

# **MAHATMA GANDHI UNIVERSITY**

**PRIYADARSINI HILLS  
KOTTAYAM-686560**

**RESTRICTED SYLLABUS FOR POST-GRADUATE  
PROGRAMME UNDER CREDIT SEMESTER SYSTEM**

**IN**

## **MATHEMATICS**

*(w.e.f 2012 Admission onwards)*

**MAHATMA GANDHI UNIVERSITY  
KOTTAYAM**

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## P R E F A C E

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The present time is experiencing unprecedented progress in the field of Science and technology in which mathematics is playing a vital role; and so the curriculum and syllabi of any academic programme has to be systematically subjected to thorough revision so as to make them more relevant and significant.

Mahatama Gandhi University, in line with the proposals put forward by the University Grants Commission, has already brought about quality improvement in the Under Graduate Programmes by introducing the Choice Based Credit Semester and Grading System.

The University is also committed to prepare a comprehensive plan of action for introducing the CBCSS in the Post Graduate programmes as well. Various workshops with the participation of the teachers from affiliated colleges and inviting experts from other Universities were conducted at various institutions. The syllabus and curriculum we present here is the follow-up of such workshops.

We gratefully acknowledge the assistance and guidance received from the University and all those who have contributed in different ways in this venture.

It is recommended that the content of this syllabus be reviewed and adapted in the light of the consultative process, as well as during its application in future curriculum revision initiatives, and also the syllabus and curriculum be revised periodically.

I hope this restructured syllabus and curriculum would enrich the students.

Prof. Alexander K Samuel  
Chairman Board of Studies (PG)

**MASTER DEGREE PROGRAMME IN MATHEMATICS**  
**Restructured under credit semester system**

**BOARD OF STUDIES**  
**Mathematics (PG)**  
**Mahatma Gandhi University**  
**Kottayam**

- 1 .Prof. Alexander K Samuel, Principal,  
St. Thomas College, Kozhenchery (Chairman)*
  - 2 .Prof. D.Salim Kumar, Associate Professor,  
Dept. of Mathematics, S.N.M College, Maliankara*
  - 3 .Prof. J. Chandramohanan, Associate Professor and Head,  
Dept. of Mathematics, St. Thomas College, Pala*
  - 4. Prof. B. Rema, Associate Professor and Head,  
Dept. of Mathematics, D.B. College, Thalayolaparampu*
  - 5 .Prof. K.V. Neelakanda Sharma, Associate Professor and Head,  
Dept. of Mathematics, St. Paul's College, Kalamassery.*
  - 6. Prof. V.N. Ramachandran Pillai, Associate Professor,  
Dept. of Mathematics, N.S.S.Hindhu College, Changanasserry.*
  - 7. Prof. P.V. Mathai, Associate Professor,  
Dept. of Mathematics, Maharaja's College, Ernakulam.*
  - 8. Prof. P. Rajasekharan Pillai, Associate Professor,  
Dept. of Mathematics, D.B. Pampa College, Parumala*
  - 9 .Prof. M.G Mohanan Nair, Associate Professor,  
Dept. of Mathematics, S.V.R.N.S.S College, Vazhoor*
  - 10. Dr. C. Jayasri, Associate Professor,  
Dept. of Mathematics, University of Kerala, Kariavattom*
  - 11.Dr. P.T. Ramachandran, Associate Professor,  
Dept. of Mathematics, Calicut University, Calicut*
- External Expert : Dr. Sunny Kuriakose, Principal,  
B.P.C College, Piravom.*

**MAHATMA GANDHI UNIVERSITY PG PROGRAMME  
REGULATIONS FOR CREDIT AND SEMESTER SYSTEM  
(MGU-CSS-PG)**

**1. SHORT TITLE**

**1.1. These Regulations shall be called Mahatma Gandhi University Regulations (2011) governing Post Graduate Programmes under the Credit Semester System (MGU-CSS-PG)**

**1.2 These Regulations shall come into force from the Academic Year 2012-2013 onwards.**

**2. SCOPE**

**2.1 The regulation provided herein shall apply to all regular post-graduate programmes, MA/MSc/MCom, conducted by the affiliated colleges/Institutions (Government/ Aided/unaided/ Self-financing, and Constituent colleges of Mahatma Gandhi University with effect from the academic year 2012-2013 admission onwards.**

**2.2 The provisions here in supersede all the existing regulations for the regular post-graduate programmes conducted by the affiliated colleges and centres of the Mahatma Gandhi University unless otherwise specified.**

**2.3 These shall not apply for the programme conducted in distance/ off campus and private registration mode which will continue to be in annual scheme.**

**3. DEFINITIONS**

**3.1 ‘University’ means Mahatma Gandhi University, Kottayam, Kerala**

**3.2 ‘Academic Committee’ means the Committee constituted by the Vice-Chancellor under this regulation to monitor the running of the Post-Graduate programmes under the Credit Semester System (MGU-CSS-PG)**

**3.3 ‘Programme’ means the entire course of study and Examinations.**

**3.4 ‘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.**

**3.5 ‘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.**

**3.5(a) ‘Academic Week’ is a unit of 5 working days in which distribution of works is organised from day 1 to day 5, with 5 contact hours of 1 hour duration in each day. A sequence of 18 such academic week constitutes a semester.**

**3.5 (b) 'Zero semester'** means a semester in which a student is permitted to opt out due to unforeseen genuine reasons.

**3.6 '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 / seminar / project / practical training / assignments/evaluation etc., to meet effective teaching and learning needs.

**3.7 'Credit' (Cr)** of a course is a measure of the weekly unit of work assigned for that course in a semester.

**3.8 'Course Credit'** One credit of the course is defined as a minimum of one hour lecture / minimum of 2 hours lab/field work per week for 18 weeks in a Semester. The course will be considered as completed only by conducting the final examination. No regular student shall register for more than 24 credits and less than 16 credits per semester. The total minimum credits, required for completing a PG programme is 80.

**3.9 '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.

**3.10 'Programme Elective course'** Programme Elective course means a course, which can be substituted, by equivalent course from the same subject and a minimum number of courses are required to complete the programme.

**3.11 '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 research center in order to submit a dissertation on the project work as specified.

