CURRICULUM AND SYLLABI

CHOICE BASED CREDIT SYSTEM

(CBCS-PG)

M. Sc MATHEMATICS PROGRAMME

INTRODUCED FROM 2016 ADMISSION ONWARDS

BOARD OF STUDIES IN MATHEMATICS

Sacred Heart College (Autonomous), Thevara, Kochi, Kerala

Board of Studies in Mathematics

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SACRED HEART COLLEGE (AUTONOMOUS) –THEVARA, KOCHI -13.

1. **SCOPE**

1.1. These regulations provided herein shall apply to all post-graduate programmes, conducted by Sacred Heart College (S.H. College), Thevara with effect from the academic year 2016-2017 admission onwards.

2. **DEFINITIONS**

2.1 'Academic **Committee'** means the Committee constituted by the principal under this regulation to monitor the running of the Post-Graduate programmes under the Choice Based Credit System (CBCS-PG).

2.2 'Programme' means the entire course of study and examinations.

2.3 'Duration **of Programme'** means the period of time required for the conduct of the programme. The duration of post-graduate programme shall be of 4 semesters.

2.4 **'Semester'** means a term consisting of a minimum of 90 working days, inclusive of examination, distributed over a minimum of 18 weeks of 5 working days, each with 5 contact hours of one hour duration

2.5 'Course' means a segment of subject matter to be covered in a semester. Each Course is to be designed variously under lectures / tutorials / laboratory or fieldwork / study tour /seminar / project / practical training / assignments/evaluation etc., to meet effective teaching and learning needs.

2.6 'Credit' (Cr) of a course is the numerical value assigned to a paper according to the relative importance of the content of the syllabus of the programme.

2.7 '**Programme Credit'** means the total credit of the PG Programmes, ie; **80 credits**.

2.8 '**Programme Core course'** Programme Core course means a course that the student admitted to a particular programme must successfully complete to receive the Degree and which cannot be substituted by any other course.

2.9 'Programme Elective course' Programme Elective course means a course, which can be chosen from a list of electives and a minimum number of courses is required to complete the programme.

2.10 '**Programme Project'** Programme Project means a regular project work with stated credits on which the student undergo a project under the supervision of a teacher in the parent department /

any appropriate Institute in order to submit a dissertation on the project work as specified.

2.11 '**Plagiarism**' Plagiarism is the unreferenced use of other authors' material in dissertations and is a serious academic offence.

2.12 '**Tutorial'** Tutorial means a class to provide an opportunity to interact with students at their individual level to identify the strength and weakness of individual students.

2.13 '**Seminar'** seminar means a lecture expected to train the student in self-study, collection of relevant matter from the books and Internet resources, editing, document writing, typing and presentation.

2.14 '**Evaluation'** means every course shall be evaluated by 25% internal assessment and 75% external assessment.

2.15 '**Repeat course'** is a course that is repeated by a student for having failed in that course in an earlier registration.

2.16 **'Audit Course'** is a course for which no credits are awarded.

2.17 '**Department'** means any teaching Department offering a course of study approved by the college / Institute as per the Act or Statute of the University.

2.18 '**Parent Department'** means the Department which offers a particular Post graduate programme.

2.19 '**Department Council'** means the body of all teachers of a Department in a College.

2.20 **'Faculty Advisor'** is a teacher nominated by a Department Council to coordinate the continuous evaluation and other academic activities undertaken in the Department.

2.21 '**College Co-ordinator** means a teacher from the college nominated by the College Council to look into the matters relating to CBCS-PG System

2.22 **'Letter Grade'** or simply '**Grade**' in a course is a letter symbol (S, A, B, C, D, etc.) which indicates the broad level of performance of a student in a course.

2.23 Each letter grade is assigned a **'Grade point'** (GP) which is an integer indicating the numerical equivalent of the broad level of performance of a student in a course.

2.24 **'Credit point'** (CP) of a course is the value obtained by multiplying the grade point (GP) by the Credit (Cr) of the course CP=GP x Cr.

2.25 **'Extra credits'** are additional credits awarded to a student over and above the minimum credits required for a programme for achievements in co-curricular activities carried out outside the regular class hours as directed by the College/ department.

2.26 '**Semester Grade point average'** (SGPA) is the value obtained by dividing the sum of credit points (CP) obtained by a student in the various courses taken in a semester by the total number of credits taken by him/her in that semester . The grade points shall be rounded off to two decimal places. SGPA determines the overall performance of a student at the end of a semester.

2.27 **Cumulative Grade point average'** (CGPA) is the value obtained by dividing the sum of credit points in all the courses taken by the student for the entire programme by the total number of credits and shall be rounded off to two decimal places.

2.28 '**Grace Marks'** means marks awarded to course/s, as per the orders issued by the college from time to time, in recognition of meritorious achievements in NCC/NSS/Sports/Arts and cultural activities.

2.29 'Words **and expressions'** used and not defined in this regulation but defined in the Mahatma Gandhi University Act and Statutes shall have the meaning assigned to them in the Act and Statute.

3. ACADEMIC COMMITTEE

3.1 There shall be an Academic Committee constituted by the principal to manage and monitor the working of (CBCS-PG) 2016.

3.2 The Committee consists of

(a) The principal
(b) The vice principal
(c) Deans of the faculties of science, arts and commerce
(d) The Controller of Examinations
(e) IQAC –Co-ordinator
(f) The superintendent of the college

4. PROGRAMME STRUCTURE

4.1 Students shall be admitted into post graduate programmes under the various faculties.

4.2 The programme shall include two types of courses, Program Core (C) courses and Program Elective (E) Courses. There shall be a Program Project (D) with dissertation to be undertaken by all students. The Programme will also include assignments, seminars, practical (P), viva (V), study tour etc., if they are specified in the Curriculum

4.3 There shall be various groups of four Programme Elective courses for a programme such as Group A, Group B etc. for the choice of students subject to the availability of faculty and infrastructure in the institution and the selected group shall be the subject of specialization of the programme.

4.4 Project work

4.4.1 Project work shall be completed by working outside the regular teaching hours.

4.4.2 Project work shall be carried out under the supervision of a teacher in the concerned department.

4.4.3. A candidate may, however, in certain cases be permitted to work on the project in an industrial / Research Organization/ Institute on the recommendation of the Supervisor.

4.4.4 There should be an internal assessment and external assessment for the project work in the ratio 1:3

4.4.5 The external evaluation of the Project work is followed by presentation of work including dissertation and Viva-Voce.

4.4.6 The mark and credit with grade awarded for the program project should be entered in the grade card issued by the college.

4.5. **Assignments**: Every student shall submit one assignment as an internal component for every course.

4.6 Seminar Lecture: Every PG student may deliver one seminar lecture as an internal component for every course. The seminar lecture is expected to train the student in self-study, collection of relevant matter from the books and Internet resources, editing, document writing, typing and presentation.

4.7 Every student shall undergo **two class tests** as an internal component for every course.

4.8 The attendance of students for each course shall be another component of internal assessment.

4.9 Comprehensive Viva-voce shall be conducted at the end of the programme which covers questions from all courses in the programme as per the syllabus.

5. ATTENDANCE

5.1 The minimum requirement of aggregate attendance during a semester for appearing the end semester examination shall be 75%. Condonation of shortage of attendance to a maximum of 10 days in a semester subject to a maximum of two times during the whole period of Post Graduate programme may be granted by the College as forwarded on the recommendation by the class teacher/HOD.

5.2 If a student represents the college in University, State or Nation in Sports, NCC, NSS or Cultural or any other officially sponsored activities such as College union / University union activities, he/she shall be eligible to claim the attendance for the actual number of days participated subject to a maximum of 10 days in a Semester based on the specific recommendations of the Head of the concerned Department and Principal of the College.

5.3 A student who does not satisfy the requirements of attendance shall not be permitted to take the

end Semester examinations.

5.4 Those students who are not eligible even with condonation of shortage of attendance shall repeat the course along with the next batch

6. **BOARD OF STUDIES AND COURSES.**

6.1 The Board of Studies concerned shall design all the courses offered in the PG programme. The Boards shall design and introduce new courses, modify or re-design existing courses and replace any existing courses with new/modified courses to facilitate better exposures and training for the students.

6.2 The syllabus of a course shall include the title of the course, contact hours, the number of credits and reference materials.

6.3 Each course shall have an alpha numeric code number which includes abbreviation of the subject in two letters, the semester number, the code of the course and the serial number of the course ('C' for Program Core course, 'E' for Program Elective course, 'O' for Open Elective course, 'P' for Practical and 'D' for Project/ Dissertation and 'V' for Comprehensive Viva voce).

6.4 Every Programme conducted under Choice Based Credit System shall be monitored by Academic committee and the College Council.

7. **REGISTRATION**.

7.1 A student shall be permitted to register for the programme at the time of admission. The duration of the PG Programme shall be 4 semesters.

