuity, Consequences of the Radon-Nikodym theorem, Bounded linear functionals on L^p, The Riesz representation Theorem

[Chapter 6 : All sections from the text]

Unit IV

Integration on Product Spaces: Measurability on Cartesian products, Product measures The Fubini's Theorem, Completion of product measures, Convolutions

[Chapter 7: All sections from the text]

References

[1] **R.G. Bartle**: The Elements of Integration and Lebesgue Measure Theory; Wiley Inter. Science Publication; 1995

[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] **Johns, Frank**: Lebesgue Integration of Euclidean space; Boston: Jones & Bartlett Publishers;1993

[6] **Paul R. Halmos**: Measure Theory; D. Van Nostrand, Princeton; 1950

[7] **D.W.Stroock**: A Concise Introduction to the theory of Integration; Birkhauser; 1994

[8] **C. Swartz**: Measure, Integration and Function Spaces; World Scientific Publishing; 1994

MAT4E04: ALGEBRAIC GRAPH THEORY
No. of Credits: 3

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 knowledge of various families of graphs and action of groups on graphs.
- Learn mappings between graphs homomorphisms, isomorphisms and automorphisms. Develop basic properties of Transitive graphs.

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

(Pre requisites: A basic course in Group Theory and Graph theory)

Unit I

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]

Unit II

Groups: Permutation Groups, Counting, Asymmetric Graphs, Orbits on Pairs, Primitivity, Primitivity and Connectivity

[Chapter 2: Sections 2.1 to 2.6 from the text]

Unit III

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; Cam-bridge University Press; 2005

[2] **N.L. Biggs and A.T. White**: Permutation Groups and Combinatorial Structures; CambridgeUniversity Press; 1979

[3] **J.A. Bondy and U.S.R. Murthy**: Graph Theory with Applications; Springer; 2008

MAT4E05: ALGEBRAIC TOPOLOGY
No. of Credits: 3

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 basics of homology theory and apply it to get a generalization of Euler's formula to a general polyhedra.
- Learn to associate various groups namely homology groups of various dimensions and the homotopy group- the fundamental group to every topological space.
- 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.

(Pre requisites: Fundamentals of group theory and Topology)

Unit 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]

Unit II

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]

Unit III

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

MAT4E06: CRYPTOGRAPHY
No. of Credits: 3

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

- 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.

Unit 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.

Unit 2

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

Unit 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 functions-MD5, 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.

MAT4E07: DIFFERENTIAL GEOMETRY
No. of Credits: 4

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

- Understand how calculus of several variables can be used to develop the geometry of n-dimensional oriented n- surface in $\mathbb{R}^{n+1}$.
- Understand locally n- surfaces and parametrized n- surfaces are the same.
- Develop a knowledge of the Gauss and Weingarten maps and apply them to apply them to describe various properties of surfaces.

TEXT: J.A.THORPE, ELEMENTARY TOPICS IN DIFFERENTIAL GEOMETRY, Springer- Verlag, New York, Inc. 1979.

(Pre requisites: Fundamentals of Real Analysis, Linear Algebra and Differential Equations)

Unit I

Graphs and level sets; Vector fields; The tangent space; Surfaces; Vector fields on Surfaces; Orientation
[Chapters 1; 2; 3; 4; 5 from the text.]

Unit II

The Gauss map; Geodesics; Parallel transport
[Chapters 6; 7; 8 from the text].

Unit III

The Weingarten Map; Curvature of plane curves; Arc length and Line Integrals
[Chapters 9; 10; 11 from the text]

Unit IV

Curvature of Surfaces; Parametrized Surfaces; Local equivalence of surfaces and parametrizedSurfaces
[Chapters 12; 14; 15 from the text]

References

[1] **W. L. Burke**: Applied Differential Geometry; Cambridge University Press; 1985.

[2] **M. de Carmo**: Differential geometry of curves and surfaces; Prentice Hall Inc. Englewood CliffsNJ; 1976

[3] **V. Guillemin and A. Pollack**: Differential Topology; Prentice Hall Inc Englewood Cliffs NJ;1974

[4] **B. O'Neil**: Elementary Differential Geometry; Academic press NY; 1966

[5] **M. Spivak**: A comprehensive introduction to Differential Geometry-volumes 1 to 5

MAT4E08: GRAPH THEORY
No. of Credits: 2

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

- **Learn Different types of connectivity in graphs.**
- **Learn independent sets and matching.**
- **Learn graph colouring and related results.**

TEXT: R. BALAKRISHNAN and K. RANGANATHAN, A TEXT BOOK OF GRAPH THEORY, Springer-Verlag New York, Inc., 2000.

Unit I

Connectivity: Connectivity and Edge Connectivity, Blocks, Cyclical Edge Connectivity of a Graph,Menger's Theorem; Independent Sets and Matchings: Vertex Independent Sets and Vertex Coverings; Edge Independent Sets

[Chapter III: Sections 3.2 (3.2.5 to3.2.11), 3.3, 3.4, 3.5; Chapter V: Sections 5.1, 5.2 from the Text]

Unit II

Graph Colorings: Vertex Coloring, Critical Graph, Triangle- Free Graphs, Edge Colorings ofGraphs, Snarks, Kirkman's Schoolgirls Problem, Chromatic Polynomials

[Chapter VII: All Sections (Omit Theorem 7.1.7) from the text]

References

[1] **F. Harary**: Graph Theory; Narosa Pub. House, New Delhi; 1992

[2] **C. Berge**: Graphs and Hypergraphs; North Holland, Amsterdam; 1973

[3] **N. Biggs**: Algebraic Graph Theory; Cambridge University Press; 1974

[4] **Narasing Deo**: Graph Theory with applications to Engineering and Computer Science; PrenticeHall of India, New Delhi; 1987.