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

**3.13 '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.

**3.14 '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.

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

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

**3.17 'Improvement course' is a course registered by a student for improving his performance in that particular course.**

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

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

**3.20 'Parent Department' means the Department which offers a particular post graduate programme.**

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

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

**3.23 'Course Teacher' means the teacher who is taking classes on the course.**

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

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

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

**3.27 'Credit point' (P) of a course is the value obtained by multiplying the grade point (G) by the Credit (Cr) of the course  $P=G \times Cr$ .**

**3.27(a) 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 decided by the university.**

**3.28 'Weight' is a numerical measure quantifying the comparative range of an answer or the comparative importance assigned to different components like theory and practical, internal and external examinations, core and elective subjects, project and viva-voce etc.**

**3.29 'Weighted Grade Point' is grade points multiplied by weight.**

**3.29(a)' Weighted Grade Point Average' (WGPA) is an index of the performance of a students in a course. It is obtained by dividing the sum of the weighted Grade Points by the sum of the weights of the grade points. WGPA shall be obtained for CE and ESE separately and then the combined WGPA shall be obtained for each course.**

**3.30 '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 point obtained in the course by the sum of the weights of Course.**

**3.31 'Semester Grade point average' (SGPA) is the value obtained by dividing the sum of credit points (P) 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.**

**3.32 '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.**

**3.33 'Grace Grade Points' means grade points awarded to course/s, as per the choice of the student, in recognition of meritorious achievements in NCC/NSS/Sports/Arts and cultural activities.**

**3.34 '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.**

#### **4. ACADEMIC COMMITTEE**

**4.1 There shall be an Academic Committee constituted by the Vice-Chancellor to manage and monitor the working of (MGU-CSS-PG) 2011.**

**4.2 The Committee consists of**  
**(a) The Vice-Chancellor**  
**(b) The Pro-Vice-Chancellor**  
**(c) The Registrar**  
**(d) The Controller of Examinations**  
**(e) Two Teacher Syndicate members.**

**4.3 There shall be a subcommittee nominated by the Vice Chancellor to look after the day to day affairs of the ...MGU-CSS-PG 2011programme.**

#### **5. PROGRAMME STRUCTURE**

**5.1 Students shall be admitted into post graduate programme under the faculties.**

**5.2 The programme shall include two types of courses, Program Core (PC) courses and Program Elective (PE) Courses. There shall be a Program Project (PP) with dissertation to be undertaken by all students. The Programme will also include assignments, seminars / practical viva etc., if they are specified in the Curriculum.**

**5.3. There shall be various groups of Programme Elective courses for a programme such as Group A, Group B etc. for the choice of students subject to the availability of**

**facility and infrastructure in the institution and the selected group shall be the subject of specialization of the programme.**

#### **5.4 Project work**

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

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

**5.4.3. A candidate may, however, in certain cases is permitted to work on the project in an industrial / Research Organization on the recommendation of the Supervisor. In**

**5.4.4 There should be an internal assessment and external assessment for the project work.**

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

**5.4.6. The title and the credit with grade awarded for the program project should be entered in the grade card issued by the university.**

**5.5. Assignments: Every student shall submit one assignment as an internal component for every course with a weightage one. The Topic for the assignment shall be allotted within the 6th week of instruction.**

**5.6. Seminar Lecture: Every PG student shall deliver one seminar lecture as an internal component for every course with a weightage two. 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.**

**5.7. Every student shall undergo at least two class tests as an internal component for every course with a weightage one each. The weighted average shall be taken for awarding the grade for class tests.**

**5.8. The attendance of students for each course shall be another component of internal assessment as prescribed with weightage one.**

**5.9 .No course shall have more than 4 credits.**

**5.10. Comprehensive Viva-voce shall be conducted at the end semester of the program comprehensive Viva-Voce covers questions from all courses in the programme.**

#### **6. ATTENDANCE**

**6.1. 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 University.

6.2 .If a student represents his/her institution, 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 Department and Principal of the College concerned.

6.3 .A student who does not satisfy the requirements of attendance shall not be permitted to take the end Semester examinations.

## **7. BOARD OF STUDIES AND COURSES.**

7.1 The PG 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.

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

7.3 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).

7.4 Every Programme conducted under Credit Semester System shall be monitored by the College Council.

## **8. REGISTRATION/ DURATION**

8.1 .The duration of PG programmes shall be 4 semesters.

8.2 .The duration of each semester shall be 90 working days. Odd semesters from June to October and even semesters from December to April. There will be one month semester breaks each in November and May.

8.3 A student may be permitted to complete the programme, on valid reasons, with in a period of 8 continuous semesters from the date of commencement of the first semester of the programmes.

## **9. ADMISSION**

9.1 The admission to all PG programmes shall be as per the rules and regulations of the University

**9.2** The eligibility criteria for admission shall be as announced by the University from time to time.

**9.3** Separate rank lists shall be drawn up for reserved seats as per the existing rules.

**9.4** The college shall make available to all students admitted a Prospectus listing all the courses offered including programme elective during a particular semester. The information provided shall contain title of the course and credits of the course.

**9.5** There shall be a uniform academic and examination calendar prepared by the University for the Conduct of the programmes. The University shall ensure that the calendar is strictly followed.

**9.6** There shall be provision for inter collegiate and inter University transfer in 3rd semesters within a period of two weeks from the date of commencement of the semester.

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

## **10. ADMISSION REQUIREMENTS**

**10.1** Candidates for admission to the first semester of the PG programme through CSS 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 Mahatma Gandhi University as equivalent thereto.

**10.2** The candidate must forward the enrollment form to the Controller of Examinations of the University through the Head of the Institution, in which he / she is currently studying.

**10.3** 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.

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

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

## **12. EXAMINATIONS**

**12.1** There shall be University examination at the end of each semester.

**12.2** Practical examinations shall be conducted by the University at the end of each semester.

**12.3 Project evaluation and Viva -Voce shall be conducted at the end of the programme only. Practical examination, Project evaluation and Viva-Voce shall be conducted by two external examiners and one internal examiner.**

**12.4 End-Semester Examinations: The examinations shall normally at the end of each semester.**

**12.5 There shall be one end-semester examination of 3 hours duration in each lecture based course and practical course.**

**12.6 A question paper may contain short answer type/annotation, short essay type questions/problems and long essay type questions. Different types of questions shall have different weightage to quantify their range. Weightage can vary from course to course depending on their comparative importance, but a general pattern may be followed by the Board of Studies.**

### **13. EVALUATION AND GRADING**

**13.1 Evaluation: The evaluation scheme for each course shall contain two parts; (a) internal evaluation and (b) external evaluation. 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. Both internal and external evaluation shall be carried out using direct grading system.**