7.2 A student who registered for the course shall complete the course within a period of 8 continuous semesters from the date of commencement of the programme.

8. **ADMISSION**

8.1 The admission to all PG programmes shall be as per the rules and regulations of the college.

8.2 The eligibility criteria for admission shall be as announced by the college from time to time.

8.3 There shall be provision for inter collegiate and inter University transfer within a period of two weeks from the date of commencement of the semester.

8.4 There shall be provision for credit transfer subject to the conditions specified by the Board of Studies concerned.

9. ADMISSION REQUIREMENTS

9.1 Candidates for admission to the first semester of the PG programme through CBCS shall be required to have passed an appropriate Degree Examination of Mahatma Gandhi University as specified or any other examination of any recognized University or authority accepted by the

Academic council of the college as equivalent thereto.

9.2 The candidate must forward the enrolment form to the Controller of Examinations of the college through the Head of the Department.

9.3 The candidate has to register all the courses prescribed for the particular semester. Cancellation of registration is applicable only when the request is made within two weeks from the time of admission.

9.4 Students admitted under this programme are governed by the Regulations in force.

10. .**PROMOTION**: A student who registers for the end semester examination shall be promoted to the next semester

11. EXAMINATIONS

11.1 There shall be an external examination at the end of each semester.

11.2 The answers must be written in **English** except for those coming under Faculty of languages.

11.3 Practical examinations shall be conducted by the college at the end of the semesters as per the syllabus.

11.4 Project evaluation and Comprehensive Viva -Voce shall be conducted as per the syllabus. Practical examination, Project evaluation and Comprehensive Viva-Voce shall be conducted by two external examiners.(For professional courses, one examiner can be opted from the same college itself)

11.5 There shall be one end-semester examination of 3 hours duration in each lecture based course (Theory).

11.6 A question paper may contain multiple choice /objective type , short answer type/annotation, short essay type questions/problems and long essay type questions. Different types of questions shall have different marks, but a general pattern may be followed by the Board of Studies.

12 **EVALUATION AND GRADING**

12.1 Evaluation: The evaluation scheme for each course shall contain two parts; (a) internal evaluation (ISA) and (b) end semester evaluation (ESA). 25 marks shall be given to internal evaluation and 75 marks to external evaluation so that the ratio between internal and external mark is 1:3. Both internal and external evaluation shall be carried out in mark system. Both internal and external marks are to be mathematically rounded to the nearest integer.

12.2 Internal evaluation: The internal evaluation shall be based on predetermined transparent

system involving periodic written tests, assignments, seminars/viva/field survey and attendance in respect of theory courses and based on written tests, lab skill/records/viva and attendance in respect of practical courses. The marks assigned to various components for internal evaluation is a follows.

12.3 Components of Internal Evaluation

All the components of the internal evaluation are mandatory

a) For Theory

	Components	**Marks**
i.	Assignment	5
ii	Seminar/Quiz/Field survey /Viva etc.	5
iii	Attendance	5
iv	Two Test papers(2x5)	10
	Total	25

b) For Project

Components	**Marks**
Topic/Area selected	2
Experimentation/Data collection	5
Punctuality	3
Compilation	5
Content	5
Presentation	5
Total	**25**

12.4 Evaluation of

Attendance

% of attendance	Mark
Above 90%	5
Between 85 and < 90	4
Between 80 and below 85	3
Between 76 and below 80	2
75	1

Assignment

Components	**Marks**
Punctuality	1
Content	2
Conclusion	1
Reference/Review	1
Total	**5**

Seminar

Components .	**Marks**
Content	2
Presentation	2
Reference/Review	1
Total .	**5**

12.5 To ensure transparency of the evaluation process, the internal assessment marks awarded to the students in each course in a semester shall be published on the notice board at least one week before the commencement of external examination. There shall not be any chance for improvement for internal mark.

12.6 The course teacher and the faculty advisor shall maintain the academic record of each student registered for the course which shall be forwarded to the controller of examinations through the Principal and a copy should be kept in the college for at least two years for verification.

12.7 External Evaluation: The external examination in theory courses shall be conducted by the college with question papers set by external experts/ question bank. The evaluation of the answer scripts shall be done by the examiners based on a well-defined scheme of evaluation given by the question paper setters. The external evaluation shall be done immediately after the examination preferably through the centralised valuation.

12.8 12.8 The question paper should be strictly on the basis of model question paper set by BoS with due weightage for each module of the course and there shall be a combined meeting of the question paper setters and experts for scrutiny for finalisation of question paper. Each set of question should be accompanied by its scheme of valuation.

12.9 For all courses (theory & practical), Letter grades and grade point are given on a 10-point

scale based on the total percentage of marks, (ISA+ESA) as given below:-

Percentage of Marks	Grade	Grade Point (GP)
95 and above	O Outstanding	10
85 to below 95	A^+ Excellent	9
75 to below 85	A Very Good	8
65 to below 75	B^+ Good	7
55 to below 65	B Above Average	6
45 to below 55	C Average	5
40 to below 45	D Pass	4
Below 40	F Fail	0
	Ab Absent	0

Grades for the different semesters and overall programme are given based on the corresponding GPA as shown below:

GPA	Grade
Equal to 9.5 and above	***O Outstanding***
Equal to 8.5 and below 9.5	***A+ Excellent***
Equal to 7.5 and below 8.5	***A Very Good***
Equal to 6.5 and below 7.5	***B+ Good***
Equal to 5.5 and below 6.5	***B Above Average***
Equal to 4.5 and below 5.5	***C Average***
Equal to 4.0 and below 4.5	***D Pass***
Below 4.0	***F Failure***

12.10 A **separate minimum of 40% marks** (D grade) required for a pass for both internal evaluation and external evaluation for every course.

12.11 A candidate who has not secured minimum marks/credits in internal examinations can re-do the same registering along with the end semester examination for the same semester, subsequently.

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

There will be no improvement examinations

12.13 After the successful completion of a semester, Semester Grade Point Average (SGPA) of a student in that semester is calculated using the formula given below. For the successful completion of semester, a student should pass all courses and score a minimum SGPA of 4.0 However, a student is permitted to move to the next semester irrespective of her/his SGPA.

Credit Point (CP) of a course is calculated using the formula

CP = Cr x GP, where Cr = Credit; GP = Grade point

Semester Grade Point Average (SGPA) of a Semester is calculated using the formula

SGPA = TCP/TCr, where

TCP = Total Credit Point of that semester $= \sum_1^n$ CPi***;***

TCr = Total Credit of that semester $= \sum_1^n$ Cri

Where n is the number of courses in that semester

Cumulative Grade Point Average (CGPA) of a Programme is calculated using the formula

$$CGPA = \frac{\sum(TCP \times TCr)}{\sum TCr}$$ ***GPA shall be round off to two decimal places***

12.14 PATTERN OF QUESTIONS

Questions shall be set to assess knowledge acquired, standard, application of knowledge, application of knowledge in new situations, critical evaluation of knowledge and the ability to synthesize knowledge. The question setter shall ensure that questions covering all skills are set. He/She shall also submit a detailed scheme of evaluation along with the question paper.

A question paper shall be a judicious mix of, multiple /objective, short answer type, short essay type /problem solving type and long essay type questions.

Pattern of questions for external examination for theory paper

Type of Questions	Total no. of questions	Number of questions to be answered	Marks of each question	Total marks
Section A – Short Answer	10	10	1.5	15
Section B- Short essay/ Problems	6	4	5	20
Section C- Long essay	8	4	10	40
	24	**18**		**75**

Pattern of questions for external examination of practical papers will decided by Practical exam board chairman as per the guidelines of Board of Studies.

13. **GRADE CARD**

The colleges under its seal shall issue to the students, a grade card on completion of each semester, which shall contain the following information.

- **a)** Name of the College
- **b)** Title of the Postgraduate Programme
- **c)** Name of the Semester
- **d)** Name and Register Number of the student
- **e)** Code, Title, Credits and Max. Marks (Internal, External & Total) of each course (theory& Practical) in the semester.
- **f)** Internal, External and Total Marks awarded, Grade, Grade point and Credit point in each course in the semester
- **g)** The total credits, total marks (Max. & Awarded) and total credit points in the semester
- **h)** Semester Grade Point Average (SGPA) and corresponding Grade.
- **i)** Cumulative Grade Point Average (CGPA)
- **j)** The final Mark cum Grade Card issued at the end of the final semester shall contain the details of all courses(theory & practical) taken during the final semester examination and shall include the final grade/marks scored by the candidate from 1st to 3rd semester, and the overall grade/marks for the total programme.

14. **AWARD OF DEGREE**

The successful completion of all the courses with 'D' grade (40%) shall be the minimum requirement for the award of the degree

15**. MONITORING COMMITTEE**

There shall be a Monitoring Committee constituted by the principal consisting of faculty advisors, HOD, a member from teacher learning evaluation committee (TLE) and college coordinator to monitor the internal evaluations conducted by college. The Course teacher, Faculty Advisor, and the College Coordinator should keep all the records of the internal evaluation, for at least a period of two years, for verification.

