SACRED HEART COLLEGE (AUTONOMOUS), THEVARA
KOCHI, KERALA, 682013

CURRICULUM AND SYLLABUS

FOR

M.Sc. MATHEMATICS

CHOICE BASED CREDIT AND SEMESTER SYSTEM (CBCSS)

INTRODUCED FROM 2024 ADMISSIONS ONWARDS

Prepared by

Board of Studies in Mathematics

Sacred Heart College Thevara, Kochi.

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SACRED HEART COLLEGE (AUTONOMOUS), THEVARA, KOCHI, KERALA

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1. INTRODUCTION

The Department of Mathematics, Sacred Heart College (Autonomous) Thevara, offers a post graduate degree program in Mathematics with a total of twenty theory courses and a project. The program not only enables the students at mastering the theoretical concepts of various branches of mathematics but also equips them with the necessary skills to succeed in competitive examinations like CSIR-NET, GATE and PhD entrance examinations of institutions such as the IIT's and the Indian Institute of Science.

The syllabus of the program is developed on the O.B.E. (Outcome Based Education) pattern and the program outcomes, program specific outcomes and in particular the course outcomes of each course are clearly elucidated. The total credits of the program is 80, of which 60 credits are allotted for the core courses (there are 5 courses of 4 credits each in each of the first three semesters), 15 credits are allotted to the five elective courses (3 credits for each elective course) in the final semester, 3 credits are allotted for the project and 2 credits are allotted for the comprehensive viva-voce to be conducted at the end of the fourth semester. The project is to be completed during the third and fourth semesters.

The overall focus of the syllabus is on enabling the students to mathematically model real world problems, develop their problem solving skills and enhance their logical skills and critical thinking ability.

Eligibility for Admission

The candidate must have passed B.Sc Mathematics under Core group (Core + Complementary + Open courses) or BSc Statistics (core) or B.Sc Computer Applications with not less than CGPA of 5.0 out of 10 or B.Sc Mathematics under Part III(Main/Core + Subsidiary /Complementary subjects) B.Sc Statistics (main) or B.Sc Computer Application with not less than 50% of marks or B Tech with not less than 50% marks in Mathematics (aggregate of all mathematics papers and a total of 50% for the entire course)

2. REGULATIONS FOR POST GRADUATE PROGRAMMES UNDER CREDIT SEMESTER SYSTEM (CSS) – 2024

2.1 TITLE

These regulations shall be called 'SACRED HEART COLLEGE REGULATIONS FOR POST GRADUATE PROGRAMMES UNDER CREDIT SEMESTER SYSTEM (CSS) – 2024

2.2 SCOPE

Applicable to all Post Graduate (PG) programmes of the college with effect from 2024-25 admissions. The provisions herein supersede all the existing regulations for the post graduate programmes of the college.

2.3 DEFINITIONS

2.3.1 '**Programme**' means the entire course of study and examinations.

2.3.2 'Duration of Programme' means the period of time required for the conduct of the programme. The duration of post graduate programme shall be of four semesters spread over two academic years.

2.3.3 'Semester' means a term consisting of a minimum of ninety working days, inclusive of examination, distributed over a minimum of eighteen weeks each having five working days, each with five contact hours of one hour duration.

2.3.4 '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 requirements.

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

2.3.6 '**Extra credits**' are additional credits awarded to a student over and above the minimum credits required for a programme.

2.3.7 '**Programme Credit'** means the total credits of the PG Programmes. For PG programmes the total credits shall be eighty.

2.3.8 **'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.

2.3.9 **'Elective Group'** means a group consisting of elective courses for the programme.

2.3.10 '**Programme Project'** means a regular project work with stated credits on which the student undergoes 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.

2.3.11 '**Internship**' is on-the-job training for professional careers.

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

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

2.3.14 **'Evaluation'** is the process by which the knowledge acquired by the students is quantified as per the criteria detailed in the regulations.

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

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

2.3.17 **'Department'** means any teaching department offering a programme of study approved by the college / institute as per the Act or Statute of the University.

2.3.18 **'Department Council'** means the body of all teachers of a department in a college.

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

2.3.20 'College Coordinator' means a teacher from the college nominated by the College Council to look into the matters relating to CSS-PG system.

2.3.21 'Letter Grade' or simply **'Grade'** in a course is a letter symbol (A^+, A, B^+, B etc.) which indicates the broad level of performance of a student in a course.

2.3.22 'Grade Point' (GP), is an integer indicating the numerical equivalent of the broad level of performance of a student in a course.

2.3.23 'Grade Point Average' (GPA) is an index of the performance of a student in a course. It is obtained by dividing the sum of the weighted grade points obtained in the course by the sum of the weights of the course ($GPA = \sum WGP/\sum W$).

2.3.24 'Weighted Grade Point' (WGP) is obtained by multiplying the grade point by its weight (WGP = GP x weight).

2.3.25 'Credit Point' (CP) of a course is the value obtained by multiplying the grade point (GPA) by the credit (Cr) of the course (CP = GPA x Cr).

2.3.26 '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 of the courses taken by him/her in that semester. The SGPA shall be rounded off to two decimal places and it determines the overall performance of a student at the end of a semester.

2.3.27 '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.

2.3.28 '**Grace Grade Points'** means grade points awarded to a student for course(s), in recognition of meritorious achievements in NSS/Sports/Arts and cultural activities, as per the orders issued by the college from time to time.

2.4 ATTENDANCE

Being a regular college, physical presence in the regular activities, especially, classes and exams, is mandatory for the students. However, if a student secures 75% of attendance he/she is eligible to appear for the exams, provided there are no other impediments like disciplinary proceedings, malpractice record etc.

2.4.1 Absence: A student found absent for one hour in the forenoon or afternoon session is deprived of the attendance for the entire session as far as eligibility for final exam is concerned.

2.4.2 Leave: A student has to formally report his/her absence with reasons either in advance, or immediately after the absence for obtaining an approved leave. This applies to all sorts of leave – medical, on duty or similar cases.

2.4.3 The student has to retain a copy/section of the approved leave form and produce the same as proof, in case there is any confusion regarding the leave sanctioning. In the absence of such proof, the claims will not be entertained.

2.4.4 Duty Leave: A student representing the college in sports, arts, social service or academic matters, has to get sanction from the class teacher concerned and submit the leave application form duly endorsed by the class teacher and the Head of the Department, and submit it to the Vice Principal. The same will be forwarded by the Vice Principal for attendance entry. The approval of the Department of Physical Education and the class teacher is required for granting attendance related to sports. The time limit for submission mentioned above is applicable in the case of duty leave as well.

2.4.5 Condonation: A student may have the privilege of condonation of attendance shortage (up to a maximum of ten days) on the basis of genuineness of the grounds of absence (medical reasons or college duty), duly recommended by the department. This is not a matter of right. It is a matter of privilege based on Principal's discretion and the good conduct of the student on the campus. A student of PG programme may have only one such opportunity.

2.4.6 Re-admission: A student whose attendance is inadequate will have to discontinue the studies. Such students, whose conduct is good, may be re-admitted with the approval of Governing Body, on the basis of recommendation from the department, and assurance from the student and

the guardian regarding good conduct and compliance in academic and discipline matters. For this the prescribed re-admission fee has to be paid.

2.4.7 Unauthorised absence & removal from rolls: A student, absent from the classes continuously for ten consecutive working days without due intimation or permission, shall be removed from the rolls, and the matter shall be intimated to the student concerned. On the basis of recommendation of the department concerned, re-admission process may be permitted by the Principal.

2.5 PROGRAMME REGISTRATION

2.5.1 A student shall be permitted to register for the programme at the time of admission.

2.5.2 A PG student who registered for the programme shall complete the same within a period of eight continuous semesters from the date of commencement of the programme.

2.6 PROMOTION

A student who registers for the end semester examination shall be promoted to the next semester. However, in extreme circumstances, a student having sufficient attendance who could not register for the end semester examination may be allowed to register notionally by the Principal with the recommendation of the Head of the Department concerned and by paying the prescribed fee.

2.7 EXAMINATIONS

All the end semester examinations of the college will be conducted by the Controller of Examinations. The Principal will be the Chief Controller of Examinations. An Examination Committee consisting of the Chief Controller of Examinations, Controller of Examinations, Additional Chief Superintendent, Deans, IQAC Coordinator and other faculty members nominated by the Principal will act as an advisory body on the matters relating to the conduct of examinations.

2.8 EVALUATION AND GRADING

2.8.1 Evaluation

The evaluation scheme for each course shall contain two parts:

a. Continuous Internal Assessment (CIA)

b. End Semester Examination (ESE)

25% weightage shall be given to internal evaluation and the remaining 75% to external evaluation and the ratio and weightage between internal and external is **1:3**, for the courses with or without practicals (except the courses offered by the School of Communications). In the case of courses offered by the School of Communications, the internal-external assessment ratio shall be **1:1**. In their case, the components for evaluation and their respective weightage shall be determined by their Board of Studies. Both internal and external evaluation shall be carried out in the grading system and the GPAs are to be rounded to two places of decimals.

2.8.2 Direct Grading: The direct grading for the components of CIA shall be based on six letter grades (A+, A, B, C, D and E) with numerical values of 5, 4, 3, 2, 1 and 0 respectively as per the following scale of accuracy/level of quality. The questions for internal test papers and the end semester examination shall be prepared in such a way that the answers can be awarded A+, A, B, C, D and E grades.