**13.2 Internal evaluation: The internal evaluation shall be based on predetermined transparent system involving periodic written tests, assignments, seminars, Internal viva and attendance in respect of theory courses and based on written tests, lab skill/records/viva and attendance in respect of practical courses. The weightage assigned to various components for internal evaluation is as follows.**

#### **13.3 Components of Internal Evaluation**

<b>Component</b>	<b>Weightage</b>
<b>i) Assignment-----</b>	<b>1</b>
<b>ii) Seminar -----</b>	<b>2</b>
<b>iii) Attendance -----</b>	<b>1</b>
<b>iv) Two Test papers—</b>	<b>2</b>

<b>Letter Grade</b>	<b>Performance</b>	<b>Grade point (G)</b>	<b>Grade Range</b>
<b>A</b>	<b>Excellent</b>	<b>4</b>	<b>3.5 to 4.00</b>
<b>B</b>	<b>Very Good</b>	<b>3</b>	<b>2.5 to 3.49</b>
<b>C</b>	<b>Good</b>	<b>2</b>	<b>1.5 to 2.49</b>
<b>D</b>	<b>Average</b>	<b>1</b>	<b>0.5 to 1.49</b>
<b>E</b>	<b>Poor</b>	<b>0</b>	<b>0.00 to 0.49</b>

### 13.4 Grades for Attendance

<u>% of attendance</u>	<u>Grade</u>
>90 %	A
Between 85 and 90	B
Between 80 and below 85	C
Between 75 and below 80	D
< 75	E

### Assignment

<u>Component</u>	<u>weight</u>
Punctuality	1
Review	1
Content	2
Conclusion	1
Reference	1

### Seminar

<u>Component</u>	<u>weight</u>
Area/ topic selected	1
Review/reference	1
Content	2
Presentation	2
Conclusion	1

### Project evaluation

#### Internal

<u>Component</u>	<u>weight</u>
Punctuality	1
Experimentation/ data collection	1
Compilation	1
Content	1

## External

<u>Component</u>	<u>weight</u>
Area/ topic selected	1
Objectives	2
Review	1
Materials and methods	2
Analysis	2
Presentation	2
Conclusion/ Application	2

**13.5** 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 at least one week before the commencement of external examination. There shall not be any chance for improvement for internal grade.

**13.6** 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 University through the college Principal and a copy should be kept in the college for at least two years for verification.

**13.7 External evaluation:** The external Examination in theory courses is to be conducted by the University with question papers set by external experts. The evaluation of the answer scripts shall be done by examiners based on a well-defined scheme of valuation. The external evaluation shall be done immediately after the examination preferably through Centralized Valuation

**13.8** Photocopies of the answer scripts of the external examination shall be made available to the students for scrutiny on request and revaluation/scrutiny of answer scripts shall be done as per the existing rules prevailing in the University.

**13.9.** The question paper should be strictly on the basis of model question paper set by BOS and there shall be a combined meeting of the question paper setters for scrutiny and finalisation of question paper. Each set of question should be accompanied by its scheme of valuation.

**13.10. DIRECT GRADING SYSTEM** Direct Grading System based on a 5 - point scale is used to evaluate the performance (External and Internal Examination of students)

### **13.11. DIRECT GRADING SYSTEM**

Letter Grade	Performance	Grade point (G)	Grade Range
A	Excellent	4	3.5 to 4.00
B	Very Good	3	2.5 to 3.49
C	Good	2	1.5 to 2.49
D	Average	1	0.5 to 1.49
E	Poor	0	0.00 to 0.49

**13.12. The overall grade for a programme for certification shall be based on CGPA with a 7- point scale given below**

<b>CGPA</b>	<b>Grade</b>
<b>3.80 to 4.00</b>	<b>A+</b>
<b>3.50 to 3.79</b>	<b>A</b>
<b>3.00 to 3.49</b>	<b>B+</b>
<b>2.50 to 2.99</b>	<b>B</b>
<b>2.00 to 2.49</b>	<b>C+</b>
<b>1.50 to 1.99</b>	<b>C</b>
<b>1.00 to 1.49</b>	<b>D</b>

**A separate minimum of C Grade for internal and external are required for a pass for a course. For a pass in a programme a separate minimum grade C is required for all the courses and must score a minimum CGPA of 1.50 or an overall grade of C and above.**

**13.13 Each course is evaluated by assigning a letter grade (A, B, C, D or E) to that course by the method of direct grading. The internal (weightage =1) and external weightage =3) components of a course are separately graded and then combined to get the grade of the course after taking into account of their weightage.**

**13.14 A separate minimum of C grade is required for a pass for both internal evaluation and external evaluation for every course.**

**13.15 A student who fails to secure a minimum grade for a pass in a course will be permitted to write the examination along with the next batch. There will be no supplementary examination.**

**13.16 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 1.50. However, a student is permitted to move to the next semester irrespective of her/his SGPA. For instance, if a student has registered for 'n' courses of credits C1, C2 .....Cn in a semester and if she/he has scored credit points P1, P2.....,Pn respectively in these courses, then SGPA of the student in that semester is calculated using the formula.  $SGPA = \frac{(P1+P2+.....+Pn)}{(C1+C2+.....+Cn)}$**

**$CGPA = \frac{[(SGPA)1*S1 + (SGPA)2*S2 + (SGPA)3*S3 + (SGPA)4*S4]}{(S1+S2+S3+S4)}$   
Where S1, S2, S3, and S4 are the total credits in semester1, semester2, semester3 and semester 4**

**13.17 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 short answer type, short essay type/ problem solving type and long essay type questions.

**Weight:** Different types of questions shall be given different weights to quantify their range as follows.

<u>Sl. No</u>	<u>Type of questions</u>
1.	Short answer type questions
2.	Short essay(problem solving type questions)
3.	Long essay type questions

#### **14. GRADE CARD**

**14.1** The University 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 University.
- b) Name of college
- c) Title of the PG Programme.
- d) Name of Semester
- e) Name and Register Number of students
- f) Code number, Title and Credits of each course opted in the semester, Title and Credits of the Project Work
- g) Internal, external and Total grade, Grade Point (G), Letter grade and Credit point (P) in each course opted in the semester.
- h) The total credits, total credit points and SGPA in the semester.

**14.2** The Final Grade Card issued at the end of the final semester shall contain the details of all courses taken during the entire programme including those taken over and above the prescribed minimum credits for obtaining the degree. The Final Grade Card shall show the CGPA and the overall letter grade of a student for the entire programme.