16. GRIEVENCE REDRESSAL MECHANISM

In order to address the grievance of students regarding Continuous internal assessment (CIA) a three-level Grievance Redressal mechanism is envisaged. A student can approach the upper level only if grievance is not addressed at the lower level.

Level 1: At the level of the concerned course teacher

Level 2: At the level of a department committee consisting of the Head of the Department, a coordinator of internal assessment for each programme nominated by the HoD and the course teacher concerned.

Level 3: A committee with the Principal as Chairman, Dean of the concerned Faculty, HOD of concerned department and one member of the Academic council nominated by the principal every year as members.

17. **TRANSITORY PROVISION**

Notwithstanding anything contained in these regulations, the Principal shall, for a period of three year from the date of coming into force of these regulations, have the power to provide by order that these regulations shall be applied to any programme with such modifications as may be necessary

18. **REPEAL**

The Regulations now in force in so far as they are applicable to programmes offered by the college and to the extent they are inconsistent with these regulations are hereby repealed. In the case of any inconsistency between the existing regulations and these regulations relating to the Choice Based Credit System in their application to any course offered in the College, the latter shall prevail.

SACRED HEART COLLEGE (AUTONOMOUS)
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POSTGRADUATE PROGRAMMES IN MATHEMATICS 2016 Admission Onwards

Semester	Course	Teaching hrs	Credits	Total Credits
I	16P1MATT01	5	4	20
	16P1MATT02	5	4	
	16P1MATT03	5	4	
	16P1MATT04	5	4	
	16P1MATT05	5	4	
II	16P2MATT06	5	4	20
	16P2MATT07	5	4	
	16P2MATT08	5	4	
	16P2MATT09	5	4	
	16P2MATT10	5	4	
III	16P3MATT11	5	4	20
	16P3MATT12	5	4	
	16P3MATT13	5	4	
	16P3MATT14	5	4	
	16P3MATT15	5	4	
IV	ELECTIVE 1	5	3	20
	ELECTIVE 2	5	3	
	ELECTIVE 3	5	3	
	ELECTIVE 4	5	3	
	ELECTIVE 5	5	3	
	16P4MATPJ	PROJECT	3	
	16P4MATCV	Viva –Voce	2	
TOTAL				80

COURSE CODE	SEM	NAME OF THE COURSE	HR/ W	CR	T CR	T HR/SEM
16P1MATT01	I	LINEAR ALGEBRA	5	4	20	75
16P1MATT02		BASIC TOPOLOGY	5	4		75
16P1MATT03		MEASURE THEORY AND INTERATION	5	4		75
16P1MATT04		ORDINARY DIFFERENTIAL EQUATIONS	5	4		75
16P1MATT05		COMPLEX ANALYSIS	5	4		75
16P2MATT06	II	ABSTRACT ALGEBRA	5	4	20	75
16P2MATT07		ADVANCED TOPOLOGY	5	4		75
16P2MATT08		ADVANCED COMPLEX ANALYSIS	5	4		75
16P2MATT09		FUNCTIONAL ANALYSIS	5	4		75
16P2MATT10		REAL ANALYSIS	5	4		75
16P3MATT11	III	PARTIAL DIFFERENTIAL EQUATIONS	5	4	20	75
16P3MATT12		ADVANCED FUNCTIONAL ANALYSIS	5	4		75
16P3MATT13		GRAPH THEORY	5	4		75
16P3MATT14		OPERATION RESEARCH	5	4		75
16P3MATT15		NUMBER THEORY	5	4		75
16P4MATT16EL	(Electives 5 of 7) Semester IV	DIFFERENTIAL GEOMETRY	5	3	20	75
16P4MATT17EL		MULTIVARIATE CALCULUS AND INTEGRAL TRANSFORMS	5	3		75
16P4MATT18EL		COMBINATORICS	5	3		75
16P4MATT19EL		THEORY OF WAVELETS	5	3		75
16P4MATT20EL		NUMERICAL ANALYSIS	5	3		75
16P4MATT21EL		CODING THEORY AND CRYPTOGRAPHY	5	3		75
16P4MATT22EL		PROBABILITY THEORY	5	3		75
16P4MATPJ		PROJECT/ DISSERTATION		3		100
16MATCV		VIVA VOCE		2		100
TOTAL CREDITS						**80**

SEMESTER- I

COURSE: 16P1MATT01: LINEAR ALGEBRA

Hours per week: 5 **Total Credits: 4**

Text Book: Kenneth Hoffman / Ray Kunze (Second Edition), *Linear Algebra*, Prentice-Hall of India Pvt. Ltd., New Delhi, 1992.

Module-1 **(12 hours.)**

Vector spaces, subspaces, basis and dimension

(Chapter 2, 2.1, 2.2, 2.3 of the text)

(Proof of theorems excluded). Co-ordinates, summary of row-equivalence

(Chapter 2- 2.4 & 2.5 of the text)

Module 2 **(25 hours.)**

Linear transformations, the algebra of linear transformations, isomorphism, Representation of transformations by matrices, linear functional, double dual, Transpose of a linear transformation.

(Chapter 3 - 3.1, 3.2, 3.3, 3.4, 3.5, 3.6 & 3.7 of the text)

Module 3 **(15 hours.)**

Introduction to elementary canonical forms, characteristic values, annihilating Polynomials.

(Chapter 6 - 6.1, 6.2, and 6.3 of the text)

Module 4 **(23 hours.)**

Invariant subspaces, simultaneous triangulations, simultaneous diagonalisation, direct sum decompositions, invariant direct sums.

(Chapter 6 - 6.4, 6.5 & 6.6 of the text)

References:

1. Klaus Jonich. Linear Algebra, Springer Verlag.

2. Paul R. Halmos, Linear Algebra Problem Book, The Mathematical Association of America.

3. S. Lang, Algebra, 3rd edition, Addison-Wesley, 1993.

4. K.B. Datta, Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.

5. S. Kumaresan, Linear Algebra A Geometrical Approach, Prentice Hall of India, 2000.

Question paper Pattern

Module	**Part A** **(1.5 Marks Question)** **Answer all Questions**	**Part B** **(5 Marks Question)** **Answer any four**	**Part C** **(10 Marks Question)** **Answer one from each module**
1	2	1	2
2	3	2	2
3	2	1	2
4	3	2	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

COURSE: 16P1MATT02: BASIC TOPOLOGY

Hours per week: 5 **Total Credits: 4**

Text Book: K.D. Joshi, Introduction to General Topology, Wiley Eastern Ltd, 1984.

Module 1: Definition of a topological space – examples of topological spaces, bases and sub bases – sub spaces. Basic concepts: closed sets and closure – neighborhood, interior and accumulation points (Chapter 4 Section – 1, 2, 3, 4 - Chapter 5 Section -. 1 and 2 of the text. 5.2.11 & 5.2.12 excluded.) (21 hours)

Module 2: Continuity and related concepts: making functions continuous, quotient spaces. Spaces with special properties: Smallness condition on a space (Chapter 5. Section. 3 and 4 of the text, 5.3.2(4) excluded) (Chapter 6 Sec. 1 of the text) (18 hours)

Module 3: Connectedness: Local connectedness and paths (Chapter 6 Section. 2 & 3 of the text) (18 hours)

Module 4: Separation axioms: Hierarchy of separation axioms – compactness and separation axioms (Chapter – 7 Section 1 & 2 of the text) (2.13 to 2.16 of section.2 excluded) (18 hours)

References:-

1. Munkres J.R, Topology-A First Course, Prentice Hall of India Pvt. Ltd., New Delhi, 2000
2. J.L Kelley, General Topology, Van Nostrand, Reinhold Co., New York, 1995.
3. Stephen Willard, General Topology, Addison-Wesley.
4. Dugundji, Topology, Universal Book Stall, New Delhi.
5. George F Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1963.

Question paper Pattern

Module	Part A (1.5 Marks Question) Answer all Questions	Part B (5 Marks Question) Answer any four	Part C (10 Marks Question) Answer one from each module
I	3	2	2
II	3	2	2
III	2	1	2
IV	2	1	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

COURSE: 16P1MATT03: MEASURE THEORY AND INTEGRATION

Hours per week: 5 **Total Credits: 4**

Text 1: H.L. Royden, Real Analysis, Third edition, Prentice Hall of India Private Limited.
Text 2: G. de Barra, Measure Theory and Integration, New Age International (P) Linnilect Publishers.