Grade	Grade Points	Scale of accuracy/Level of quality
A+	5	Greater than or equal to 90%
A	4	80% to less than 90%
B	3	60% to less than 80%
C	2	40% to less than 60%
D	1	20% to less than 40%
E	0	Less than 20%

2.8.3 Grade Point Average (GPA): Internal and external components are separately graded and the combined GPA shall be calculated for each course with weightage **1** for internal and **3** for external.

2.8.4 Components of Continuous Internal Assessment (CIA): Grades shall be given to the evaluation of theory/practical/project/comprehensive viva-voce and all internal evaluations are based on the Direct Grading System.

The Board of studies of the respective subject is permitted to make changes, if necessary, with regard to the weightages for the components of CIA without changing the total weightage of 5.

a. Components of Internal Evaluation (for theory)

Sl.No	**Components**	**Weightage**
i.	Assignments	1
ii.	Seminar	1
iii.	Quiz/Field study/Industrial Visit/Viva Voce/Study Tour	1
iv.	Test paper-1	1

v.	Test paper-2	1
	Total	5

b. Components of Internal Evaluation (for practical)

Components	Weightage
Laboratory Involvement	1
Written/ Lab Test	2
Record	1
Viva Voce	1
Total	5

c. Components of Internal Evaluation (for project)

Components	Weightage
Relevance of the topic and analysis	2
Project content and presentation	2
Project viva voce	1
Total	5

d. Components of Internal Evaluation(for comprehensive viva voce)

Components	Weightage
Comprehensive viva voce (all courses from first semester to fourth semester)	5
Total	5

Components of End Semester Examination (ESE):

a. For Theory

Evaluation shall be based on the following pattern of questions:

Sl. No.	Type of Questions	Weight	*Number of questions to be answered
1	Short answer type questions	1	8 out of 10
2	Short essay/problem solving type questions	2	6 out of 8
3	Long essay/problem solving type questions	5	2 out of 4

*Board of studies of respective subjects can decide on the number questions in each type of questions.

b. For Practical

Components of External Evaluation (for practical)

Components	Weightage
Laboratory Involvement	3
Written/ Lab Test	6
Record	3
Viva Voce	3
Total	15

The Board of studies of the respective subject is permitted to make changes, if necessary, with regard to the weightages for the components of Practical Examinations (External) without changing the total weightage i.e. 15. The pattern of questions for external evaluation of practical examinations can also be prescribed by the respective Board of Studies.

c. Components of External Evaluation (for project)

Components	Weightage
Relevance of the topic and analysis	3
Project content and presentation	7
Project viva voce	5
Total	15

d. Components of External Evaluation(for comprehensive viva voce)

Components	Weightage
Comprehensive viva voce (all courses from first semester to fourth semester)	15
Total	15

2.8.6 **Project:** Project work is a part of the syllabus of most of the programmes offered by the college. The guidelines for doing projects are as follows:

i. Project work shall be completed by working outside the regular teaching hours.
ii. Project work shall be carried out under the supervision of a teacher in the concerned department or an external supervisor.
iii. 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.
iv. There should be an internal assessment and external assessment for the project work in the ratio 1:3
v. The external evaluation of the project work consists of valuation of the dissertation (project report) followed by presentation of the work and viva voce.

2.9 PERFORMANCE GRADING

2.9.6 Students are graded based on their performance (GPA/SGPA/CGPA) at the examination on a 7 point scale as detailed below

Range	Grade	Indicator
4.50 to 5.00	**A+**	**Outstanding**
4.00 to 4.49	**A**	**Excellent**
3.50 to 3.99	**B+**	**Very Good**
3.00 to 3.49	**B**	**Good (Average)**
2.50 to 2.99	**C+**	**Fair**
2.00 to 2.49	**C**	**Marginal (Pass)**
Up to 1.99	**D**	**Deficient (Fail)**

2.9.7 No **separate minimum** is required for internal evaluation for a pass, but a minimum a '**C'** grade is required for a pass in an external examination. However, a minimum '**C'** grade is required for pass in a course and the programme as well.

2.9.8 A student who fails to secure a minimum grade '**C'** for a pass in a course shall be permitted to write the examination along with the next batch.

2.9.9 **Improvement of GPA:** The candidates who wish to improve the GPA of the external examinations of a course/courses can do the same by appearing in the external examination of the semester concerned along with the immediate junior batch. The facility is restricted to first and second semesters of the programme.

2.9.10 **Computation of SGPA and CGPA:** For the successful completion of a semester, a student should pass all the courses and score at least the minimum SGPA grade **'C'**. After the successful completion of a semester, Semester Grade Point Average (**SGPA**) of a student in that semester is calculated as the ratio of the sum of the credit points of all courses taken by a student in the semester to the total credits of that semester.

Thus, **SGPA = TCP/TCr**, where **TCP** is **Total Credit Point of that semester (** $\sum_{i=1}^{n} CP_i$ **)** and **TCr is Total Credit of that semester (** $\sum_{i=1}^{n} Cr_i$ **)** where '**n**' is the number of courses in that semester.

Cumulative Grade Point Average (**CGPA**) of a programme is calculated as the ratio of the sum of the credit points of all the courses of the programme to the total credits of the programme.

$$\mathbf{CGPA} = \frac{\sum(\mathbf{SGPA} \times \mathbf{TCr})}{\sum \mathbf{TCr}}$$

The SGPA/CGPA shall be rounded off to two decimal places.

For the successful completion of a programme, a student should pass all the courses and score at least the minimum CGPA grade **'C'**. However, a student is permitted to move to the next semester irrespective of her/his SGPA.

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

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 Head of the Department and a copy should be kept in the department for at least two years for verification.

2.10 REGISTRATION FOR THE EXAMINATION

A. All students admitted in a programme with remittance of prescribed fee are eligible for the forthcoming semester examinations.
B. Online application for registration to the various End Semester Examinations shall be forwarded to the CE along with prescribed fee for each course in prescribed format.
C. The eligible candidates who secure the prescribed minimum attendance of the total duration of the course and possess other minimum qualification prescribed in the regulations for each course shall be issued the hall tickets. The hall ticket shall be downloaded by the students from the college website.

The mode of fee remittance shall be through the prescribed bank.

2.11 SUPPLEMENTARY EXAMINATIONS

Candidates who failed in an examination can write the supplementary examination conducted by the College along with regular examinations.

2.12 PROMOTION TO THE NEXT HIGHER SEMESTER

A candidate shall be eligible for promotion from one semester to the next higher semester if,

A. He / she secures a minimum 75 % attendance and registered for the End Semester Examination of the programme for which he/she is studying.

B.His / her progress of study and conduct are satisfactory during the semester completed, as per the assessments recorded by the course teachers and the Head of the Department concerned.

2.13 CERTIFICATES

1. Diploma and Degree certificates are issued by the Mahatma Gandhi University, Kottayam as per the act and statues of the University on the submission of the consolidated mark / score cards of the students by the College.
2. A consolidated mark / scored card shall be issued to the candidates after the publication of the results of the final semester examination taken by the candidate.
3. A Course Completion Certificate with classification shall be issued to students till the provisional certificate is issued by the university.

2.14 RANK CERTIFICATE

Candidates shall be ranked in the order of merit based on the CGPA secured by them. Grace grade points awarded to the students shall not be counted for fixing the rank/positions. Rank certificates shall be issued to the candidates who secure positions from the first to the third in the order of merit. The position certificates shall be issued to the next seven candidates in the order of merit.

2.15 AWARD OF DEGREE

The successful completion of all the courses with **'C'** grade shall be the minimum requirement for the award of the degree.

2.16 MONITORING

There shall be a Monitoring Committee constituted by the Principal consisting of faculty advisors, HoD, a member from Teaching Learning Evaluation Committee (TLE) and the Deans to monitor the internal evaluations conducted by college. The course teacher, class teacher and the deans should keep all the records of the internal evaluation, for at least a period of two years, for verification.

Every programme conducted under Credit Semester System shall be monitored by the College Council under the guidance of IQAC Coordinator, Controller of Exams, Academic Deans and HoDs. An academic committee consisting of the vice principal, deans and teachers nominated by the Principal shall look after the day-to-day affairs of these regulations.

2.17 GRIEVANCE 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: Level of the course teacher concerned

Level 2: 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 Faculty concerned, HOD of the department concerned and one member of the Academic Council nominated by the Principal every year as members

2.18 TRANSITORY PROVISION

Notwithstanding anything contained in these regulations, the Principal of the college has the power to make changes in these regulations, by due orders, that shall be applied to any programme with such modifications as may be necessary on the recommendations of the Board of Studies of the respective programme.