#### **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

#### **16. MONITORING COMMITTEE**

There shall be a Monitoring Committee constituted by the Vice-chancellor to monitor the internal evaluations conducted by institutions. 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.

#### **17. GRIEVENCE REDRESSAL COMMITTEE**

**17.1** College level: The College shall form a Grievance Redress Committee in each Department comprising of course teacher and one senior teacher as members and the Head of the Department as Chairman. The Committee shall address all grievances relating to the internal assessment grades of the students. There shall be a college level Grievance Redress Committee comprising of Faculty advisor, two senior teachers and

two staff council members (one shall be an elected member) and the Principal as Chairman.

**17.2 University level:** The University shall form a Grievance Redress Committee as per the existing norms.

**18. TRANSITORY PROVISION**

Notwithstanding anything contained in these regulations, the Vice-Chancellor 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

**19. REPEAL**

The Regulations now in force in so far as they are applicable to programmes offered by the University 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 Semester System in their application to any course offered in a College, the latter shall prevail. Models of distribution of course and credit are given in the following tables. BOS can make appropriate changes subject to the following conditions.

1. Total credit of the programme shall be 80)
  2. The minimum credit of a course is 2 and maximum credit is 4
  3. Semester-wise total credit can vary from 16 to 24
  4. Number of courses per semester can be decided by the BOS concerned.
  5. The credits of Projects, Dissertations and viva-voce can be prescribed by the BOS
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**M.Sc Mathematics programme**

Semester	Course	Teaching Hrs.	Credits	Total Credits
I	PC- 1	5	4	20
	PC- 2	5	4	
	PC- 3	5	4	
	PC- 4	5	4	
	PC- 5	5	4	
II	PC- 6	5	4	20
	PC- 7	5	4	
	PC- 8	5	4	
	PC- 9	5	4	
	PC- 10	5	4	
III	PC- 11	5	4	20
	PC- 12	5	4	
	PC- 13	5	4	
	PC- 14	5	4	
	PC- 15	5	4	

IV	PC- 16	5	3	20
	PE -X	5	3	
	PE -Y	5	3	
	PE -Z	5	3	
	PE - K	5	3	
	Project(PP)		3	
	Viva-voce(PV)		2	

- PC means Programme core
- PE means programme electives
- A list of elective papers will be given by the Board of Studies. Each College can select a group of four electives according to their infrastructure facilities. X, Y, Z and K represent the numbers of the elective courses in the ascending orders.
- All students shall submit the project before the end of the fourth semester external examination
- The external evaluation of the project will be done by the viva-voce board
- Viva-voce (PV) means the comprehensive viva-voce based on all the core courses.

The following pattern of questions will be followed for M.Sc. Mathematics programme

Sl. No	Type of Questions	Weight	Number of questions to be answered	Total weight
1	Short answer type questions (½ to 1 page)	1	5 out of 8	5
2	Short essay type questions (1 to 2 page)	2	5 out of 8	10
3	Long essay type questions	5	3 out of 6	15

Total Weight - 30

Total time allotted: - 3 hours

### **SDE / PRIVATE POST-GRADUATE STUDY CANDIDATES**

SDE candidates and private-registered candidates for post-graduate examination will continue to be under the annual scheme. They will however be following the restructured syllabi with the difference that they will have no internal evaluation component in their scheme of examination. The total marks 2200(100 marks for each paper) will follow for these candidates. The first year examination will be for 1000 marks for 10 courses in Semester I and Semester II and the second year examination for 1100 marks(for 11 courses) of 100 marks each consisting of 5 core courses in Semester III and 1 core course in Semester IV and 5 electives selected from the set of electives in Semester IV. ( The above candidates

will have the option to choose an elective paper in lieu of the project/dissertation as the 5<sup>th</sup> elective). Candidates electing to write a dissertation can do so under the guidance of college teachers approved by the SDE / Board of studies. The viva voce at the end of the second year examination will account for 100 marks. The existing regulations relating to conduct the course and examinations will be applicable to these candidates.

The SDE / Board of studies will identify the cluster of papers – four papers and an additional one for candidates who do not opt for the dissertation - to be studied in the second year, in addition to the six core papers.

The following question paper pattern (in setting each paper) will be followed for the above categories.

Sl. No	Type of Questions	Marks	Number of questions to be answered	Total marks
1	Short answer type questions (½ to 1 page)	3	5 out of 8	15
2	Short essay type questions (1 to 2 page)	8	5 out of 8	40
3	Long essay type questions	15	3 out of 6	45
Grand total for a paper				100

### M.Sc. MATHEMATICS PROGRAMME

Sl.No	Progr- amme code	Course code	Name of the course	Marks	Total Hours
<b>Semester – 1</b>					
1	PC 1	MT01C01	Linear Algebra	100	90
2	PC 2	MT01C02	Basic Topology	100	90
3	PC 3	MT01C03	Measure Theory and Integration	100	90
4	PC 4	MT01C04	Graph Theory	100	90
5	PC 5	MT01C05	Complex Analysis	100	90
<b>Semester – 2</b>					
6	PC 6	MT02C06	Abstract Algebra	100	90
7	PC 7	MT02C07	Advanced Topology	100	90
8	PC 8	MT02C08	Advanced Complex Analysis	100	90
9	PC 9	MT02C09	Partial Differential Equations	100	90
10	PC10	MT02C10	Real Analysis	100	90
<b>Semester – 3</b>					
11	PC 11	MT03C11	Multivariate Calculus and Integral	100	90

			Transforms		
12	PC 12	MT03C12	Functional Analysis	100	90
13	PC 13	MT03C13	Differential Geometry	100	90
14	PC 14	MT03C14	Number Theory and Cryptography	100	90
15	PC 15	MT03C15	Optimization Techniques	100	90
<b>Semester – 4</b>					
16	PC 16	MT04C16	Spectral Theory	100	90
<b>Elective Courses</b>					
17	PE 1	MT04E01	Analytic Number Theory	100	90
18	PE 2	MT04E02	Combinatorics	100	90
19	PE 3	MT04E03	Classical Mechanics	100	90
20	PE 4	MT04E04	Probability Theory	100	90
21	PE 5	MT04E05	Mathematical Economics	100	90
22	PE 6	MT04E06	Mathematics for Computing	100	90
23	PE 7	MT04E07	Operations Research	100	90
24	PE 8	MT04E08	Special Functions	100	90
25	PE 9	MT04E09	Theory of Wavelets	100	90
26	PE 10	MT04E10	Signal Theory	100	90
27	PE 11	MT04E11	Commutative Algebra	100	90
28	PE 12	MT04E12	Fractional Calculus	100	90
29	PE 13	MT04E13	Algorithmic Graph Theory	100	90
30	PE 14	MT04E14	Coding Theory	100	90
31	PE 15	MT04E15	Complex Algebraic Curves	100	90
32	PE 16	MT04E16	Algebraic Geometry	100	90
33	PE 17	MT04E17	Fractal Geometry	100	90
34	PE 18	MT04E18	Lie Algebras	100	90
35	PE 19	MT04E19	Algebraic Topology	100	90
36	PE 20	MT04E20	Financial Mathematics	100	90
37	PP	MT04P01	Project / Dissertation	100	-----
38	PV	MT04V01	Viva-voce	100	-----

## Semester - 1

PC 1

MT01C01

### LINEAR ALGEBRA

**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  
(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) (15 hours.)