Pre-requisites: Algebras of sets, the axiom of choice and infinite direct products, open and closed sets of real numbers.
(Chapter 1 - section 4, 5 Chapter 2 - section 5 of Text 1). (5 hours)
(No questions shall be asked from this section)

Module 1: Lebesgue measure: introduction, outer measure, measurable sets and Lebesgue measure, & non-measurable sets, measurable functions.
(Chapter 3 - Sec. 1 to 6. of Text 1) (15 hours)

Module 2: Lebesgue integral: the Riemann integral, The Lebesgue integral of a bounded function over a set of finite measures, the integral of a non-negative function, the general Lebesgue integral.
(Chapter 4 - Sec. 1 – 4. of Text 1 (20 hours)

Module 3: Measure and integration: measure spaces, measurable functions, Integration, general convergence theorems, signed measures, outer measure and measurability, the extension theorem.
(Chapter 11 - Sec. 1 to 5 of Text 1Chapter 12 - Sec. 1& 2 of Text 1) (20 hours)

Module 4: Measurability in a product space, the product measure and Fubini's theorem.
(Chapter 10 - Sec. 10.1& 10.2 of Text 2)
(15 hours)

References:-
1. Halmos P.R, Measure Theory, D.van Nostrand Co.
2. P.K. Jain and V.P. Gupta, Lebesgue Measure and Integration, New Age International (P) Ltd., New Delhi, 1986(Reprint 2000).
3. R.G. Bartle, The Elements of Integration, John Wiley & Sons, Inc New York, 1966.
4. Inder K Rana, An Introduction to Measure and Integration, Narosa Publishing House

Question Paper Pattern

Module	Part A (1.5 Marks Question) Answer all Questions	Part B (5 Marks Question) Answer any four	Part C (10 Marks Question) Answer one from each module
I	3	2	2
II	3	2	2
III	3	1	2
IV	1	1	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

COURSE: 16P1MATT04: ORDINARY DIFFERENTIAL EQUATIONS

Hours per week: 5 **Total Credits: 4**

Text Book 1: Differential Equations, George F Simmons, Steven G Krantz,

Tata McGraw-Hill -2011

Text Book 2: Differential Equations, Shepley L Ross, Wiley Student Edition. Third edition

1. System of Linear Differential Equations : Basic theory of Linear systems in normal form, Homogeneous linear systems with constant coefficients, Matrix method for homogeneous linear systems
   Chapter 7 sections 7.3, 7.4, 7.5 and 7.6 of Text 2. (15 hours)
2. Power series solutions : Introduction and review of power series, series solutions of first order differential equations , second order linear equations , ordinary points , Regular singular points , Gauss hyper geometric equations , Picards existence and uniqueness theorem
   (Chapter 3 section 3.3 and chapter 4 of Text 1) (20 hours)
3. Boundary Value Problems : Sturm Liouville Problems , Orthogonally of Characteristic functions , the expansion of a function in a series of ortho normal functions
   (Chapter 12, Sections 12.1, 12.2, 12.3 of text 2) (20 hours)
4. THE LAPLACE TRANSFORM : Introduction , applications to differential equations , derivatives and Integrals , Convolutions , The unit step and impulse functions
   Chapter 7 of Text 1 (20 hours)
   Reference:
   - Elementary Differential Equations, 9th edition (7th or 8th ed ok), W. E. Boyce and R.C. Diprima, John Wiley and Sons, Inc
   - Differential Equations, Second Edition, by J. Polking, A. Boggess and D. Arnold. Prentice Hall, 2006.

Question Paper Pattern

Module	**Part A** **(1.5 Marks Question)** **Answer all Questions**	**Part B** **(5 Marks Question)** **Answer any four**	**Part C** **(10 Marks Question)** **Answer one from each module**
I	3	2	2
II	2	1	2
III	2	1	2
IV	3	2	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

COURSE: 16P1MATT05: COMPLEX ANALYSIS

Hours per week: 5 **Total Credits: 4**

Text: Lars V. Ahlfors, Complex Analysis, Third edition, McGraw Hill Internationals

Module 1: Analytic functions as mappings. Conformality: arcs and closed curves, analytic functions in regions, conformal mapping, length and area. Linear transformations: linear group, the cross ratio, symmetry, oriented circles, family of circles. Elementary conformal mappings: the use of level curves, a survey of elementary mappings, elementary Riemann surfaces. (Chapter 3 – sections 2, 3 and 4. of the text) (18hours)

Module 2: Complex Integration Fundamental theorem: line integrals, rectifiable arcs, line integrals as functions of arcs, Cauchy's theorem for a rectangle, Cauchy's theorem in a disk Cauchy's integral formula: the index of a point with respect to a cloud curve, the integral formula, higher derivatives.
(Chapter 4 – Sections 1 and 2. of the text.) (17 hours.)

Module 3: Local properties of analytical functions: removable singularities, Taylor's theorem, zeroes and poles, the local mapping, the maximum principle.
The general form of Cauchy's theorem: chains and cycles, simple connectivity, homology, general statement of Cauchy's theorem, proof of Cauchy's theorem, locally exact differentiation, multiply connected regions.
(Chapter 4 – Sections 3 and 4. of the text) (20 hours.)

Module 4: Calculus of Residues: the residue theorem, the argument principle, evaluation of definite integrals. Harmonic functions: definition and basic properties, the mean value property, Poisson's formula, Schwarz theorem, the reflection principle.
(Chapter 4 – Sections 5 and 6 of the text) (20 hours.)

References:

1. Chaudhary. B, The elements of Complex Analysis, Wiley Eastern.
2. Cartan. H (1973), Elementary theory of Analytic functions of one or several variable, Addison Wesley.
3. Conway .J.B, Functions of one Complex variable, Narosa publishing.
4. Lang. S, Complex Analysis, Springer.
5. H.A. Priestly, Introduction to Complex Analysis, Clarendon press, Oxford, 1990.

Question Paper Pattern

Module	**Part A** **(1.5 Marks Question)** **Answer all Questions**	**Part B** **(5 Marks Question)** **Answer any four**	**Part C** **(10 Marks Question)** **Answer one from each module**
I	3	2	2
II	3	1	2
III	2	1	2
IV	2	2	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

SEMESTER II

COURSE: 16P2MATT06: ABSTRACT ALGEBRA

Hours per week: 5 **Total Credits: 4**

Text Book: John B. Fraleigh, A First Course in Abstract Algebra, 7th edition, Pearson Education.

Module 1:

Direct products and finitely generated Abelian groups, fundamental theorem (without proof), Group action on a set. Sylow's theorems (without proof), Applications of the Sylow theory

(Part II – Section 11) (Part III- Section 16)

(Part VII Sections 36 & 37)

(22 hours)

Module 2:

Rings of polynomials, factorisation of polynomials over a field, Ideal Structure in F[x], Introduction to extension fields, algebraic extensions.

(Part IV – Sections 22 & 23)

(Part V-Section 27.21 -27.27)

(Part VI – Section 29, 31 – 31.1 to 31.18)

(20 hours)

Module 3:

Geometric Constructions, Finite fields, Automorphism of fields, the isomorphism extension theorem

(proof of the theorem excluded)

(Part VI-Sections 32 and 33)

(Part X – Section 48 & Section 49.1 - 49.5)

(18 hours)

Module 4:

Splitting fields, separable extensions, Galois theory.

(Part X – Sections 50, 51, & Sections 53) (15 hours)

References:-

1. Contemporary Abstract Algebra –Joseph .A.Gallian, Narosa Publishing House.
2. Abstract Algebra, by Davd S. Dummit and Richard M Foote, Wiley Publications.
3. I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
4., Algebra, Hungerford, Springer
5. M. Artin, Algebra, Prentice -Hall of India, 1991

Question Paper Pattern

Module	**Part A** **(1.5 Marks Question)** **Answer all Questions**	**Part B** **(5 Marks Question)** **Answer any four**	**Part C** **(10 Marks Question)** **Answer one from each module**
I	4	2	2
II	2	2	2
III	2	1	2
IV	2	1	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

COURSE: 16P2MATT07: ADVANCED TOPOLOGY

Hours per week: 5 **Total Credits: 4**

Text Book: K.D. Joshi, Introduction to General Topology, Wiley Eastern Ltd.

Module 1:

Urysohn Characterisation of Normality – Tietze Characterisation of Normality. (Chapter 7 Section-.3 and 4 of the text.) (Proof of 3.4, 4.4, and 4.5 excluded)
Products and co-products: Cartesian products of families of sets– Product Topology – Productive properties. (Chapter 8 Section. 1, 2 & 3 of the text) (proof of 1.6 &1.7 excluded)
(21 hours)

Module 2:

Embedding and Metrisation – Evaluation Functions in to Products, Embedding Lemma and Tychnoff Embedding, The Urysohn Metrisation Theorem. (Chapter 9. Sec. 1, 2 & 3 of the text) (12 hours)

Module 3:

Nets and Filters: Definition and Convergence of Nets, Topology and Convergence of Nets, Filters and their Convergence, Ultra filters and Compactness. (Chapter – 10 Sections -1, 2, 3 & 4 of the text) (21 hours)

Module 4:

Compactness: Variations of compactness – local compactness – compactification. Chapter 11. Section 1 (Proof of theorem 1.4 & 1.12 excluded), Section 3 Section 4(from 4.1 to 4.7) of the text (21 hours)

References:-

1. Munkres J.R, Topology-A First Course, Prentice Hall of India Pvt. Ltd., NewDelhi, 2000.
2. J.L Kelley, General Topology, Van Nostrand, Reinhold Co., New York, 1995.
3. Stephen Willard, General Topology, Addison-Wesley.
4. Dugundji, Topology, Universal Book Stall, New Delhi.
5. George F Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1963.