3. SYLLABUS FOR M.SC. MATHEMATICS PROGRAMME

Course Structure for MSc Mathematics

Semester	Course	Teaching hours/ week	Credits	Total Credits
I	24P1MATT01	**5**	**4**	**20**
	24P1MATT02	**5**	**4**	
	24P1MATT03	**5**	**4**	
	24P1MATT04	**5**	**4**	
	24P1MATT05	**5**	**4**	
II	24P2MATT06	**5**	**4**	**20**
	24P2MATT07	**5**	**4**	
	24P2MATT08	**5**	**4**	
	24P2MATT09	**5**	**4**	
	24P2MATT10	**5**	**4**	
III	24P3MATT11	**5**	**4**	**20**
	24P3MATT12	**5**	**4**	
	24P3MATT13	**5**	**4**	
	24P3MATT14	**5**	**4**	
	24P3MATT15	**5**	**4**	
IV	24P4MATT16	**5**	**3**	**20**
	24P4MATT17	**5**	**3**	
	ELECTIVE 1	**5**	**3**	
	ELECTIVE 2	**5**	**3**	
	ELECTIVE 3	**5**	**3**	
	24P4MATPJ	**PROJECT**	**3**	
	24P4MATCV	**Viva –Voce**	**2**	
TOTAL				**80**

COURSE CODE	SEM	NAME OF THE COURSE	HR/ W	CR	T CR
24P1MATT01	I	LINEAR ALGEBRA	5	4	20
24P1MATT02		ALGEBRA – I	5	4	
24P1MATT03		REAL ANALYSIS	5	4	
24P1MATT04		ORDINARY DIFFERENTIAL EQUATIONS	5	4	
24P1MATT05		OPTIMIZATION TECHNIQUES	5	4	
24P2MATT06	II	BASIC TOPOLOGY	5	4	20
24P2MATT07		COMPLEX ANALYSIS	5	4	
24P2MATT08		ALGEBRA – II	5	4	
24P2MATT09		ALGEBRAIC NUMBER THEORY	5	4	
24P2MATT10		MEASURE THEORY AND INTEGRATION	5	4	
24P3MATT11	III	PARTIAL DIFFERENTIAL EQUATIONS	5	4	20
24P3MATT12		FUNCTIONAL ANALYSIS – I	5	4	
24P3MATT13		ADVANCED TOPOLOGY	5	4	
24P3MATT14		ADVANCED COMPLEX ANALYSIS	5	4	
24P3MATT15		MULTIVARIATE CALCULUS AND FOURIER SERIES	5	4	
24P4MATT16	IV*	FUNCTIONAL ANALYSIS - II	5	3	20
24P4MATT17		DIFFERENTIAL	5	3	

		GEOMETRY			
24P4MATT18EL		PROBABILITY THEORY	5	3	
24P4MATT19EL		NUMERICAL ANALYSIS WITH PYTHON 3	5	3	
24P4MATT20EL		THEORY OF WAVELETS	5	3	
24P4MATT21EL		ALGEBRAIC TOPOLOGY	5	3	
24P4MATT22EL		INTRODUCTION TO CHAOTIC DYNAMICAL SYSTEMS	5	3	
24P4MATT23EL		ABSTRACT HARMONIC ANALYSIS	5	3	
24P4MATT24EL		GRAPH THEORY	5	3	
24P4MATPJ		PROJECT/ DISSERTATION		3	
24P4MATCV		VIVA VOCE		2	
TOTAL CREDITS					80

*(Any three elective courses of seven in semester IV)

Programme Outcomes

At the end of the programme the students are able to,

PO1	Exercise their critical thinking in creating new knowledge leading to innovation, entrepreneurship and employability
PO2	Effectively communicate the knowledge of their study and research in their respective disciplines to their stakeholders and to the society at large.
PO3	Make choices based on the values upheld by the institution, and have the readiness and know-how to preserve the environment and work towards sustainable growth and development.
PO4	Develop an ethical view of life and have a broader (global) perspective transcending the provincial outlook.

PO5	Explore new knowledge independently for the development of the nation and the world and are able to engage in a lifelong learning process.

Programme Specific Outcomes

At the end of the programme a student should be able to:

PSO1	Explain the advanced concepts in Mathematics.
PSO2	Develop problem-solving skills and apply them independently to solve problems in pure and applied mathematics.
PSO3	Develop skills to mathematically model real-time problems and apply mathematical tools to solve them.
PSO4	Recognize the need to engage in lifelong learning through continuing education and research

SEMESTER- I

COURSE: 24P1MATT01 LINEAR ALGEBRA

Total Hours: 75 **Credits: 4**

At the end of this course, students will be able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs	Lab Hrs
CO1	Summarize the concepts of vector spaces, subspaces, basis and dimension, coordinates and properties of row equivalence.	**PO1/PSO 1**	**U**	**C**	**12**	**0**
CO2	Explain the linear transformations and their algebra and representation of transformations by matrices.	**PO1/PSO 1**	**U**	**C**	**25**	**0**
CO3	Demonstrate the ideas of commutative Rings, determinant functions, permutation and uniqueness of determinants, additional properties of determinants.	**PO1/PSO 1**	**U**	**C**	**15**	**0**
CO4	Illustrate the ideas of characteristic values, annihilating polynomials, invariant subspaces, direct sum decompositions	**PO1/PSO 1**	**U**	**C**	**23**	**0**

Text Book:

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

Module 1

Vector spaces, subspaces, basis and dimension (Proof of theorems excluded). Co-ordinates, summary of row-equivalence. (Chapter 2: Sec 2.1, 2.2, 2.3, 2.4 & 2.5 of the text) **(12 hours)**

Module 2

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) **(25 hours)**

Module 3

Determinants: commutative Rings, determinant functions, permutation and uniqueness of determinants, additional properties of determinants. (Chapter 5 - 5.1, 5.2, 5.3 & 5.4 of the text)

(15 hours)

Module 4

Introduction to elementary canonical forms, characteristic values, annihilating polynomials, invariant subspaces, direct sum decompositions. (Chapter 6 - 6.1, 6.2, 6.3, 6.4, 6.6 of the text)

(23 hours)

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 Weight Question) Answer any 8**	**Part B (2 Weight Question) Answer any six**	**Part C (5 Weight Question) Answer any two**
1	2	2	1
2	3	2	1
3	3	2	1
4	2	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

COURSE: 24P1MATT02 ALGEBRA - I

Total Hours: 75 **Credits: 4**

At the end of this course, students will be able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs	Lab Hrs
CO1	Analyze groups using generating sets, direct products, finitely generated abelian groups, and group action on a set.	**PO1/PSO 1**	**An**	**C**	**17**	0
CO2	Comprehend Isomorphism Theorems, subnormal/normal series, and solvable groups,	**PO1/PSO 1**	**An**	**C**	**20**	0
CO3	Apply free groups and free abelian groups in the proof of the fundamental theorem of abelian groups and in group presentations.	**PO1/PSO 1**	**A**	**C**	**20**	0
CO4	Comprehending Sylow theorems, students will apply the Sylow theory to study groups of different orders.	**PO1/PSO 1**	**E**	**C**	**18**	0

Text Book: John B. Fraleigh and Neal E Brand, A First Course in Abstract Algebra, 8th edition, Pearson Education.

Module 1

Generating Sets, Direct Products and Finitely generated Abelian Groups, fundamental theorem of finitely generated abelian groups (without proof), Group Action on a set, p-Groups, Cauchy's theorem.(Sections 7.1-7.6, Section 9 and Section 14)

(19 hours)

Module 2

Isomorphism Theorems. (Proof of Theorem 16.2 is excluded). Subnormal and Normal Series, Solvable Groups(Section 16, Sections 18.1-18.3 and 18.12-18.14 and 18.19-18.20)

(20 hours)

Module 3

Free Abelian Groups, Free Groups, Group Presentations (Section 19, Section 20 and Section 21)

(20 hours)

Module 4

Sylow theorems, Applications of the Sylow Theory.

(Sections 17 Proofs of Lemma 17.2, Corollary 17.3, theorem 17.4,

Theorem 17.6 and Theorem 17.7 are excluded.) **(16 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 Weight Question)** **Answer any 8**	**Part B** **(2Weight Question)** **Answer any six**	**Part C** **(5 Weight Question)** **Answer any two**
1	2	2	1
2	3	2	1
3	3	2	1
4	2	2	1
Total	10	8	4
Total **Weight 30**	**8**	**12**	**10**

COURSE: 24P1MATT03 REAL ANALYSIS

Total Hours: 75 **Credits: 4**

At the end of this course, students will be able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Explain the functions of bounded variations, rectifiable curves, paths and equivalence of paths.	**PO1/PSO 1**	**U**	**C**	**17**	**0**
CO2	Illustrate the properties of Riemann-Stieljes integral.	**PO1/PSO 1**	**U**	**C**	**18**	**0**
CO3	Analyze the uniform convergence of a sequence of functions with continuity, integrability, differentiability.	**PO1/PSO 1**	**U**	**C**	**22**	**0**
CO4	Apply the properties of power series to exponential, logarithmic and trigonometric functions.	**PO1/PSO 1**	**U**	**C**	**18**	**0**

Text Books:

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

Module 1

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) **(17 hours)**

Module 2

The Riemann-Stieljes Integral. Definition and existence of the integral, properties of the integral, integration and differentiation. (Chapter 6 - Section 6.1 to 6.22 of Text 2) **(18 hours)**

Module 3

Discussion of main problem, Uniform convergence, Uniform convergence and Continuity, Uniform convergence and Integration, Uniform convergence and Differentiation (Chapter 7 Section. 7.1 to 7.18 of Text 2) **(22 hours)**

Module 4

Equi continuous families of functions, the Stone - Weierstrass theorem, Power series, the exponential and logarithmic functions, the trigonometric functions, the algebraic completeness of complex field. (Chapter 7 – Sections 7.19 to 7.27, Chapter 8 - Section 8.1 to 8.8 of Text 2)