[5] **O. Ore**: Graphs and their uses; Random House NY; 1963

[6] **Robin J. Wilson**: Introduction to Graph Theory; Longman Scientific and Technical Essex; 1985

[7] **Bondy J. R. and U. S. R. Murti**: Graph Theory; Springer; 2008

[8] **Reinhard Diestel**: Graph Theory (3rd Edn.); Springer-Verlag, Berlin; 2005

[9] **Bela Bollobas**: Modern Graph Theory; Springer - Verlag, New York; 1998

MAT4E09: MEASURE AND INTEGRATION
No. of Credits: 3

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

- Learn how a measure will be helpful to generalize the concept of an integral.
- Learn how a smallest sigma algebra containing all open sets be constructed on a topological space which ensures the measurability of all continuous function and how a measure called Borel measure is defined on this sigma algebra which ensures the integrability of a huge class of continuous functions.
- Understand the regularity properties Borel measures.
- Realise a meaure may take real values even complex values.
  Learn to characterize bounded linear functionals on L^p

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

(Pre requisites: A basic Course in Real Analysis)

Unit I

Abstract Integration: The concept of measurability, Simple Functions, Elementary Properties of measures, Arithmetic in [0, ∞], 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].

Unit II

Positive Borel Measures: Topological preliminaries(up to 2.13 - a quick review), The Riesz Repre-sentation 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)]

Unit III

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 EducationalPublishers, San Francisco; 1972

MAT4E10: NON-LINEAR PROGRAMMING
No. of Credits: 2

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

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

- Learn certain methods and algorithms for solving some particular class of nonlinear programming- convex, quadratic, dynamic and geometric programming problems and realizes the limitations in handling nonlinear programming.
- Learn how to formulate certain games as programming problems and learn Min-Max theorem and some techniques for solving rectangular games.

(Pre requisites: A basic course in calculus, geometry and Linear Algebra)

Unit I

Kuhn - Tucker Theory and Non-Linear Programming; Dynamic Programming
[Chapter 8: Sections 1 to 6; Chapter 10: Sections 1 to 5 from the text]

Unit II

Dynamic Programming(continued); Theory of Games
[Chapter 10: Sections 6 to 9; Chapter 12: All Sections from the text]

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

MAT4E11: OPERATIONS RESEARCH
No. of Credits: 3

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

- Learn certain methods and algorithms for solving some particular class of nonlinear programming- convex, quadratic, dynamic and geometric programming problems and realizes the limitations in handling nonlinear programming.
- Learn how to formulate certain games as programming problems and learn Min-Max theorem and some techniques for solving rectangular games.

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

(Pre requisites: A basic course in calculus, geometry and Linear Algebra)

Unit I

Kuhn - Tucker Theory and Non Linear Programming; Dynamic Programming
[Chapter 8: Sections 1 to 6; Chapter 10: Sections 1 to 4 from the text]

Unit II

Dynamic Programming(continued); Geometric Programming
[Chapter 10: Sections 5 to 9; Chapter 9: Sections 1 to 4 from the text]

Unit III

Theory of Games
[Chapter 12: All Sections from the text]

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

MAT4E12: WAVELET THEORY
No. of Credits: 4

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

- Learn the concept of discrete Fourier Transforms and its basic properties.
- Learn how to construct Wavelets on $\mathbb{Z}_N$ and $\mathbb{Z}$.
- Learn Wavelets on $\mathbb{R}$ and construction of MRA.

TEXT : MICHAEL W. FRAZIER, AN INTRODUCTION TO WAVELETS THROUGH LINEAR ALGEBRA, Springer, New York, 1999.

Unit I

The discrete Fourier Transforms: Basic Properties of Discrete Fourier Transforms, Translation Invariant Linear Transforms, The Fast Fourier Transforms

[Chapt. II: Section 2.1-2.3]

Unit II

Wavelets on Z_n: Construction of Wavelets on Z_n-the First Stage, Construction of Wavelets on Z_n-the Iteration Step

[Chapt. III: 3.1-3.2]

.Unit III

Wavelets on Z_n: $l^2(Z)$, Complete Orthonormal Sets in Hilbert Spaces, $L^2([-\pi, \pi])$ and Fourier Series, The Fourier Transform and Convolution on $l^2(Z)$, First-Stage Wavelets on Z, Implementation and Examples

[Chapt IV: 4.1-4.5, 4.7]

Unit IV

Wavelets on R: $L^2(R)$ and Approximate Identities, The Fourier Transform on R, Multiresolution Analysis and Wavelets, Construction of Multiresolution Analysis

[Chapt V: 5.1-5.4]

References

[1] **C. K. Chui**: An Introduction to Wavelets; Academic Press; 1992

[2] **Jaideva C. Goswami and Andrew K. Chan**: Fundamentals of Wavelets Theory Algorithms and Applications; John Wiley adn Sons, Newyork; 1999

[3] **Yves Nievergelt**: Wavelets made easy; Birkhauser, Boston; 1999

[4] **G. Bachman, L. Narici and E. Beckenstien**: Fourier and Wavelet Analysis; Springer; 2006

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