Question paper Pattern

Module	**Part A** **(1.5 Marks Question)** **Answer all Questions**	**Part B** **(5 Marks Question)** **Answer any four**	**Part C** **(10 Marks Question)** **Answer one from each module**
I	3	2	2
II	2	1	2
III	3	2	2
IV	2	1	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

COURSE: 16P2MATT08: ADVANCED COMPLEX ANALYSIS

Hours per week: 5 **Total Credits: 4**

Text Book: Lars V. Ahlfors, Complex Analysis, Third edition, McGraw Hill Internationals

Module 1:

Elementary theory of power series: sequences, series, uniform convergence, power series, Abel's limit theorem. Power series expansions: Weierstrass' theorem, the Taylor's series, the Laurent's series Partial fractions and factorization: partial fractions, infinite products, canonical products, the gamma functions.

(Chapter 2, Section 2 - Chapter 5, Sections 1, 2.1 to 2.4 of the text) (20 hours)

Module 2:

Entire functions: Jenson's formula, Hadamard's theorem (without proof) the Riemann zeta function: the product development, extension of ξ to the whole plane, the functional equation, the zeroes of zeta function Arzela's theorem (without proof)

(Chapter 5 - Sections 3, 4, and 5.3 of the text) (20 hours)

Module 3:

The Riemann mapping theorem: statement and proof, boundary behavior, use of reflection principle, analytic arcs. Conformal mappings of polygons: the behavior of an angle, the Schwarz Christoffel formula (Statement only). A closer look at harmonic functions: functions with mean value property, Harnack's principle. The Dirichlet problem: sub harmonic functions, solution of Dirichlet problem (statement only)

(Chapter 6 Section 1, 2.1, 2.2, 3, 4.1 & 4.2 of the text) (20 hours)

Module 4:

Elliptic functions: simply periodic functions, representation of exponentials, the Fourier development, functions of finite order. Doubly periodic functions: The period module, unimodular transformations, the canonical basis, general properties of elliptic functions. The Weirstrass theory: the Weierstrass function, the functions ξ (y) and σ (y), the differential equation.

(Chapter 7 Sections 1, 2, 3 of the text) (15 hours)

References:

1. Chaudhary. B, The elements of Complex Analysis, Wiley Eastern.
2. Cartan. H (1973), Elementary theory of Analytic functions of one or several variable, Addison Wesley.
3. Conway .J.B, Functions of one Complex variable, Narosa publishing.
4. Lang. S, Complex Analysis, Springer.
5. H.A. Priestly, Introduction to Complex Analysis, Clarendon press, Oxford, 1990

Question Paper Pattern

Module	**Part A** **(1.5 Marks Question)** **Answer all Questions**	**Part B** **(5 Marks Question)** **Answer any four**	**Part C** **(10 Marks Question)** **Answer one from each module**
I	3	2	2
II	3	2	2
III	2	1	2
IV	2	1	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

COURSE: 16P2MATT09: FUNCTIONAL ANALYSIS

Hours per week: 5 **Total Credits: 4**

Text Book: Erwin Kreyszig, Introductory Functional Analysis with applications, John Wiley and sons, New York

Module 1:

Vector Space, normed space. Banach space, further properties of normed spaces, finite dimensional normed spaces and subspaces, compactness and finite dimension, linear Operators, bounded and continuous linear operators. (Chapter 2 - Sections 2.1 – 2.7 of the text, excluding section 2 (20 hours)

Module 2:

Linear functionals, linear operators and functionals on finite dimensional spaces, normed spaces of operators. dual space, inner product space. Hilbert space, further properties of inner product space. (Chapter 2 - Section 2.8 to 2.10, chapter 3 - Sections 3.1 to 3.2 of the text, excluding section 3.2.3 (20 hours)

Module 3:

Orthogonal complements and direct sums, orthonormal sets and sequences, series related to orthonormal sequences and sets, total orthonormal sets and sequences. Representation of functionals on Hilbert spaces, Hilbert adjoint operators, Self adjoint, unitary and normal operators.

(Chapter 3 - Sections 3.3 to 3.6, 3.8 to 3.10 of the text, excluding section 3.5) (20 hours)

Module 4:

Zorn's lemma, Hahn- Banach theorem for real vector space (statement only), Hahn- Banach theorem for complex vector spaces and normed spaces, adjoint operators, reflexive spaces, category theorem (Statement only), uniform boundedness theorem (Chapter 4 – Sections 4.1 to 4.3, 4.5 to 4.7 of the text) (15 hours)

References

1. Simmons, G.F, Introduction to Topology and Modern Analysis, McGraw –Hill, New York 1963.

2. Siddiqi, A.H, Functional Analysis with Applications, Tata McGraw –Hill, New Delhi: 1989

3. Somasundaram. D, Functional Analysis, S.Viswanathan Pvt. Ltd, Madras, 1994

4. Vasistha, A.R and Sharma I.N, Functional analysis, Krishnan Prakasan Media (P) Ltd (1996)

5. M. Thamban Nair, Functional Analysis, A First Course, Prentice – Hall of India Pvt. Ltd,. 2008

6. Walter Rudin, Functional Analysis, TMH Edition, 1974.

Question Paper Pattern

Module	**Part A** **(1.5 Marks Question)** **Answer all Questions**	**Part B** **(5 Marks Question)** **Answer any four**	**Part C** **(10 Marks Question)** **Answer one from each module**
I	1	2	2
II	3	2	2
III	4	1	2
IV	2	1	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

COURSE: 16P2MATT10: REAL ANALYSIS

Hours per week: 5 **Total Credits: 4**

Text 1: Tom Apostol, Mathematical Analysis (second edition), Narosa Publishing House.
Text 2: Walter Rudin, Principles of Mathematical Analysis (Third edition), International Student Edition.

Module-1 **(17 hours.)**

Functions of bounded variation and rectifiable curves Introduction, properties of monotonic functions, functions of bounded variation, total variation, additive property of total variation, total variation on(a, x) as a functions of x, functions of bounded variation expressed as the difference of increasing functions, continuous functions of bounded variation, curves and paths, rectifiable path and arc length, additive and continuity properties of arc length, equivalence of paths, change of parameter.

(Chapter 6, Section: 6.1 - 6.12. of Text 1)

Module 2 **(18 hours.)**

The Riemann-Stielljes Integral. Definition and existence of the integral, properties of the integral, integrationand differentiation.

(Chapter 6 - Section 6.1 to 6.22 of Text 2)

Module 3 **(22 hours.)**

Sequence and Series of Functions Discussion of main problem, uniform convergence, uniform convergence and continuity, uniform convergence and integration, uniform convergence and differentiation, the Stone-Weierstrass theorem (without proof).

(Chapter 7 Section. 7.7 to 7.18 of Text 2)

Module 4 **(18 hours.)**

Some Special Functions, Power series, the exponential and logarithmic functions, the trigonometric functions, the algebraic completeness of complex field.

(Chapter 8 - Section 8.1 to 8.8 of Text 2)

References:

1. Royden H.L, Real Analysis, 2nd edition, Macmillan, New York.

2. Bartle R.G, The Elements of Real Analysis, John Wiley and Sons.

3. S.C. Malik, Savitha Arora, Mathematical Analysis, New Age International Ltd.

4. Edwin Hewitt, Karl Stromberg, Real and Abstract Analysis, Springer International,1978

Question Paper Pattern

Module	**Part A** **(1.5 Marks Question)** **Answer all Questions**	**Part B** **(5 Marks Question)** **Answer any four**	**Part C** **(10 Marks Question)** **Answer one from each module**
I	2	1	2
II	3	2	2
III	3	2	2
IV	2	1	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

SEMESTER III : COURSE: 16P3MATT11: PARTIAL DIFFERENTIAL EQUATIONS

Hours per week: 5 **Total Credits: 4**

Text Book:-Ian Sneddon, Elements of partial differential equations, Mc Graw Hill Book Company.

Module:-1.

Methods of solutions of dx/p = dy/Q = dz/R. Orthogonal trajectories of a system of curves on a surface. Pfaffian differential forms and equations. Solution of Pfaffian differential equations in three variables Partial differential equations. Orgins of first order partial differential equation. Cauchy's problem for first order equation. Linear equations of first order. Integral surfaces passing through a given curve. Surfaces orthogonal to a given system of surfaces. (Sections 1.3 to 1.6 & 2.1 to 2.6 of the text) (21 hours)

Module:-2.