(18 hours)

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 Weight Question) Answer any 8**	**Part B (2 Weight Question) Answer any 6**	**Part C (5 Weight Question) Answer any 2**
1	3	2	1
2	2	2	1
3	3	2	1
4	2	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

COURSE: 24P1MATT04 ORDINARY DIFFERENTIAL EQUATIONS

Total Hours:75 **Credits: 4**

At the end of this course, students will be able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Summarize the concepts of Sturm Separation theorem and Sturm Liouville problems	**PO1/PSO 1**	**U**	**C**	**17**	**0**
CO2	Explain the properties of Legendre and Bessel's polynomials	**PO1/PSO 2**	**U**	**P**	**20**	**0**
CO3	Analyze the concept of linear and nonlinear systems and their stability	**PO1/PSO 2**	**U**	**C**	**20**	**0**
CO4	Illustrate the ideas of existence and uniqueness of solutions	**PO1/PSO 1**	**U**	**C**	**18**	**0**

Text Book

George F. Simmons, Differential Equations with Applications and Historical Notes, Second Edition, Tata McGraw Hill Publishing Company Limited

Module 1

Qualitative properties of solutions and Boundary value problems Oscillations and the Sturm separation theorem, the Sturm comparison theorem, Eigen values, eigen functions and the vibrating string, Sturm – Liouville problems(Sections 24, 25, 40 and 43 of the text)

(17 hours)

Module 2

Some Special Functions of Mathematical Physics, Legendre polynomials, Properties of Legendre polynomials, Bessel`s functions, the gamma function, properties of Bessel functions, Additional properties of Bessel functions (Sections 44, 45, 46, 47 and Appendix C of the text) **(20 hours)**

Module 3

System of First order Equations and Nonlinear Equations, General remarks on systems, Linear systems, Homogeneous linear systems with constant coefficients, Nonlinear systems. Volterra`s prey- predator equations, Autonomous systems. The phase plane and its phenomena, Types of Critical points. Stability, Critical Points and stability for linear systems, Stability by Liapunov`s direct method (proof excluded) **(**Sections 54 to 61 of the text)

(20 hours)

Module 4

The Existence and Uniqueness of Solutions, The method of successive approximations, Picard`s theorem, Systems. The second order linear equation (Sections 68, 69 and 70 of the text)

(18 hours)

REFERENCES:

1. Shepley L. Ross - Differential Equations, 3rd ed., (Wiley India).
2. E.A. Coddington - An Introduction to Ordinary Differential Equation, PHI.
3. W.E. Boyce & R.C. Diprima - Elementary Differential Equations and boundary value Problems, (Wiley India)

Question paper pattern

Module	**Part A (1 Weight Question) Answer any 8**	**Part B (2 Weight Question) Answer any six**	**Part C (5 Weight Question) Answer any two**
1	2	2	1

2	3	2	1
3	3	2	1
4	2	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

COURSE: 24P1MATT05 OPTIMIZATION TECHNIQUES

Total Hours: 75 **Credits: 4**

At the end of this course, students will be able to

CO	CO Statement	PO/ PSO	CL	KC	Class Hrs	Lab Hrs
CO1	Apply simplex method to solve Linear Programming problem.	PO1/PSO1,2	U	P	20	0
CO2	Evaluate the optimal solution of Integer programming problem by using cutting plane method and branch and bound method.	PO1/PSO1	A	P	15	0
CO3	Apply algorithm to find the solution of Goal programming problem, minimum path problem and maximum flow problem.	PO1/PSO3	A	P	15	0
CO4	Solve Non – linear programming problem using different algorithm.	PO1/PSO2	A	P	25	0

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.

Module 1

Linear Programing

Simplex Method, Canonical form of equations, Simplex Method (Numerical Example), Simplex Tableau, Finding the first BFS and artificial variables, Degeneracy, Simplex multipliers, Revised simplex method, Duality in LPP, Duality theorems, Applications of Duality, Dual simplex method, Summary of simplex methods. (Chapter 3; sections: 9 – 21 of text – 1) **(20 hours)**

Module 2

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 – examples –general description – the 0 – 1 variable.

(Chapter 6; sections: 6.1 – 6.10 of text – 1) **(15 hours)**

Module 3

Goal Programming, Flow and Potentials in Networks

Goal programming. Graphs- definitions and notation – minimum path problem – spanning tree of minimum length – problem of minimum potential difference – scheduling of sequential activities – maximum flow problem – duality in the maximum flow problem – generalized problem of maximum flow. (Chapter – 5 & 7 Sections 5.9 & 7.1 to 7.9, 7.15 of text - 1) **(15 hours)**

Module 4

Non- Linear Programming

Basic concepts – Taylor's series expansion – Fibonacci Search - golden section search– Hooke and Jeeves search algorithm – gradient projection search – Lagrange multipliers – equality constraint optimization, constrained derivatives – non-linear optimization: Kuhn-Tucker conditions – complimentary Pivot algorithms.

(Chapter 11; Sections: 11.1 – 11.7, 11.9- 11.11 of text – 2) **(25 hours)**

REFERENCES:

1. Rao, Optimization Theory and Applications, 2nd edition, New Age International Pvt.
2. J.K. Sharma, 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 Weight Question)** **Answer any 8**	**Part B** **(2 Weight Question)** **Answer any six**	**Part C** **(5 Weight Question)** **Answer any two**
1	3	2	1
2	2	2	1
3	2	2	1
4	3	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

COURSE: 24P2MATT06 BASIC TOPOLOGY

Total Hours: 75 **Credits: 4**

At the end of this course, students will be able to

CO	CO Statement	PO/ PSO	CL	KC	Class Hrs	Lab Hrs
CO1	Classify and compare different topological spaces their base and subbase.	PO1/PSO1	U	C	21	0
CO2	Apply the concept of continuity and quotient spaces on different topology.	PO1/PSO1	U	C	18	0
CO3	Summarize the concept of local connectedness, path connected and local connectedness.	PO1/PSO1	U	C	18	0
CO4	Differentiate levels of spaces based on separation axioms.	PO1/PSO1	U	C	18	0

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 &5.2.12excluded.) **(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, NewDelhi.
5. George F Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1963.

Question Paper Pattern

Module	**Part A (1 Weight Question) Answer any 8**	**Part B (2 Weight Question) Answer any six**	**Part C (5 Weight Question) Answer any two**
1	3	2	1
2	3	2	1
3	2	2	1
4	2	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

COURSE: 24P2MATT07 COMPLEX ANALYSIS

Total Hours: 75 **Credits: 4**

At the end of this course, students will be able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Understand concept of representation of complex numbers in the extended complex plane.	**PO1/PSO 1**	**U**	**C**	**20**	**0**
CO2	Explain the concept of (complex) differentiation and integration of functions defined on the complex plane and their properties.	**PO1/PSO 2**	**U**	**C**	**20**	**0**
CO3	Represent analytic functions as power series	**PO1/PSO 2**	**U, AP**	**C**	**20**	**0**
CO4	Identify zeros and classify singularities of complex functions	**PO1/PSO 1**	**U, AN**	**C**	**15**	**0**

Text: John B. Conway, Functions of One Variable, SecondEdition.

Module 1:

I. The Complex Number System - 6.

II. The extended plane and its spherical representation

III. Analytic functions

1. Power series
2. Analytic functions
3. Analytic functions as mappings, Mobius transformations **(20 hours)**

Module 2:

IV. Complex Integration

2. Power series representation of analytic functions
3. Zeros of an analytic function
4. The index of a closed curve,
5. Cauchy's Theorem and Integral Formula
6. The Homotopic version of Cauchy's Theorem and simple connectivity

(20 hours)

Module 3:

IV. Complex Integration

1. Counting zeros, the Open Mapping Theorem
2. Goursat's Theorem

V. Singularities

1. Classification of singularities
2. Residues
3. The Argument Principle

(20 hours)

Module 4:

VI. The Maximum Modulus Theorem

1. The Maximum Principle,
2. Schwarz's Lemma,
3. Convex Functions and Hadamard's Three circles Theorem

(15 hours)

REFERENCES:

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

Question Paper Pattern

Module	**Part A** **(1 Weight Question)** **Answer any 8**	**Part B** **(2 Weight Question)** **Answer any six**	**Part C** **(5 Weight Question)** **Answer any two**
1	3	2	1
2	3	2	1
3	2	2	1

4	2	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

COURSE: 24P2MATT08 ALGEBRA -II

Total Hours: 75 **Credits: 4**

At the end of this course, students will be able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Explain ring of polynomials, polynomial factorization, and the ideal structure in F[x].	**PO1/PSO 1**	**A**	**C**	**18**	**0**
CO2	Comprehend the concept of field extension and the types of extensions.	**PO1/PSO 2**	**An**	**C**	**17**	**0**
CO3	Analyze finite fields and field automorphisms.	**PO1/PSO 2**	**An**	**C**	**20**	**0**
CO4	Analyze splitting fields, separable extensions, and the main theorem of Galois Theory.	**PO1/PSO 1**	**E**	**C**	**20**	**0**

Text: A First Course in Abstract Algebra by John B Fraleigh, 8th Edition, Pearson Education.

Module: 1

Rings of Polynomials, Factorization of Polynomials over a field. Ideal Structure in F[x]

(Sections 27, Section 28 and Sections 31.21-31.27) **(18 hours)**

Module: 2

Introduction to extension fields, algebraic extensions, Geometric Constructions.