**Module 2:** Linear transformations, the algebra of linear transformations, isomorphism, representation of transformations by matrices, linear functionals, 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) (30 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) (18 hours.)

**Module 4:** Introduction to elementary canonical forms, characteristic values, annihilatory polynomials, invariant subspaces, simultaneous triangulations, simultaneous diagonalisation, direct sum decompositions, invariant direct sums

(Chapter 6 - 6.1, 6.2, 6.3, 6.4, 6.5 & 6.6 of the text) (27 hours.)

### Question paper Pattern

	Part A	Part B	Part C
	Short questions	Short essays	Long essays
Module I	2	1	1
Module II	2	3	2
Module III	2	1	1
Module IV	2	3	2
Total	8	8	6

### 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, 3<sup>rd</sup> 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.

## BASIC TOPOLOGY

**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.) (24 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) (22 hours)

**Module 3:** Connectedness: Local connectedness and paths

(Chapter 6 Section. 2 & 3 of the text) (22 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) (22 hours)

### Question paper Pattern

	Part A	Part B	Part C	
	Short questions	Short essays	Long essays	
Module I	2	2	1	1
Module II	2	2	1	
Module III	2	2	1	1
Module IV	2	2	1	
<b>Total</b>	<b>8</b>	<b>8</b>	<b>6</b>	

### 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.

**PC 3**

**MT01C03**

## **MEASURE THEORY AND INTEGRATION**

**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 5. of Text 1) (20 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, differentiation of monotone functions.

(Chapter 4 - Sec. 1 – 4. of Text 1

Chapter 5 - Sec. 1. of Text 1) (20 hours)

**Module 3:** Measure and integration: measure spaces, measurable functions, Integration, general convergence theorems, signed measures, the Radon-Nikodym theorem, outer measure and measurability, the extension theorem.

(Chapter 11 - Sec. 1 to 6 of Text 1

Chapter 12 - Sec. 1& 2 of Text 1) (20 hours)

**Module 4:** Convergence: convergence in measure, almost uniform convergence, measurability in a product space, the product measure and Fubini's theorem.

(Chapter 8 - Sec. 7.1 & 7.2 of Text 2

Chapter 10 - Sec. 10.1& 10.2 of Text 2) (25 hours)

**Question paper pattern**

	Part A Short questions	Part B Short essays	Part C Long essays
Module I	2	2	1
Module II	2	2	2
Module III	2	2	2
Module IV	2	2	1
Total	8	8	6

### 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, 1997.

PC 4

MT01C04

## GRAPH THEORY

**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)

(20 hours)

### Module:- 2 Trees:

Definition, characterization and simple properties, centres and cenroids, counting the number of spanning trees, Cayley's formula, applications

(Chapter 4 Sections 4.1 to 4.4

Chapter 10 Sections 10.1 to 10.4 of the text)

(20 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 of the text)

(25 hours)

**Module:- 4 :**

Edge colouring and planarity- Edge colouring of graphs, planar and non planar graphs, Euler formula and its consequences,  $K_5$  and  $K_{3,3}$  are non planar graphs, dual of a plane graph. the four colour theorem and Heawood five colour theorem.

(Chapter 7 Section 7.4

Chapter 8 Sections 8.1 to 8.5 of the text)

(25 hours)

### Question Paper Pattern

	Part A	Part B	Part C	
	Short questions	Short essays	Long essays	
Module I	2	2	1	1
Module II	2	2	1	
Module III	2	2	1	1
Module IV	2	2	1	
Total	8	8	6	

**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.

## COMPLEX ANALYSIS

**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) (20 hours.)

**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 closed curve, the integral formula, higher derivatives.  
 (Chapter 4 – Sections 1 and 2. of the text.) (20 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) (25 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) (25 hours.)

### Question paper Pattern

	Part A	Part B	Part C	
	Short questions	Short essays	Long essays	
Module I	2	2	1	

Module II	2	2	1	1
Module III	2	2	1	1
Module IV	2	2	1	
Total	8	8	6	

**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.

## Semester 2

**PC 6**

**MT02C05**

### ABSTRACT ALGEBRA

**Text Book:** John B. Fraleigh, A First Course in Abstract Algebra, 7<sup>th</sup> edition, Pearson Education.

**Module 1:** Direct products and finitely generated Abelian groups, fundamental theorem (without proof), Applications

Rings of polynomials, factorisation of polynomials over a field.

(Part II – Section 11) & (Part IV – Sections 22 & 23) (25 hours)

**Module 2:** Introduction to extension fields, algebraic extensions, Geometric constructions. Finite fields.

(Part VI – Section 29, 31 – 31.1 to 31.18, 32, 33) (25 hours)

**Module 3:** Sylow’s theorems (without proof), Applications of sylow theory

Automorphism of fields, the isomorphism extension theorem

(proof of the theorem excluded)

(Part VII Sections 36 & 37) (Part X – Sections 48 & 49, (49.1 to 49.5)

(20 hours)

**Module 4:** Splitting fields, separable extensions, Galois theory

(Part X – Sections 50, 51, 53 -53.1 to 53.6)

(20 hours)

### Question Paper Pattern

	Part A Short questions	Part B Short essays	Part C Long essays
Module I	2	2	2
Module II	2	2	2
Module III	2	2	1
Module IV	2	2	1
Total	8	8	6

### References:-

1. I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
2. Hungerford, Algebra, Springer
3. M. Artin, Algebra, Prentice -Hall of India, 1991
4. N. Jacobson, Basic Algebra Vol. I, Hindustan Publishing Corporation
5. P.B. Bhattacharya, S.K. Jain, S.R. Nagapaul, Basic Abstract Algebra, 2<sup>nd</sup> edition, Cambridge University Press, Indian Edition, 1997.