Nonlinear partial differential equation of the first order. Cauchy's method of characteristics. Compatible systems of first order equations. Charpits Method. Special types of first order equations. Solutions satisfying given conditions. Jacobi's method. (Section 2.7 to 2.13 of the text) (21 hours)

Module:-3

The origin of second order equations. Linear partial differential equations with constant coefficients. Equations with variable coefficients., Characteristic curves of second order equations . (Section 3.1, 3.4, 3.5, 3.6 of the text) (17 hours)

Module:-4.

The solution of linear Hyperbolic equations. Separation of variables. Non linear equations of the second order . Elementary solutions of Laplace equation. Families of equipotential surfaces. Boundary value problems. (Section 3.8, 3.9, 3.11 ,4.2, 4.3,4.4 of the text) (16 hours)

References:

1 . Phoolan Prasad and Renuka Ravindran, Partial differential Equations, New Age International (p) Limited

2 K Sankara Rao, Introduction to Partial Differential Equations, Prentice-Hall of India

3 E.T Copson , Partial differential equations , S .Chand & Co

Question paper pattern

Module	**Part A** **(1.5 Marks Question)** **Answer all Questions**	**Part B** **(5 Marks Question)** **Answer any four**	**Part C** **(10 Marks Question)** **Answer one from each module**
I	3	2	2
II	2	1	2
III	3	2	2
IV	2	1	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

COURSE: 16P3MATT12- ADVANCED FUNCTIONAL ANALYSIS

Hours per week: 5 **Total Credits: 4**

Text Book: Erwin Kreyszig, Introductory Functional Analysis with applications, John Wiley and sons, New York

Module I

Strong and weak convergence, convergence of sequence of operators and functionals, open mapping theorem, closed linear operators, closed graph theorem, Banach fixed point theorem

(Chapter 4 - Sections 4.8, 4.9, 4.12 & 4.13 - Chapter 5 – Section 5.1 of the text) (20 hours)

Module 2

Spectral theory in finite dimensional normed space, basic concepts, spectral properties of bounded linear operators, further properties of resolvant and spectrum, use of complex analysis in spectral theory, Banach algebras, further properties of Banach algebras.

(Chapter 7 - Sections 71. to 7.7 of the text) (20 hours)

Module 3

Compact linear operators on normed spaces, further properties of compact linear operators, spectral properties of compact linear operators on normed spaces, further spectral properties of compact linear operators,

(Chapter 8 - Sections 8.1 to 8.4 of the text) (15 hours)

Module 4

Spectral properties of bounded self adjoint linear operators, further spectral properties of bounded self adjoint linear operators, positive operators, projection operators, further properties of projections

(Chapter 9 - Sections 9.1, 9.2, 9.3, 9.5, 9.6 of the text) (20 hours)

References

1. Simmons, G.F, Introduction to Topology and Modern Analysis, McGraw –Hill, New York 1963.

2. Siddiqi, A.H, Functional Analysis with Applications, Tata McGraw –Hill, New Delhi : 1989

3. Somasundaram. D, Functional Analysis, S.Viswanathan Pvt. Ltd, Madras, 1994

4. Vasistha, A.R and Sharma I.N, Functional analysis, Krishnan Prakasan Media (P) Ltd (1996)

5. M. Thamban Nair, Functional Analysis, A First Course, Prentice – Hall of India Pvt. Ltd, . 2008
6.Walter Rudin, Functional Analysis, TMH Edition, 1974.

Question paper Pattern

Module	**Part A** **(1.5 Marks Question)** **Answer all Questions**	**Part B** **(5 Marks Question)** **Answer any four**	**Part C** **(10 Marks Question)** **Answer one from each module**
1	3	2	2
2	2	2	2
3	2	1	2
4	3	1	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

COURSE: 16P3MATT13: GRAPH THEORY

Hours per week: 5 **Total Credits: 4**

Text:R.Balakrishnan and K. Ranganathan, A Text book of Graph Theory, Springer
Module: -1 Basic results and directed graphs

Basic concepts. sub graphs, degrees of vertices. Paths and connectedness, automorphism of a simple graph, line graphs, basic concepts and tournaments. Connectivity Vertex cuts and edge cuts. Connectivity and edge connectivity, blocks.(Chapter 1 Sections 1.1 to 1.5 and 1.6 (Up to 1.6.3)
Chapter 2 Sections 2.1 and 2.2 Chapter 3 Sections 3.1 to 3.3 of the text) (18 hours)

Module:- 2 Trees:
Definition, characterization and simple properties, centres and centroids, counting the number of spanning trees, Cayley's formula, Connector Problems ,Kruskal's Algorithm, Prim's algorithm and Djikstra's algorithm.
(Chapter 4 Sections 4.1 to 4.4 Chapter 10 Sections 10.1 to 10.4 of the text) (17 hours)

Module:- 3
Independent Sets, Eulerian Graphs; Hamiltonian Graphs and Vertex Colouring, Vertex independent sets and vertex coverings. edge independent sets, Eulerian graphs, Hamiltonian graphs, vertex colourings, critical graphs, triangle free graphs.
(Chapter 5 Sections 5.1 and 5.2 Chapter 6 Sections 6.1 and 6.2Chapter 7 Sections 7.1 to 7.3 of the text)
(20 hours)

Module:- 4 :
Edge colouring and planarity- Edge colouring of graphs, planar and non planar graphs, Euler formula and its consequences, K5 and K3,3 are non planar graphs, dual of a plane graph.Kuratowski's theorem, The four colour theorem and the Heawood five colour theorem.
(Chapter 7 Section 7.4 .1 to 7.4.4 , Chapter 8 Sections 8.1 to 8.6 of the text) (20 hours)

References:
1. John Clark and Derek Allan Holton, A First Look at Graph Theory, Allied Publishers.
2. Douglas B West, Introduction to Graph Theory, Prentice Hall of India
3. F.Harary, Graph Theory, Addison-Wesley, 1969.

Question paper pattern

Module	**Part A** **(1.5 Marks Question)** **Answer all Questions**	**Part B** **(5 Marks Question)** **Answer any four**	**Part C** **(10 Marks Question)** **Answer one from each module**
I	2	1	2
II	3	2	2
III	3	2	2
IV	2	1	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

16P3MATT14: OPERATIONS RESEARCH

Hours per week: 5 **Total Credits : 4**

Text - 1- K.V. Mital and C. Mohan, Optimization Methods in Operation Research and Systems Analysis, 3rd edition.

Text -2- Ravindran, Philips and Solberg. Operations Research Principle and Practice, 2nd edition, John Wiley and Sons.

Text - 3- K.V. Mital and C. Mohan, Optimization Methods in Operation Research and Systems Analysis, 3rd edition, New Age International Pvt. Ltd.

Text - 4 -Man Mohan, P.K. Gupta and Kanti Swarup, Operations Research, Sultan Chand and Sons. Module I: INVENTORY MODELS

Module I:

INVENTORY MODELS :Introduction –The inventory decisions-Cost associated with inventory-Factors affecting inventory control - Economic order quantity-Deterministic inventory Problems with no shortages - Deterministic inventory Problems with shortages – EOQ problems with price breaks. (Chapter 19; Section 19.1 – 19.8 of text 4)
(15 hours)

Module 2:

NON- LINEAR PROGRAMMING : Basic concepts – Taylor's series expansion – Fibonacci Search - golden section search – Hooke and Jeeves search algorithm – gradient projection search – Lagrange multipliers –non-linear optimization: Kuhn-Tucker conditions (Chapter 8; Sections: 8.1 – 8.6 and 8.9 of text – 2)
(15 hours)

Module 3:

DYNAMIC PROGRAMMING : Introduction - Minimum path problem – Single additive constraint, additively separable return – Single multiplicative constraints, additively separable return - Single additive constraint, multiplicatively separable return - Examples of failure – Decomposition – backward and forward recursions – Systems with more than one constraint (Chapter: 10; Sections: 10.1 – 10.12 of text – 1, excluding 10.6, 10.7)
(15 hours)

Module 4:

INTEGER PROGRAMMING: I.L.P in two dimensional space – General I.L.P. and M.I.L.P problems – cutting planes – remarks on cutting plane methods – branch and bound method (Chapter 6 ; sections: 6.1 – 6.9 of text – 1)
(10 hours)

FLOW AND POTENTIALS IN NETWORKS : Graphs- definitions and notation – minimum path problem – spanning tree of minimum length – problem of minimum potential difference – scheduling of sequential activities – maximum flow problem (Chapter 5–Sections 5.1 – 5.7of text - 1) (20 hours)

Reference.

1.S.S. Rao, Optimization Theory and Applications, 2nd edition, New Age International Pvt. 2. J.K. Sharma,

2.Operations Research: Theory and Applications, Third edition, Macmillan India Ltd. 3. Hamdy A. Thaha,

3.Operations Research – An Introduction, 6th edition, Prentice Hall of India Pvt. Ltd.