(Part VIII – Section 39, Sections 40.1 to 40.18, Section 41) **(17 hours)**

Module: 3

Finite Fields, Introduction to Galois Theory.

(Section 42 and Section 43) **(20 hours)**

Module: 4

Splitting Fields, The isomorphism Extension Theorem (Statement Only), Separable Extensions, Galois Theory.

(Part X – Section 44, Section 45 and Section 46) **(20 hours)**

REFERENCES:

1. Contemporary Abstract Algebra by 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 Weight Question) Answer any 8**	**Part B (2 Weight Question) Answer any six**	**Part C (5 Weight Question) Answer any two**
1	3	2	1
2	3	2	1
3	2	2	1
4	2	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

COURSE: 24P2MATT09 ALGEBRAIC NUMBER THEORY

Total Hours: 75 **Credits: 4**

At the end of this course, students will be able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Explain the properties of algebraic numbers, algebraic integers and integral bases.	PO1/PSO1	U	C	15	0
CO2	Distinguish quadratic and cyclotomic extensions and traces and norms.	PO1/PSO1	U	C	20	0
CO3	Analyze factorization into irreducibles in Euclidean Domains and quadratic fields.	PO1/PSO1	U	C	20	0
CO4	Analyze prime factorization of Ideals, the norm of an ideal, non-unique factorization of cyclotomic fields.	PO1/PSO1	U	C	20	0

Text Book:

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

Bridge Course: Modules and Free abelian groups. (Chapter-1 Sections 1.5, 1.6) (No questions will be asked in the question paper from these sections)

Module-1

Algebraic Numbers, Conjugates and Discriminants, Algebraic Integers, Integral Bases. (Chapter 2- Sections 2.1-2.4) **(15 hours)**

Module 2

Norms and Traces, Rings of Integers, Quadratic Fields, Cyclotomic Fields (Chapter 2- Sections 2.5, 2.6), (Chapter 3, Section-3.1, 3.2) **(20 hours)**

Module 3

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) **(20 hours)**

Module 4

Prime factorization of ideals, the norm of an ideal, and non-unique factorization of Cyclotomic fields. (Chapter 5-Sections 5.1 to 5.4 of Text 2) **(20 hours)**

REFERENCES:

1. Leveque W.J, Topics in Number Theory, Addison Wesley, 1961.
2. J.P Serre, A Course in Arithmetic, GTM Vol. 7, Springer-Verlag, 1973
3. D Marcus, Number Fields (Springer-Verlag, New York-Heidelberg)
4. M Artin, Algebra, Pearson Education, 2013

Question Paper Pattern

Module	**Part A (1 Weight Question) Answer any eight**	**Part B (2 Weight Question) Answer any six**	**Part C (5 Weight Question) Answer any two**
1	3	2	1
2	2	2	1
3	3	2	1
4	2	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

COURSE: 24P2MATT10 MEASURE THEORY AND INTEGRATION

Total Hours: 75 **Credits: 4**

At the end of the course, a student is able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Define measurable set, measurable function, Lebesgue integral and to relate Lebesgue integral with Riemann integral.	PO1/PSO1	U	C	15	0
CO2	explain the relevance of Lebesgue integration and to classify	PO1/PSO1	U	C	15	0
CO3	solve problems related to Lebesgue integral , Lebesgue and abstract measure, Lebesgue and abstract outer measure , signed measure ,Integral with respect to a measure , Integral with respect to product measure .	PO1/PSO1	U	C	15	0
CO4	Analyze the algebraic properties of Lebesgue integral functions and Lebesgue measurable functions.	PO1/PSO1	U	C	15	0
CO5	Develop an algebraic as well as a geometrical structure for the collection of all integrable functions.	PO1/PSO1	U	C	15	0

Text Book: H. L. Royden, P.M. Fitzpatrick, Real Analysis Fourth Edition, Pearson Education

Module 1

Lebesgue Measure: Introduction, Lebesgue outer measure, The σ algebra of Lebesgue measurable sets, Outer and inner approximation of Lebesgue measurable sets, Countable additivity, continuity and Borel-Cantelli Lemma - Non measurable sets, The Cantor set Chapter 2 - Sections 2.1 to 2.7 **(20 Hours)**

Module 2

Lebesgue Measurable Functions and Lebesgue Integration: Sums, products and compositions – Sequential pointwise limits and simple approximation –The Riemann Integral – The Lebesgue integral of a bounded measurable function over a set of finite measure – The Lebesgue integral of a measurable Non negative function – The general Lebesgue integral. (Chapter 3 - Sections 3.1 to 3.2, Chapter 4 - Sections 4.1 to 4.4)

(20 Hours)

Module 3

General Measure Space and Measurable Functions: Measures and measurable sets – Signed Measures: The Hanh and Jordan decompositions – The Caratheodory measure induced by an outer measure – Measurable functions (Chapter 17 - Sections 17.1 to 17.3, Chapter 18 - Section 18.1 upto corollory 7) **(18 Hours)**

Module 4

Integration over General Measure Space and Product Measures: Integration of non-negative measurable functions – Integration of general measurable functions – The Radon Nikodym Theorem – Product measure: The theorems of Fubini and Tonelli (Chapter 18 - Sections 18.2 to 18.4, Chapter 20 - Section 20.1)

(17 Hours)

REFERENCES:

1. G de Barra, Measure Theory and Integration, New Age international Publishers
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
5. An Introduction to Measure and Integration, Inder K Rana , American Mathematical Society

Question Paper Pattern

Module	**Part A** **Weight - 1 for each question** **Answer any eight**	**Part B** **Weight-2 for each question** **Answer any six**	**Part C** **Weight – 5 for each question** **Answer any two**
1	3	2	1
2	3	2	1
3	3	2	1
4	1	2	1
Total	10	8	4
Total weight	**8**	**12**	**10**

SEMESTER-3

COURSE: 24P3MATT11 PARTIAL DIFFERENTIAL EQUATIONS

Total Hours: 75 **Credits: 4**

At the end of the course, a student is able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Explain the classification of first order pde and their solutions	PO1/PSO 1	U	C	21	0
CO2	Illustrate the integrals of nonlinear pde's	PO1/PSO 2	U	P	21	0
CO3	Analyze linear pde with constant coefficients and special second order pde's	PO1/PSO 2	U	C	17	0
CO4	Analyze solutions of Laplace's equation	PO1/PSO 2	U	p	16	0

Text Book:

1) **Partial Differential equations with numerical solutions, Nagendra Kumar, Rakesh Kumar**
2) **Elements of Partial differential equations –Ian Sneddon**
3) **K Sankara Rao, Introduction to Partial Differential Equations, Prentice-Hall of India**

Module 1

Classification of first order pde, Classification of integrals, Lagrange's pde, Pfaffian differential equations (Text-1, sections 1.1-1.6)

(21 hours)

Module 2

Compatible systems of first order pde's, Charpit's method, Some standard forms, Jacobi's method, integral surfaces through given curves

(Text-1 sections 1.7-1.11) **(21 hours)**

Module 3

Linear partial differential equations with constant coefficients. Equations with variable coefficients, Reduction to canonical form

(text-2 chapter-3 section 4, text-1 sections 1.12) **(17 hours)**

Module 4

Monge's method, Separation of variables, Elementary solutions of Laplace equation, Dirichlet problem for a rectangle, The Neumann problem for a rectangle

(Text-2, chapter 3 sections 9, 11 and

Text-3 Chapter 2 – sections 2.5, 2.6, and 2.7) **(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 Weight Question) Answer any 8**	**Part B (2 Weight Question) Answer any six**	**Part C (5 Weight Question) Answer any two**
1	2	2	1
2	3	2	1

3	3	2	1
4	2	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

COURSE: 24P3MATT12 FUNCTIONAL ANALYSIS - I

Total Hours: 75 **Credits: 4**

At the end of the course a student is able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Analyze normed linear spaces and the continuity of linear maps.	**PO1/PSO 1**	**An**	**C**	**19**	**0**
CO2	Analyze the Hahn Banach Theorems and Banach spaces	**PO1/PSO 1**	**An**	**C**	**19**	**0**
CO3	Analyze the Uniform boundedness principle, the closed graph theorem and the open mapping theorem.	**PO1/PSO 1**	**E**	**C**	**19**	**0**
CO4	Analyze the spectrum of a bounded operator.	**PO1/PSO 1**	**An**	**C**	**18**	**0**

Text Book: Functional Analysis, 2nd Edition, B V LIMAYE, New Age International Publishers.

Pre requisites: A quick review of chapter I of the Text is to be done as a prerequisite to the Functional Analysis course.

Module 1

Normed spaces and continuity of linear maps.
(Chapter II: Section 5 and Chapter II: Section 6 (Excluding 6.5 (d) and Theorem 6.8)

(20 hours)

Module 2

Hahn-Banach theorems and Banach spaces.

(Chapter II: Section 7-Section 7.10, and Chapter II: Section 8) **(20 hours)**

Module 3

Uniform boundedness principle, closed graph and open mapping theorems

(Chapter III: Sections 9 to 9.3 and 10 of the Text)

(18 hours)

Module 4

Bounded inverse theorem, spectrum of a bounded operator (Section 11.1 and12 (Excluding 12.4) of the text).