**PC 7**

**MT02C07**

### ADVANCED TOPOLOGY

**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)

(25 hours)

**Module 2:** Embedding and Metrisation – Evaluation Functions in to Products, Embedding Lemma and Tychonoff Embedding, The Urysohn Metrisation Theorem.

(Chapter 9. Sec. 1, 2 & 3 of the text)

(15 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)

(25 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

(25 hours)

### Question Paper Pattern

	Part A	Part B	Part C
	Short questions	Short essays	Long essays
Module I	3	2	2
Module II	1	1	1
Module III	2	3	2
Module IV	2	2	1
Total	8	8	6

### 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.

## ADVANCED COMPLEX ANALYSIS

**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 factorisation: 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)

( 25 hours)

**Module 2:** Entire functions: Jensen's formula, Hadamard's theorem (without proof)

the Riemann zeta function: the product development, extension of  $\zeta$  to the whole plane, the functional equation, the zeroes of zeta function.

Normal families: Equi continuity, normality and compactness, Arzela's theorem (without proof)

(Chapter 5 - Sections 3, 4, 5.1, 5.2, and 5.3 of the text) ( 25 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 Weierstrass theory: the Weierstrass function, the functions  $\xi(y)$  and  $\sigma(y)$ , the differential equation.

Analytic continuation: the Weierstrass theorem, Germs and Sheaves, sections and Riemann surfaces, analytic continuation along arcs, homotopic curves.

(Chapter 7 Sections 1, 2, 3.1, 3.2, 3.3

Chapter 8 Sections 1.1 to 1.5 of the text)

( 20 hours)

### Question Paper Pattern

	Part A	Part B	Part C
	Short questions	Short essays	Long essays
Module I	2	2	1
Module II	2	2	1
Module III	2	2	2
Module IV	2	2	2
Total	8	8	6

#### 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

**PC 9**

**MT02C09**

## PARTIAL DIFFERENTIAL EQUATIONS

**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. Origins 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) (25 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) (25 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) (20 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) (20 hours)

### Question paper pattern

	Part A	Part B	Part C
	Short questions	Short essays	Long essays
Module I	2	2	2
Module II	2	2	2
Module III	2	2	1
Module IV	2	2	1
Total	8	8	6

### 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

PC 10

MT02C10

## REAL ANALYSIS

**Text 1:** Tom Apostol, Mathematical Analysis (second edition), Narosa Publishing House.

**Text 2:** Walter Rudin, Principles of Mathematical Analysis (Third edition), International Student Edition.

**Pre-requisites**

A quick review on continuity, uniform continuity, convergence of sequence and series. (5 hours.)

(No question shall be asked from this section.)

**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) (20 hours.)

**Module 2: The Riemann-Stieltjes Integral**

Definition and existence of the integral, properties of the integral, integration and differentiation, integration of vector valued functions.

(Chapter 6 - Section 6.1 to 6.25 of Text 2) (20 hours.)

**Module 3: 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) (25 hours.)

**Module 4: Some Special Functions**

Power series, the exponential and logarithmic functions, the trigonometric functions, the algebraic completeness of complex field, Fourier series.

(Chapter 8 - Section 8.1 to 8.16 of Text 2) (20 hours.)

**Question Paper Pattern**

	Part A Short questions	Part B Short essays	Part C Long essays
Module I	2	2	1
Module II	2	2	2
Module III	2	2	2
Module IV	2	2	1
Total	8	8	6

**References:-**

1. Royden H.L, Real Analysis, 2<sup>nd</sup> 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.

## Semester – 3

PC 11

MT03C11

### MULTIVARIATE CALCULUS AND INTEGRAL TRANSFORMS

**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) (20 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) (20 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 (25 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 (25 hours.)

### Question Paper Pattern

	Part A	Part B	Part C
	Short questions	Short essays	Long essays
Module I	2	2	1
Module II	2	2	2
Module III	2	2	2
Module IV	2	2	1
Total	8	8	6

#### References:-

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

PC 12

MT03C12

### FUNCTIONAL ANALYSIS

**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)

(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) (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)

(25 hours)

#### Module 4

Zorn's lemma, Hahn- Banach theorem, 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)

(25 hours)

#### Question Paper Pattern

	Part A	Part B	Part C
	Short questions	Short essays	Long essays
Module I	2	3	1
Module II	2	1	2
Module III	2	1	2
Module IV	2	3	1
Total	8	8	6

#### 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, Meerut: 1995-96
5. M. Thamban Nair, Functional Analysis, A First Course, Prentice – Hall of India Pvt. Ltd, . 2008
6. Walter Rudin, Functional Analysis, TMH Edition, 1974.

PC 13

MT03C13

### DIFFERENTIAL GEOMETRY

**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) (25 hours)

**Module 4:** Curvature of surfaces, Parametrized surfaces, local equivalence of surfaces and Parametrized surfaces.  
(Chapters 12, 14 & 15 of the text). (30 hours)

### Question paper pattern

	Part A Short questions	Part B Short essays	Part C Long essays
Module I	2	2	1
Module II	2	2	1
Module III	2	2	2
Module IV	2	2	2
Total	8	8	6

### References:-

1. Serge Lang, Differential Manifolds
2. I.M. Siger, J.A Thorpe, Lecture notes on Elementary topology and Geometry, Springer – Verlag, 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)

PC 14

MT03C14

## NUMBER THEORY AND CRYPTOGRAPHY

**Text Book:** Neal Koblitz, A Course in Number Theory and Cryptography, 2nd edition, Springer Verlag.

**Module 1: Some topics in Elementary Number Theory:**-Time estimates for doing arithmetic, divisibility and the Euclidean algorithm, congruences, Some applications to factoring.

(Chapter – I Sections 1, 2, 3 & 4 of the text) (28 hours)

**Module 2: Finite Fields and Quadratic Residues:**-Finite fields, quadratic residues and reciprocity

(Chapter – II Sections 1 & 2 of the text) (14 hours)

**Module 3: Public Key:** - The idea of public key cryptography, **RSA**, Discrete log.

(Chapter – IV Sections 1, 2 & 3 of the text) (25 hours)

**Module 4: Primality and Factoring:** - Pseudo primes, The rho method, Fermat factorization and factor bases, the quadratic sieve method.