Question Paper Pattern

Module	**Part A** **(1.5 Marks Question)** **Answer all Questions**	**Part B** **(5 Marks Question)** **Answer any four**	**Part C** **(10 Marks Question)** **Answer one from each module**
I	2	0	2
II	3	2	2
III	2	2	2
IV	3	2	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

COURSE: 16P3MATT15: NUMBER THEORY

Hours per week: 5 **Total Credits:4**

Text Book:

1. **Introduction to Analytic Number Theory, Tom M Apostol, *Springer International Student Edition.***
2. **Algebraic Number Theory and Fermat's Last Theorem, Ian Stewart and David Tall, *Third Edition***

Module-1 **(25 hours.)**

The Mobius function, the Euler totient function, the Dirichlet product of arithmetical functions, Dirichlet inverses and Mobius inversion formula, the Mangoldt function , multiplicative functions and Dirichlet multiplication, the inverse of completely multiplicative functions, the Liovillie's function , the divisor function , generalized convolutions.

The big oh notation, asymptotic equality offunctions, Euler's summation formula, some elementary asymptotic formulas, theaverage order of$d(n)$, The average order of the divisor function , average order of $\varphi(n)$, an application of distribution of lattice points visible from the origin, averageorder of$\mu(n)$ and of $\Lambda(n)$, the partial sums of a Dirichlet product, application to$\mu(n)$ and $\Lambda(n)$.

.(Chapter 3, Sections 3.1 to 3.11 of Text-1), (Chapter 2, Sections 2.1 to 2.14 of Text-1)

Module 2 **(18 hours.)**

Chebyshev's functions $\Psi(x)$ and $\vartheta(x)$, relation connecting$\Psi(x)$ and $\pi(x)$, some equivalent forms of prime number theorem, inequalities of$\pi(n)$ andp_n

Definition and basic properties of congruences, residue classes and complete residue systems, liner congruences , reduced residue systems and Euler – Fermat theorem,Polynomial congruences modulo, Lagrange's theorem, applications of Lagrange's theorem, simultaneous linear congruences, the Chinese reminder theorem

(Chapter 5, Sections 5.1 to 5.7 of Text-1), (Chapter 4, Sections 4.1 to 4.5 of Text-1)

Module 3 **(17 hours.)**

Trivial Factorizations, Factorization into Irreducibles, Examples of Non-Unique Factorization into Irreducibles, Prime Factorization, Euclidean Domains, Euclidean Quadratic Fields.

(Chapter 4 – Sections 4.2 to 4.7 of text Text-2)

Module 4 **(15 hours.)**

Prime Factorization of Ideals, The Norm of an Ideal, Nonunique Factorization of Cyclotomic Fields.

(Chapter 5-Sections 5.1 to 5.4 of Text 2)

References:

1. Hardy G.H and Wright E.M, Introduction to the Theory of numbers, Oxford, 1981
2. Leveque W.J, Topics in Number Theory, Addison Wesley, 1961.
3. J.P Serre, A Course in Arithmetic, GTM Vol. 7, Springer-Verlag, 1973
4. D Marcus, Number Fields (Springer-Verlag, New York-Heidelberg)

Question paper Pattern

Module	**Part A** **(1.5 Marks Question)** **Answer all Questions**	**Part B** **(5 Marks Question)** **Answer any four**	**Part C** **(10 Marks Question)** **Answer one from each module**
1	2	3	2
2	2	1	2
3	3	1	2
4	3	1	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

SEMESTER IV – ELECTIVES

COURSE: 16P4MATT16 EL: DIFFERENTIAL GEOMETRY

Hours per week: 5 **Total Credits: 3**

Text Book: John A. Thorpe, Elementary Topics in Differential Geometry

Module 1: Graphs and level sets, vector fields, the tangent space, surfaces, vector fields on surfaces, orientation. (Chapters 1 to 5 of the text) (15 hours)

Module 2: The Gauss map, geodesics, Parallel transport, (Chapters 6, 7 & 8 of the text) (20 hours)

Module 3: The Weingarten map, curvature of plane curves, Arc length and line integrals

(Chapters 9, 10 & 11 of the text) (20 hours)

Module 4: Curvature of surfaces

(Chapters 12 of the text). (20 hours)

References:- 1. Serge Lang, Differential Manifolds

2. I.M. Siger, J.A Thorpe, Lecture notes on Elementary topology and Geometry, Springer (1967)

3. S. Sternberg, Lectures on Differential Geometry, Prentice-Hall, 1964.

4. M. DoCarmo, Differential Geometry of curves and surfaces.

5. Goursat, Mathematical Analysis, Vol – 1(last two chapters)

Question Paper Pattern

Module	**Part A** **(1.5 Marks Question)** **Answer all Questions**	**Part B** **(5 Marks Question)** **Answer any four**	**Part C** **(10 Marks Question)** **Answer one from each module**
I	3	2	2
II	3	1	2
III	3	2	2
IV	1	1	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

COURSE: 16 P4MATT17EL: MULTIVARIATE CALCULUS AND INTEGRAL TRANSFORMS

Hours per week: 5 **Total Credits: 3**

Text 1: Tom APOSTOL, Mathematical Analysis, Second edition, Narosa Publishing House.
Text 2: WALTER RUDIN, Principles of Mathematical Analysis, Third edition – International Student Edition.

Module 1:
The Weirstrass theorem, other forms of Fourier series, the Fourier integral theorem, the exponential form of the Fourier integral theorem, integral transforms and convolutions, the convolution theorem for Fourier transforms. (Chapter 11 Sections 11.15 to 11.21 of Text 1) (16 hours)

Module 2:
Multivariable Differential Calculus The directional derivative, directional derivatives and continuity, the total derivative, the total derivative expressed in terms of partial derivatives, An application of complex- valued functions, the matrix of a linear function, the Jacobian matrix, the chain rate matrix form of the chain rule. (Chapter 12 Sections. 12.1 to 12.10 of Text 1) (17 hours.)

Module 3:
Implicit functions and extremum problems, the mean value theorem for differentiable functions, a sufficient condition for differentiability, a sufficient condition for equality of mixed partial derivatives, functions with non-zero Jacobian determinant, the inverse function theorem (without proof), the implicit function theorem (without proof), extrema of real- valued functions of one variable, extrema of real- valued functions of several variables. Chapter 12 Sections-. 12.11 to 12.13. of Text 1 Chapter 13 Sections-. 13.1 to 13.6 of Text 1 (21 hours.)

Module 4:
Integration of Differential Forms Integration, primitive mappings, partitions of unity, change of variables, differential forms, Stokes theorem (without proof)
Chapter 10 Sections. 10.1 to 10.25, 10.33 of Text 2 (21 hours.)

References:- 1. Limaye Balmohan Vishnu, Multivariate Analysis, Springer.
2. Satish Shirali and Harikrishnan, Multivariable Analysis, Springer

Question Paper Pattern

Module	**Part A** **(1.5 Marks Question)** **Answer all Questions**	**Part B** **(5 Marks Question)** **Answer any four**	**Part C** **(10 Marks Question)** **Answer one from each module**
I	3	2	2
II	2	1	2
III	3	2	2
IV	2	1	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

COURSE: 16P4MATT18EL -COMBINATORICS

Hours per week: 5 **Total Credits:3**

Text Book:

Chen Chuan -Chong, Koh Khee Meng, Principles and Techniques in Combinatorics, World Scientific, 1999.

Module I

Permutations and Combinations Two basic counting principles, Permutations, Circular permutations, Combinations, The injection and bijection principles, Arrangements and selection with repetitions ,Distribution problems

(Chapter I of the text) (16 hours)

Module II

Binomial Coefficients. The Piegeonhole Principle and Ramsey Numbers Introduction, The piegeonhole principle, More examples, Ramsey type problems and Ramsey numbers, Bounds for Ramsey numbers

(Chapter 2 Sections 2.1 to 2.4 and Chapter 3 of the text)

(19 hours)

Module III

Principle of Inclusion and Exclusion Introduction, The principle, A generalization, Integer solutions and shortest routes Surjective mappings and Sterling numbers of the second kind, Derangements and generalization..

(Chapter -4 Sections 4.1 to 4.7 of the text) (19 hours)

Module IV

Generating Functions Ordinary generating functions, Some modelling problems, Partitions of integer, Exponential generating functions Recurrence Relations Introduction, Two examples, Linear homogeneous recurrence relations, General linear recurrence relations, Two applications

(Chapter 5, 6 Sections 6.1 to 6.5) (21 hours)

Reference:

1. Hall, Jr, Combinatorial Theory, Wiley- Interscinice, 1998

2. Brualdi, R A, Introductory Combinatorics, Prentice 1992

Question Paper Pattern

Module	**Part A** **(1.5 Marks Question)** **Answer all Questions**	**Part B** **(5 Marks Question)** **Answer any four**	**Part C** **(10 Marks Question)** **Answer one from each module**
I	3	2	2
II	3	1	2
III	2	2	2
IV	2	1	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

COURSE: 16P4MATT19EL- THEORY OF WAVELETS

Hours per week: 5 **Total Credits:3**

Text Book:- Michael W. Frazier, An introduction to Wavelets through Linear Algebra, Springer-verlag, 2000.