(17 hours)

REFERENCES:

1. Introductory Functional Analysis, Kreyszig, Wiley classic library Edition
2. Simmons.G.FM, Introduction to Topology and modern analysis McGrow- hill, 1963 New York
3. Walter Rudin, Functional Analysis, TMH Edition, 1974
4. M. Thamban Nair, Functional Analysis A First course, Prentice-Hall of India Pvt.LtD

Question Paper Pattern

Module	**Part A** **Weight -1 for each question** **Answer any eight**	**Part B** **Weight- 2 for each question** **Answer any six**	**Part C** **Weight -5 for each question** **Answer any two**
1	3	2	1
2	3	2	1
3	2	2	1
4	2	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

COURSE: 24P3MATT13 ADVANCED TOPOLOGY

Total Hours: 75 **Credits: 4**

At the end of the course, a student is able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Analyze the concept of normality via Urysohn Characterization of Normality, Tietze Characterization of Normality. Products and co-products.	**PO1/PSO 1**	**U**	**C**	**21**	0
CO2	Analyze embedding and metrisation via Evaluation Functions, embedding Lemma and Tychnoff Embedding, The Urysohn Metrisation Theorem.	**PO1/PSO 1**	**U**	**P**	**12**	0
CO3	Develop the idea of convergence using the definition of nets and filters.	**PO1/PSO 1**	**U**	**C**	**21**	0
CO4	Classify and compare compact spaces.	**PO1/PSO 1**	**U**	**C**	**21**	0

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

Module 1

Urysohn Characterization of Normality – Tietze Characterization 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) **(21hours)**

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 **(21hours)**

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 Weight Question) Answer any 8**	**Part B (2 Weight Question) Answer any six**	**Part C (5 Weight Question) Answer any two**
1	3	2	1
2	2	2	1
3	3	2	1
4	2	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

COURSE: 24P3MATT14 ADVANCED COMPLEX ANALYSIS

Total Hours: 75 **Credits: 4**

At the end of the course, a student is able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Explain continuous functions in the complex plane, Poles and singularities	**PO1/PSO 1**	**U**	**C**	**20**	0
CO2	Extend the domain over which a complex analytic function is defined and factorize Complex functions using Weirestrass factorization theorem	**PO1/PSO 1**	Ap	**P**	**20**	0
CO3	Investigate simple connectedness using Rung's Theorem	**PO1/PSO 2**	E	**C**	**18**	0
CO4	Recite Jenson's Formula and Hadamard Factorization theorem and able to apply them to find genus and order of entire function	**PO1/PSO 1**	An	**C**	**17**	0

Text Book: Conway J.B, Functions of one Complex variable, Second Edition.

Module 1

Chapter VI1: Compactness and Convergence in the Space of Analytic Functions

1. The space of continuous functions C (G, Ω)
2. Spaces of analytic functions
4. The Riemann Mapping Theorem (Statement Only)
5. Weierstrass Factorization Theorem
6. Factorization of sine Function

(20 hours)

Module 2

Runge's Theorem

Chapter VII: Compactness and Convergence in the Space of Analytic Functions

The gamma function, 8. The Riemann zeta Function

Chapter VIII: Runge's Theorem

Runge's Theorem, 3. Simple Connectedness, 4. Mittag Leffler's Theorem **(20 hours)**

Module 3

Chapter IX: Analytic Continuation and Riemann Surfaces

1. Schwarz Reflection Principle
2. Analytic Continuation along a path
3. Mondromy Theorem (without proof) **(18 hours)**

Module 4

Chapter XI: Entire Functions

1. Jensen's Formula,
2. The genus and order of an entire function,
3. Hadamard Factorization Theorem (without proof) **(17 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. Lang. S, Complex Analysis, Springer.
4. H.A. Priestly, Introduction to Complex Analysis, Clarendon press, Oxford, 1990
5. Lars V. Ahlfors, Complex Analysis, Third edition, McGraw Hill Internationals

Question Paper Pattern

Module	**Part A (1 Weight Question) Answer any 8**	**Part B (2 Weight Question) Answer any six**	**Part C (5 Weight Question) Answer any two**
1	3	2	1
2	3	2	1
3	2	2	1
4	2	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

COURSE: 24P3MATT15 MULTIVARIATE CALCULUS AND FOURIER SERIES

Total Hours: 75 **Credits: 3**

At the end of this course student will be able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Analyze 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.	**PO1/PSO 1**	**U**	**C**	**16**	**0**
CO2	Interpret Implicit functions and extremum problems, the mean value theorem for differentiable functions, a sufficient condition for differentiability.	**PO1/PSO 1**	**U**	**C**	**17**	**0**
CO3	Explain Fourier series, trigonometric series and Parseval's formula and gamma function, stirling formula.	**PO1/PSO 1**	**U**	**C**	**18**	**0**
CO4	Explain Integration of Differential Forms, primitive mappings, partitions of unity, change of variables, differential forms, Stokes theorem.	**PO1/PSO 1**	**U**	**C**	**24**	**0**

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

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) **(16 hours)**

Module 2

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 **(17 hours)**

Module 3

Fourier series, Trigonometric series, Parseval's theorem, The gamma function, some consequences, Stirling's formula.

Chapter 8 Sections 8.9 to 8.22 of Text 2 **(18 hours)**

Module 4

Integration of Differential Forms Integration, primitive mappings, partitions of unity, change of variables, differential forms.

Chapter 10 Sections. 10.1 to 10.20 of Text 2 **(24 hours)**

REFERENCES:

1. Limaye Balmohan Vishnu, Multivariate Analysis, Springer.

2. Satish Shirali and Harikrishnan, Multivariable Analysis, Springer

Question Paper Pattern

Module	**Part A (1 Weight Question) Answer any 8**	**Part B (2 Weight Question) Answer any six**	**Part C (5 Weight Question) Answer any two**
1	3	2	1
2	2	2	1
3	2	2	1

4	3	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

SEMESTER –IV

COURSE: 24P4MATT16 FUNCTIONAL ANALYSIS - II

Total Hours: 75 **Credits: 4**

At the end of the course a student is able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Examine Duals and transposes and analyze weak and weak* convergence.	**PO1/PSO 1**	**An**	**C**	**19**	**0**
CO2	Analyze inner product spaces, Hilbert spaces and orthonormal sets.	**PO1/PSO 1**	**An**	**P**	**19**	**0**
CO3	Discuss Projection and Riesz representation theorems and their applications.	**PO1/PSO 1,4**	**E**	**C**	**19**	**0**
CO4	Distinguish between normal, unitary and self-adjoint operators and discuss spectrum and numerical range of operators.	**PO1/PSO 1,4**	**E**	**C**	**18**	**0**

Text Book: Functional Analysis, 2nd Edition, B V LIMAYE, New Age International Publishers.

Module 1

Duals and Transpose Weak and weak* Convergence
(Chapter IV Section 13.1 to Section 13.5, Sections 15.1, 15.2 (Excluding Examples 15.2(b) to 15.2(e)) Section 15.3, Section 15.4) **(18 hours)**

Module 2

Inner product spaces, Hilbert spaces and orthonormal sets
(Section 21 and 22 of the Text, omitting 21.3 (d), 22.3 (b), 22.8 (c), 22.8 (d), 22.8 (e)).

(20 hours)

Module 3

Projection and Riesz representation theorems, Bounded Operators and Adjoints
(Section 24 to 24.5 and Section 25 (Excluding 25.4(b)) of the Text,).

(20 hours)

Module 4

Bounded operators and adjoints, normal, unitary and self-adjoint operators
Spectrum and numerical range

(Section 26.1 to 26.5 (Excluding Fourier- Plancherel Transform)
Section 27.1,27.2, 27.3)

(17 hours)

REFERENCES:

1. Simmons, G.F, Introduction to Topology and Modern Analysis, McGraw –Hill, New York 1963
2. Erwin Kreyszig , Introductory Functional Analysis with applications, John Wiley and sons, New York
3. Siddiqi, A.H, Functional Analysis with Applications, Tata McGraw –Hill, New Delhi : 1989
4. Somasundaram. D, Functional Analysis, S.Viswanathan Pvt. Ltd, Madras, 1994
5. Vasistha, A.R and Sharma I.N, Functional analysis, Krishnan Prakasan Media (P) Ltd (1996)

Question paper Pattern

Module	**Part A** **(1 weight question)** **Answer any eight**	**Part B** **(2 weight question)** **Answer any six**	**Part C** **(5 weight question)** **Answer** **any two**
1	2	2	1
2	3	2	1
3	3	2	1
4	2	2	1
Total	10	8	4
Total Weight	**8**	**12**	**10**

COURSE: 24P4MATT17 DIFFERENTIAL GEOMETRY

Total Hours: 75 **Credits: 3**

At the end of this course, students will be able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Perceive the ideas of graphs and level sets, vector fields, the tangent space, surfaces, vector fields on surfaces, orientation.	**PO1/PSO 1**	**U**	**C**	**15**	**0**
CO2	Explain the fundamentals of the Gauss map, geodesics, and parallel transport.	**PO1/PSO 1,4**	**U**	**P**	**20**	**0**
CO3	Summarize the ideas of the Weingarten map, curvature of plane curves, arc length and line integrals.	**PO1/PSO 1**	**U**	**C**	**20**	**0**
CO4	estimate curvature of surfaces	**PO1/PSO 1,4**	**U**	**C**	**20**	**0**