(chapter – V Sections 1, 2, 3 & 5 of the text) (23 hours)

### Question Paper Pattern

	Part A Short questions	Part B Short essays	Part C Long essays
Module I	3	3	2
Module II	1	1	1
Module III	2	2	2
Module IV	2	2	1
Total	8	8	6

### Reference Books:

1. **Niven, H.S. Zuckerman and H.L. Montgomery**, *An introduction to the theory of numbers*, John Wiley, 5<sup>th</sup> Edition.
2. **Ireland and Rosen**, *A Classical Introduction to Modern Number Theory*. Springer, 2<sup>nd</sup> edition, 1990.
3. **David Burton**, *Elementary Number Theory and its applications*, Mc Graw-Hill Education (India) Pvt. Ltd, 2006.
4. **Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone**, *Handbook of Applied*

*Cryptography*, CRC Press, 1996

5. **Douglas R. Stinson**, *Cryptography Theory and Practice*, Chapman & Hall, 2<sup>nd</sup> edition

6. **Victor Shoup**, *A computation Introduction to Number Theory and Algebra*, Cambridge University Press, 2005

7. **William Stallings**, *Cryptography and Network Security Principles and Practice*, Third edition, Prentice-hall, India.

PC 15

MT03C15

## OPTIMIZATION TECHNIQUES

**Text – 1 K.V. Mital and C. Mohan, Optimization Methods in Operation Research and Systems Analysis, 3<sup>rd</sup> edition.**

**Text -2- Ravindran, Philips and Solberg. Operations Research Principle and Practice, 2<sup>nd</sup> edition, John Wiley and Sons.**

### Module I: 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)

(20 hours)

### Module II: SENSITIVITY ANALYSIS; FLOW AND POTENTIALS IN NETWORKS

· Introduction – changes in  $b_i$  – changes in  $c_j$  – Changes in  $a_{ij}$  – introduction of new variables – introduction of new constraints – deletion of variables - deletion of constraints –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 5.1 to 5.9 & 7.1 to 7.9, 7.15 of text - 1)

(25 hours)

### Module III: THEORY OF GAMES

Matrix (or rectangular) games – problem of games – minimax theorem, saddle point – strategies and pay off – theorems of matrix games – graphical solution – notion of dominance – rectangular game as an L.P. problem.

(Chapter 12; Sections: 12.1 – 12.9 of text – 1)

(20 hours)

### Module IV: 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 – project gradient methods with equality constraints – non-linear optimization: Kuhn-Tucker conditions – complimentary Pivot algorithms.

(Chapter 8; Sections: 8.1 – 8.14 of text – 2)

(25 hours)

Question Paper Pattern

	Part A Short questions	Part B Short essays	Part C Long essays
Module I	2	2	1
Module II	2	2	2
Module III	2	2	1
Module IV	2	2	2
Total	8	8	6

**Reference:-**

1. S.S. Rao, Optimization Theory and Applications, 2<sup>nd</sup> edition, New Age International Pvt.
2. J.K. Sharma, Operations Research: Theory and Applications, Third edition, Macmillan India Ltd.
3. Hamdy A. Thaha, Operations Research – An Introduction, 6<sup>th</sup> edition, Prentice Hall of India Pvt. Ltd.

## Semester – 4

PC 16

MT04C16

### SPECTRAL THEORY

**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)

(25 hours)

## Module 2

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

(Chapter 7 - Sections 7.1. to 7.7 of the text)

(25 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, unbounded linear operators and their Hilbert adjoint operators, Hilbert adjoint operators, symmetric and self adjoint linear operators

(Chapter 8 - Sections 8.1 to 8.4 - Chapter 10 Sections 10.1 & 10.2 of the text)

(20 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)

### Question Paper Pattern

	Part A	Part B	Part C
	Short questions	Short essays	Long essays
Module I	2	3	1
Module II	2	3	1
Module III	2	1	2
Module IV	2	1	2
Total	8	8	6

### 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, Meerut: 1995-96
5. M. Thamban Nair, Functional Analysis, A First Course, Prentice – Hall of India Pvt. Ltd, . 2008

## ELECTIVE COURSES

PE 1

MT04E01

### ANALYTIC NUMBER THEORY

**Text:** Tom M Apostol, *Introduction to Analytic Number Theory*, Springer International Student Edition, Narosa Publishing House

#### Module 1 Arithmetic Functions Dirichlet Multiplication and Averages of Arithmetical functions

Introduction to Chapter1 of the text, the Mobius function  $\mu(n)$  the Euler totient function  $\varphi(n)$ , a relation connecting  $\mu(n)$  and  $\varphi(n)$ , the Dirichlet product of arithmetical functions, Dirichlet inverses and Mobius inversion formula, the Mangoldt function  $\Lambda(n)$ , multiplicative e functions and Dirichlet multiplication, the inverse of completely multiplicative functions, the Liouville's function  $\lambda(n)$ , the divisor function  $\sigma_\alpha(n)$ , generalized convolutions, formal power series, the Bell series of an arithmetical function, Bell series and Dirichlet multiplication.

Introduction to Chapter2 of the text, the big oh notation, asymptotic equality of functions, Euler's summation formula, some elementary asymptotic formulas, the average order of  $d(n)$ , The average order of the divisor function  $\sigma_\alpha(n)$ , average order of  $\varphi(n)$ , an application of distribution of lattice points visible from the origin, average order of  $\mu(n)$  and  $\Lambda(n)$ , the partial sums of a Dirichlet product, application to  $\mu(n)$  and  $\Lambda(n)$ .

(Chapter 2 sections 2.1 to 2.17 and Chapter 3 sections 3.1 to 3.11 of the text)  
(30 hours)

#### Module 2 Some Elementary Theorems on the Distribution of Prime Numbers

Introduction to Chapter4, Chebyshev's functions  $\psi(x)$  and  $\mathcal{T}(x)$ , relation connecting  $\mathcal{T}(x)$  and  $\pi(x)$ , some equivalent forms of prime number theorem, inequalities of  $\pi(n)$  and  $\vartheta_n$ . Shapiro's Tauberian theorem, applications of Shapiro's theorem, an asymptotic formula for the partial sum  $\sum_{p \leq x} \left(\frac{1}{p}\right)$ .