Pre-requisites:- Linear Algebra, Discrete Fourier Transforms, Elementary Hilbert Space theorem.

(No questions shall be asked from these sections.)

Module – 1:- Construction of Wavelets on ZN: The First Stage.

(Chapter – 3 Section 3.1 of the text) (18 hours)

Module – 2:-Construction of Wavelets on ZN: The Iteration Step, Examples – Haar, Shannon and Daubechies). (Chapter – 3 Section 3.2 & 3.3 of the text) (18 hours)

Module – 3:- l2 (Z), Complete Orthonormal sets in Hilbert Spaces, L2 [$-\pi$, π] and Fourier Series.

(Chapter – 4 Section 4.1, 4.2 & 4.3 of the text) (19 hours)

Module – 4:- The Fourier Transform and Convolution on l2 (Z), First-stage Wavelets on Z, The Iteration step for Wave lets on Z, Examples- Haar and Daubechies.

(Chapter – 4 Section 4.4, 4.5, 4.6 & 4.7 of the text) (20 hours)

Reference

1. Mayer, Wavelets and Operators, Cambridge University Press 1993

2. Chui, Ann Introduction to Wavelets, Academic Press, Boston, 1992

Question Paper Pattern

Module	**Part A** **(1.5 Marks Question)** **Answer all Questions**	**Part B** **(5 Marks Question)** **Answer any four**	**Part C** **(10 Marks Question)** **Answer one from each module**
I	3	1	2
II	3	2	2
III	2	2	2
IV	2	1	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

COURSE: 16P4MATT20EL -CODING THEORY and CRYPTOGRAPHY

Hours per week: 5 **Total Credits: 3**

Text 1:- Vera Pless 3rd Edition, Introduction to the theory of error coding codes, Wiley Inter Science

Text 2: David M Burton, Elementary Number theory, 7th edition, Mc Graw Hill publications

Module:-1

Introduction Basic Definitions Weight, Maximum Likelihood decoding Synarome decoding, Perfect Codes, Hamming codes, Sphere packing bound, more general facts.

(chapter 1 & Chapter 2 Sections 2.1, 2.2, 2.3 of the text) (20 hours)

Module:-2 Self dual codes, The Golay codes, A double error correction BCH code and a field of 16 elements. (Chapter 2 Section 2.4 & Chapter 3 of the text) (15 hours)

Module:- 3 Cyclic Codes (20 hours)

Chapter 5 of the text 1

Module:- 4:- Introduction to cryptography Ceaser cipher to Public Key cryptography, Knapsack Cryptosystem, an application of Primitive roots to cryptography

(Chapter 10 of Text 2) (20 hours)

Reference:

1. Neal Koblitz, A Course in number theory and Cryptography, 2nd edition, Springer Verlag

2.J H Van Lint, Introduction to Coding Theory, Springer Verlag

Question Paper Pattern

Module	Part A (1.5 Marks Question) Answer all Questions	Part B (5 Marks Question) Answer any four	Part C (10 Marks Question) Answer one from each module
I	3	1	2
II	3	2	2
III	2	2	2
IV	2	1	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

COURSE: 16P4MATT21EL: NUMERICAL ANALYSIS

Hours per week: 5 **Total Credits: 3**

Text Book: Introductory Methods of Numerical Analysis, SS Sastry, PHI Publications 2007 fourth Edition

Module 1.
Numerical solution of algebraic and transcendental equations by Regula-Falsi method Newton-Raphson's method. Fixed point iteration: $x = g(x)$ method etc.

(Chapter 1 sections 1.2,1.3, 1.4 1.5 and chapter 2 Sections 2.2 to 2.7) (15 Hours)

Module 2.
Matrices and Linear System of Equations .
(Chapter 6 sections 6.3 and 6.4) (20 hours)

Module 3.
Interpolation and Differentiation – Integration
(Chapter 3 Sections 3.1, 3.2, 3.3, 3.6, 3.9and 3.10 Chapter 5 Sections 5.1, 5.2, 5.4
(20 hours)

Module 4.
Numerical Solution of Ordinary Differential Equations
(Chapter 7 Sections 7.1 to 7.6)
(20 hours)

Reference

- Numerical Methods: For Scientific and Engineering Computation, (Sixth Edition) M.K. Jain,R.K. Jain,S.R.K. Iyengar
- Numerical Methods , T Veerarajan, Tata McGraw-Hill Education, 2007

Question Paper Pattern

Module	**Part A** **(1.5 Marks Question)** **Answer all Questions**	**Part B** **(5 Marks Question)** **Answer any four**	**Part C** **(10 Marks Question)** **Answer one from each module**
I	3	2	2
II	2	1	2
III	3	2	2
IV	2	1	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

COURSE: 16P4MATT22EL - PROBABILITY THEORY

Hours per week: 5 **Total Credits: 3**

All questions shall be based on the relevant portions of the reference books given in the end of each module

Module - 1

Discrete Probability (Empirical, Classical and Axiomatic approaches), Independent events, Bayes theorem, Random variables, and distribution functions (univariate and multivariate), Expectation and moments, marginal and conditional distributions. Probability Inequalities (Chebychev, Markov). Modes of convergence, Weak and Strong laws of large numbers (Khintchine's Weak Law, Kolmogrov Strong Law, Bernaulli's Strong Law) Central Limit theorem (Lindeberg-Levy theorem).

References. 1. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, 11th Ed., Sultan Chand & Sons, 2011.

2. V.K. Rohatgi, An Introduction to Probability Theory and Mathematical Statistics, 2nd Ed. Wiley Eastern Ltd., 1986.

(15 hours)

Module – 2

Standard discrete and continuous univariate distributions (Binomial, Poisson, Negative binomial, Geometric, Exponential, Hypergeometric, Normal, Rectangular, Cauchy's, Gamma, Beta,), Multivariate normal distribution, Wishart distribution and their properties.

References. For univariate distributions, refer the book 1. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, 11th Ed., Sultan Chand & Sons, 2011.

For Multivariate distributions, refer the book 2. T.W. Anderson, An Introduction to Multivariate Statistical Analysis, 3rd Ed., Wiley Interscience, 2003.

(20 hours)

Module – 3

Methods of estimation, properties of estimators, Cramer-Rao inequality, FisherNeyman criterion for sufficiency, Rao-Blackwell theorem, completeness ,method of maximum likelihood, properties of maximum likelihood estimators , method of moments. Tests of hypothesis: most powerful and uniformly most powerful tests (Neyman – Pearson Lemma).

References. For Estimation, refer the book 1. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, 11th Ed., Sultan Chand & Sons, 2011.

For Tests of Hypothesis, refer the book 2. V.K. Rohatgi, An Introduction to Probability Theory and Mathematical Statistics, 2nd Ed. Wiley Eastern Ltd., 1986.

(20 hours)

Module- 4

Gauss-Markov models, estimability of parameters, best linear unbiased estimators, Analysis of variance and covariance. One way and two way classification with one observation per cell. (20 hours)

References.

1. D.D. Joshi, Linear Estimation and Design of Experiments, Wiley Eastern Ltd., 1990.

2. C.R. Rao, Linear Statistical Inference and its Applications, John Wiely, New York. , 1965.

3. W.G.Cochran and G.M. Cox, Experimental Designs, 2 nd Ed., John Wiely, New York. , 1957.

Question Paper Pattern

Module	**Part A** **(1.5 Marks Question)** **Answer all Questions**	**Part B** **(5 Marks Question)** **Answer any four**	**Part C** **(10 Marks Question)** **Answer one from each module**
I	3	2	2
2	3	1	2
3	2	2	2
4	2	1	2
Total (75 MARKS)	15 Marks	20 Marks	40 Marks

PROJECT: 16P4MATPJ

The M.Sc Mathematics project is an extended piece of independent study and written work. The project will involve an in-depth study of a particular advanced topic in mathematics or statistics.
It will be based around one or more published research papers, as well as advanced textbooks and other resources. Your supervisor will describe an outline of the structure of your project, and suggest some books, papers and other resources you should consult. However, it is expected that you will be proactive in finding further references and resources, and in coming up with your own ideas for further investigations, examples and results. The Project work is evaluated for 100 marks (25 internal and 75 external).

COMPREHENSIVE VIVA - VOCE: 16P4MATCV

There shall be a Comprehensive viva at the end of Semester IV. The Comprehensive viva voce is intended to assess the students understanding of the subjects that are studied during their course. The Comprehensive viva voce is evaluated for 100 marks by the Committee. There are no internal marks for the Comprehensive viva voce.