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, Parametrized surfaces, local equivalence of surfaces and Parameterized surfaces. (Chapters 12, 14 & 15 of the text, excluding the proof of the theorem 3 and the corollary to theorem 4 in chapter 15) **(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 Weight Question) Answer any 8**	**Part B (2 Weight Question) Answer any six**	**Part C (5 Weight Question) Answer any two**
1	3	2	1
2	3	2	1
3	2	2	1
4	2	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

COURSE: 24P4MATT18EL PROBABILITY THEORY

Total Hours: 75 **Credits: 3**

At the end of the course, a student is able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Explain the different approaches to probability.	**PO1/ PSO1**	**U**	**C**	**18**	**0**
CO2	Illustrate the properties of random variables	**PO1/ PSO1,4**	**U**	**C**	**20**	**0**
CO3	Analyze multiple random variables and various inequalities.	**PO1/ PSO1,3,4**	**U**	**C**	**20**	**0**
CO4	Analyze the convergence of sequence of random variables.	**PO1/ PSO1,3,4**	**U**	**C**	**17**	**0**

Text: **V.K Rohatgi (2001) *An Introduction to Probability and Statistics*, 2nd Edn, Wiley India (P) Ltd, New Delhi.**

Module 1

Introduction and different approaches to probability, Probability Axioms - Addition rule, Principle of inclusion and exclusion, Bonferroni's inequality, Boole's inequality, Implication rule, Sequence of events and their limits, Conditional Probability, Multiplication rule on Probability, Baye's Theorem, Independence of Events.

Sections 1.2, 1.3 (till Remarks 5), 1.5, 1.6 of text **(18 hours)**

Module 2

Random variable, Probability distribution, Discrete and Continuous random variables, Function of a random variable, Expectation and Moments of a random variable, Generating Functions, Moment inequalities – Markov's inequality, Chebychev Bienayme's inequality.

Chapters 2- Section 2.1 to 2.5(till example 7) and Chapter 3 –Section 3.2 except proofs of Theorem 4,5,6 , Section 3.3, Section 3.4) **(20 hours)**

Module 3

Multiple random variable, Independence of random variables, Covariance and Correlation and moments, Addition and Multiplication theorems on expectation, Cr inequality, Holder's inequality, Cauchy-Schwartz's inequality, Jensen's inequality, Minkowski's inequality, Conditional expectation**.**

Sections 4.2 to 4.3 (till example 6), 4.5 (till theorem 6 including its Corollary's 1 and 2, 4.6.

(20 hours)

Module 4

Convergence of sequence of random variables – Convergence in law, Convergence in probability, Convergence in r^{th} mean, Convergence almost surely. Weak Law of Large Numbers-Kinchine's Weak Law of Large Numbers, Strong Law of Large Numbers-Kolmogorov strong law of large numbers, Central Limit Theorem- Lindberg- Levy form and Liapunov's form of Central Limit Theorem .(simple application problems)

Section 6.2 (till Theorem 12) **(17 hours)**

REFERENCES:

1. S.C Gupta and V.K Kapoor (2002) *Fundamentals of Mathematical Statistics* Sultan Chand & Sons, New Delhi.

Question paper Pattern

Module	**Part A** **(1 Weight Question)** **Answer any 8**	**Part B** **(2 Weight Question)** **Answer any six**	**Part C** **(5 Weight Question)** **Answer any two**
1	2	2	1
2	3	2	1
3	3	2	1

4	2	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

COURSE: 24P4MATT19EL NUMERICAL ANALYSIS WITH PYTHON 3

Total Hours: 75 **Credits: 3**

At the end of the course, a student is able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Apply Python programming on mathematical equations and expression.	**PO1/PSO 1**	**U**	**C**	**17**	**0**
CO2	Apply Python programming on derivative of functions, continuity of a function at a point, curve length and area between two curves.	**PO1/PSO 2**	**U**	**P**	**20**	**0**
CO3	Solve problems using Lagrange's Method, Newton's Method. Determine roots of equations by bisection method and Newton-Raphson method.	**PO1/PSO 2,3**	**U**	**P**	**20**	**0**
CO4	Solve problems using different techniques of Numerical Integration methods.	**PO1/PSO 1,3**	**U**	**P**	**18**	**0**

Text Books

Text 1: Jason R Brigs, Python for kids – a playful introduction to programming, No Starch Press

Text 2: Amit Saha, Doing Math with Python, No Starch Press, 2015.

Text 3: JaanKiusalaas, Numerical Methods in Engineering with Python3, Cambridge University Press

Though any distribution of Python 3 software can be used for practical sessions, to avoid difficulty in getting and installing required modules like numpy, scipyetc, and for uniformity, the Python3 package Anaconda 2018.x (https://www.anaconda.com/distribution/#downloadsection) may be installed and used for the practical sessions. However, a brief introduction on how to use Python IDLE 3 also should be given.

BASICS OF PYTHON

Before going into mathematics programming part, an introduction to Python should be given.

No questions should be included in the end semester examination from this unit. Internal examinations may test the knowledge of concepts from this section.

From Text 1, Chapter 2 full – calculations and variables,

Chapter 3 – creating strings, lists are more powerful than strings, tuples,

Chapter 5- If statements, if-then-else statements, if and elif statements, combining conditions, the difference between strings and numbers,

Chapter 6 – using for loops, while we are talking about looping,

Chapter 7 – using functions, parts of a function, using modules

Chapter 9 – The functions abs, float, int, len, max, min, range, sum

From Text 2 Chapter 1 - section complex numbers

Module 1

Defining Symbols and Symbolic Operations, Working with Expressions, Solving Equations and Plotting Using SymPy, problems on factor finder, summing a series and solving single variable inequalities

Chapter 4 - From text 2 **(17 hours)**

Module 2

Finding the limit of functions, finding the derivative of functions, higher-order derivatives and finding the maxima and minima and finding the integrals of functions are to be done. in the section programming challenges, the following problems - verify the continuity of a function at a point, area between two curves and finding the length of a curve

Chapter 7- From text 2 **(20 hours)**

Module 3

Interpolation and Curve Fitting - Polynomial Interpolation - Lagrange's Method, Newton's Method and Limitations of Polynomial Interpolation, Roots of Equations - Method of Bisection and Newton-Raphson Method.

Chapter 3, sections 3.1, 3.2 Chapter 4, sections 4.1, 4.3, 4.5 From Text 3, **(20 hours)**

Module 4

Gauss Elimination Method (excluding Multiple Sets of Equations), Doolittle's Decomposition Method only from LU Decomposition Methods Numerical Integration, Newton-Cotes Formulas, Trapezoidal rule, Simpson's rule and Simpson's 3/8 rule.

Chapter 2, sections 2.2, 2.3, Chapter 6, sections 6.1, 6.2 From Text 3 **(18 hours)**

1. Instead of assignments, a practical record book should be maintained by the students. At least 15 programmes should be included in this record book.

2. Internal assessment examinations should be conducted as practical lab examinations by the faculty handling the paper.

3. End semester examination should focus on questions including concepts from theory and programming. However, more importance should be given to theory in the end semester examinations as internal examinations will be giving more focus on programming sessions

Question Paper Pattern

Module	**Part A (1 Weight Question)Answer any 8**	**PartB(2 Weight Question) Answer any six**	**PartC(5 weight Question)Answer any two**
1	2	2	1
2	3	2	1
3	3	2	1
4	2	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

COURSE: 24P4MATT20EL THEORY OF WAVELETS

Total Hours: 75 **Credits: 3**

At the end of the course a student is able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Define first stage and pth stage wavelet basis for l 2[ZN], Fourier transform including discrete case ,complete orthonormal system , first stage wavelet system and homogeneous wavelet system for l2[Z]	**PO1/PSO 1**	**U**	**C**	**15**	**0**
CO2	Explain the filter bank diagram and its use in the construction of the output of the analysis phase of the filter bank	**PO1/PSO 1**	**U**	**P**	**15**	**0**
CO3	Apply theory of wavelets in the frequency analysis of a video or audio signal.	**PO1/PSO 1,4**	**U**	**C**	**15**	**0**
CO4	Develop wavelet bases for $l^2[Z_N]$ and $l^2[Z]$,both first stage and pth stage	**PO1/PSO 1,4**	**U**	**C**	**15**	**0**
CO5	Examine how the theory of wavelets is closely associated with linear algebra	**PO1/PSO 1,4**	**U**	**C**	**15**	**0**

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 [-π, 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**)

REFERENCES:

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** **Weight-1 for each Question.** **Answer any eight**	**Part B** **Weight-2 for each Question.** **Answer any six**	**Part C** **Weight -5 for each** **Question.** **Answer any two**
1	3	3	1
2	2	2	1
3	3	2	1
4	2	1	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

COURSE: 24P4MATT21EL ALGEBRAIC TOPOLOGY

Total Hours: 75 **Credits: 3**

At the end of the course, a student is able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Explain Geometric Complexes , Polyhedra and Simplicial Homology Groups	**PO1/ PSO1**	**U**	**C**	**20**	**0**
CO2	Perceive the idea of Pseudo manifolds , the homology groups of Sn and Simplicial Approximation	**PO1/ PSO1**	**U**	**C**	**20**	**0**
CO3	Find Fundamental Group.	**PO1/ PSO1,4**	**U**	**C**	**20**	**0**
CO4	Explain the concept of covering space.	**PO1/ PSO1,4**	**U**	**C**	**15**	**0**

Textbook: Fred H. Croom., Basic Concepts of Algebraic Topology, UTM, Springer Verlag, NY, 1978.

Module 1

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)

(20 Hours)

Module 2

Simplicial Homology Groups (Contd.): The Euler Poincare's Theorem; Pseudo manifolds and the homology groups of Sn. 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)

(20 Hours)

Module 3

The Fundamental Group: Introduction; Homotopic Paths and the Fundamental Group; The Covering Homotopy Property for S1; Examples of Fundamental Groups. (Chapter 4 Sections 4.1 to 4.4 from the text)

(20 Hours)

Module 4

Covering spaces -Definition and some examples-Basic properties of covering spaces-Classification of covering spaces-Universal covering spaces.(Chapter 5) (15 Hours)

REFEENCES:

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.

Question Paper Pattern

Module	**Part A** **Weight-1 for each Question.** **Answer any eight**	**Part B** **Weight-2 for each Question.** **Answer any six**	**Part C** **Weight -5 for each** **Question.** **Answer any two**
1	3	2	1
2	2	2	1
3	3	2	1
4	2	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

COURSE: 21P4MATT22EL INTRODUCTION TO CHAOTIC DYNAMICAL SYSTEMS

Total Hours: 75 **Credits: 3**

At the end of the course, a student is able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Illustrate Orbits, Fixed, Periodic points, Doubling function.	**PO1/ PSO1**	**U**	**C**	**20**	**0**
CO2	Perceive the idea of Bifurcation and Quadratic family.	**PO1/ PSO1**	**U**	**C**	**15**	**0**
CO3	Explain Symbolic Dynamics and Chaotic System.	**PO1/ PSO1**	**U**	**C**	**20**	**0**
CO4	Comprehend Fractal	**PO1/ PSO1,4**	**U**	**C**	**20**	**0**

Text Book: Robert L Devaney, A FIRST COURSE IN CHAOTIC DYNAMICAL SYSTEMS THEORY AND EXPERIMENTS, CRC PRESS

Module 1

Orbits, Fixed and Periodic points Iteration, Orbits, Types of Orbits, Other orbits, Doubling function, A fixed point theorem, Attraction and repulsion, Calculus of fixed points, what is true, Periodic points (Chapter 3, Section 3.1 to 3.5 & Chapter 5, Section 5.1 to 5.5) **(20 hours)**

Module 2

Bifurcation and Quadratic family Dynamics of a quadratic map, The Saddle –Node Bifurcation, the period Doubling Bifurcation, The case $c = -2$, The case $c \leftarrow 2$, The cantor middle third set

Chapter 6: 6.1 to 6.3 and Chapter 7 **(15 hours)**

Module 3

Symbolic Dynamics and Chaos

Itineraries, The sequence space, The shift map, Conjugacy, The properties of a Chaotic system, Other Chaotic system, Sharkovskii's theorem (Statement of theorems Only)

Chapter 9, Chapter 10.1 to 10.2, Chapter 11(statement of theorem only) **(20 hours)**

Module 4

Fractals ,The Chaos game, The cantor set revisited, The Sierpinski Triangle, The Koch Snowflake, Fractal dimension, Iterated function system, Calculus of Complex functions, The Julia set, The squaring function,

The Chaotic quadratic function, The Julia set as repeller, The Mandelbrot set.

Chapter 14.1 to 14.7, Chapter 15.4, Chapter 16.1 to 16.2, 16.6 and Chapter 17.2 **(20 hours)**

REFERENCES:

1. Beardon, A. F., Iteration of rational functions, Springer-Verlag, 1991.
2. Carleson, L. and Gamelin, T. W., Complex dynamics, Springer-Verlag, 1993.
3. Devaney, R. L. et al, Complex dynamical systems, American Mathematical Society, 1994.
4. McMullen, C. T., Complex dynamics and renormalization, Princeton University Press, 1994.
5. Milnor, J., Dynamics in one complex variable, Princeton University Press, 2006.

Question Paper Pattern

Module	**Part A (1 weight question) Answer any eight**	**Part B (2 weight question) Answer any six**	**Part C (5 weight question) Answer any two**
1	3	2	1
2	2	2	1
3	3	2	1
4	2	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

COURSE: 24P4MATT23EL ABSTRACT HARMONIC ANALYSIS

Total Hours: 75 **Credits: 3**

At the end of this course, students will be able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Perceive the ideas of topological and locally compact groups, Haar measure. Modular function, convolutions, homogenous spaces, unitary representations, Gelfand-Raikov theorem.	**PO1/ PSO1**	**U**	**C**	**20**	**0**
CO2	Explain unitary representations, representations of a group and its group algebra, functions of positive type.	**PO1/ PSO1**	**U**	**C**	**20**	**0**
CO3	Summarize the dual group, the Fourier transform, The Pontrjagin Duality Theorem, representations of locally compact Abelian groups, closed ideals in $L^1(G)$, spectral synthesis, The Bohr Compactification.	**PO1/ PSO1,4**	**U**	**C**	**20**	**0**
CO4	Analyze the representations of Compact Groups, The Peter-Weyl Theorem, Fourier Analysis on Compact Groups.	**PO1/ PSO1,4**	**U**	**C**	**15**	**0**

Text Book- Folland G. B. A *course in Abstract Harmonic Analysis*: *Studies in Advanced mathematics*, CRC press

Module 1

Topological groups, locally compact groups, Haar measure. Modular function, convolutions, homogenous spaces, unitary representations, Gelfand-Raikov theorem [Chapter 2, Sections 2.1 to 2.6]

(20 hours)

Module 2

Unitary Representations, Representations of a group and its group algebra, Functions of positive type, notes and references (Chapter 3, Sections 3.1-3.4) **(20 hours)**

Module 3

The Dual Group, the Fourier Transform, The Pontrjagin Duality Theorem, Representations of Locally Compact Abelian Groups, Closed Ideals in L1 (G), Spectral Synthesis, The Bohr Compactification (Chapter 4 – Sections 4.1- 4.7) **(20 hours)**

Module 4

Representations of Compact Groups, the Peter-Weyl Theorem, Fourier analysis on compact groups, (Chapter 5, Sections 5.1-5.4) **(15 hours)**

REFERENCES:

1. Hewitt E. and Ross K. *Abstract Harmonic Analysis, Vol 1,* Springer
2. Gaal S. A. *Linear Analysis and Representation theory,* Springer

Question Paper Pattern

Module	**Part A (1 Weight Question) Answer any 8**	**Part B (2 Weight Question) Answer any six**	**Part C (5 Weight Question) Answer any two**
1	3	2	1
2	3	2	1
3	2	2	1

4	2	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

COURSE: 24P4MATT24EL GRAPH THEORY

Total Hours: 75 **Credits: 3**

At the end of this course, students will be able to

CO	CO Statement	PO/PSO	CL	KC	Class Hrs.	Lab Hrs.
CO1	Explain basic concepts, sub graphs, degrees of vertices. Paths and connectedness, automorphism of a simple graph, line graphs, basic concepts and tournaments.	**PO1/PSO 1**	**U**	**C**	**18**	**0**
CO2	Comprehend connectivity vertex cuts and edge cuts. Connectivity and edge connectivity, blocks. Certain definitions and simple properties, counting the number of spanning trees and Cayley's formula.	**PO1/PSO 2**	**U**	**C**	**17**	**0**
CO3	Analyze vertex and edge independent Sets, Eulerian Graphs, Hamiltonian Graphs, Vertex Coloring and certain definitions.	**PO1/PSO 2**	**U**	**C**	**20**	**0**
CO4	Explain edge coloring and planarity: certain definitions and properties, dual of a plane graph. The four color theorem and the Heawood five color theorem	**PO1/PSO 1**	**U**	**C**	**20**	**0**

Text: R. Balakrishnan and K. Ranganathan, A Text book of Graph Theory, Springer

Module 1

Basic concepts. Sub graphs, degrees of vertices. Paths and connectedness, automorphism of a simple graph, line graphs, basic concepts and tournaments.

Chapter 1 (Sections 1.1 to 1.5 and 1.6 (Up to 1.6.3))

Chapter 2 (Sections 2.1 and 2.2) **(18 hours)**

Module 2

Connectivity Vertex cuts and edge cuts. Connectivity and edge connectivity, blocks. Definition, characterization and simple properties, centres and centroids, counting the number of spanning trees, Cayley's formula.

Chapter 3 (Sections 3.1 to 3.3)

Chapter 4 (Sections 4.1 to 4.4) **(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 6.2)

Chapter 7 (Sections 7.1 to 7.3) **(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. 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 8.5 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 Weight Question) Answer any 8**	**Part B(2 Weight Question) Answer any six**	**Part C (5 Weight Question) Answer any two**
1	3	2	1
2	3	2	1
3	2	2	1
4	2	2	1
Total	10	8	4
Total Weight 30	**8**	**12**	**10**

24P4MATPJ: PROJECT

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 as per the regulations given in 2.8.

24P4MATCV: COMPREHENSIVE VIVA - VOCE

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 as per the regulations given in section 2.8 by the Committee. There are no weightage for internal assessment for the Comprehensive viva voce.