(Chapter 4 sections 4.1 to 4.8 of the text) (15 hours)

#### Module 3 Congruences

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

(Chapter 5 sections 5.1 to 5.9 of the text) (30 hours)

#### Module 4 Primitive roots and partitions

The exponent of a number mod  $m$ . Primitive roots, Primitive roots and reduced systems, The non existence of Primitive roots mod  $2^\alpha$  for  $\alpha \geq 3$ , The existence of Primitive roots mod  $p$  for odd primes  $p$ , Primitive roots and quadratic residues. Partitions – Introduction, Geometric representation of partitions, Generating functions for partitions, Euler’s pentagonal-number theorem.

(Chapter 10 sections 10.1 to 10.5 &  
Chapter 14 sections 14.1 to 14.4 of the text) (15 hours)

#### Question Paper Pattern

	Part A Short questions	Part B Short essays	Part C Long essays
Module I	3	3	2
Module II	2	1	1
Module III	2	3	2
Module IV	1	1	1
Total	8	8	6

#### 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

PE 2

MT04E02

### COMBINATORICS

**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) (20 hours)

#### Module II The Pigeonhole Principle and Ramsey Numbers

Introduction, The pigeonhole principle, More examples, Ramsey type problems and Ramsey numbers, Bounds for Ramsey numbers

(Chapter 3 of the text) (20 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 a  
generalization, The Sieve of Eratosathenes and Euler  $\varphi$ -function.

(Chapter -4 Sections 4.1 to 4.7 of the text) (25 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) (25 hours)

#### Question Paper Pattern

	Part A	Part B	Part C	
	Short questions	Short essays	Long essays	
Module I	2	2	1	1
Module II	2	2	1	
Module III	2	2	1	1
Module IV	2	2	1	
Total	8	8	6	

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#### References:-

1. V Krishnamoorthy, Combinatorics theory and applications, E. Hoewood, 1986
2. Hall,Jr, Combinatorial Theory, Wiley- Interscinice, 1998.
- 3.Brualdi, R A, Introductory Combinatorics, Prentice Hall,1992

PE 3

MT04E03

### CLASSICAL MECHANICS

**Text: L. D. Landau and E. M. Lifshitz - MECHANICS, ( Third Edition )  
(Butter worth – Heinenann)**

**Module 1:** Generalized coordinates, the Principle of least action, Galileo's relativity principle, the Lagrangian for a free particle, Lagrangian for a system of particle, energy, momentum, centre of mass, angular momentum, motion in one dimension, determination of the potential energy from the period of oscillation, the reduced mass, motion in a central field.

( Section 1 to 9, 11 to 14 of the text)

**Module 2:** Free oscillation in one dimension, angular velocity, the inertia tensor, angular momentum of a rigid body, the equation of motion of a rigid body, Eulerian angle, Euler's equation.

( Section 21, 31 to 36 of the text)

**Module 3:** The Hamilton's equation, the Routhian, Poisson brackets, the action as a function of the coordinates, Maupertui's principle.

( Section 40 to 44 of the text)

**Module 4:** The Canonical transformation, Liouville's theorem, the Hamiltonian – Jacobi equation, separation of the variables, adiabatic invariants, canonical Variables

( Section 45 – 50 of the text )

### References

1. M. G. Calkin, Lagrangian and Hamiltonian Mechanics, Allied
2. Herbert Goldstein, Classical mechanics, Narosa
3. K C Gupta, Classical mechanics of particles and Rigid Bodies, Wiley Eastern

**PE 4**

**MT04E04**

## PROBABILITY THEORY

**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 (Khinchine's Weak Law , Kolmogrov Strong Law, Bernoulli's Strong Law) Central Limit theorem (Lindeberg-Levy theorem ).

### References.

1. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, 11<sup>th</sup> Ed., Sultan Chand & Sons, 2011.
2. V.K. Rohatgi, An Introduction to Probability Theory and Mathematical Statistics, 2<sup>nd</sup> Ed. Wiley Eastern Ltd., 1986.

## **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, 11<sup>th</sup> Ed., Sultan Chand & Sons, 2011.

**For Multivariate distributions, refer the book**

2. T.W. Anderson, An Introduction to Multivariate Statistical Analysis, 3<sup>rd</sup> Ed., Wiley Interscience, 2003.

## **Module – 3**

Methods of estimation, properties of estimators, Cramer-Rao inequality, Fisher-Neyman 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, 11<sup>th</sup> Ed., Sultan Chand & Sons, 2011.

**For Tests of Hypothesis, refer the book**

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

## **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.

### **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 Wiley, New York, 1965.
3. W.G. Cochran and G.M. Cox, Experimental Designs, 2<sup>nd</sup> Ed., John Wiley, New York, 1957.

## Question paper Pattern

	Part A Short questions	Part B Short essays	Part C Long essays
Module I	3	3	1
Module II	3	3	2
Module III	1	1	2
Module IV	1	1	1
Total	8	8	6

PE 5

MT04E05

### MATHEMATICAL ECONOMICS

**Text – 1:- Singh S.P, Anil K.Parashar, Singh H.P, Econometrics and Mathematical Economics, S. Chand & Company, 2002.**

**Text – 2:- JEAN E. WEBER, MATHEMATICAL ANALYSIS Business and Economic Applications, Fourth edition, HARPER & ROW PUBLISHERS, New York.**

**Module:-1 The theory of consumer behaviour-** Introductory, Maximization of utility, Indifference curve approach, Marginal rate of substitution, Consumer's equilibrium, Demand curve, Relative preference theory of demand, Numerical problems related to these theory part.  
(Chaper – 13 .Sections 13.1, 13.2, 13.3, 13.4, 13.5, 13.6 & 13.13 of text - 1)(20 hours)

**Module:-2 The production function:-** Meaning and nature of production function, The law of variable proportion, Isoquants, Marginal technical rate of substitution, Producer's equilibrium, expansion path, The elasticity of substitution, Ridge lines and economic region of production, Euler's theorem, Cobb Douglas production function, The CES Production function, Numerical problems related to these theory parts.  
(Chapter – 14. Sections 14.1, 14.2, 14.3, 14.4, 14.5, 14.6, 14.7, 14.8, 14.9, 14.10 & 14.11 of text - 1) (30 hours)

**Module:-3 Input – Output Analysis:-** Meaning of input – output, main features of analysis, Assumptions, Leontief's static and dynamic model, limitations, Importance and Applications of analysis, Numerical problems related to these theory parts..  
(Chapter – 15. Sectios 15.1, 15.2, 15.3, 15.4, 15.5,15.6, 15.7, 15.8 & 15.9 of text - 1) (20 hours)

**Module:- 4 Difference equations** –Introduction, Definition and Classification of Difference equations, Linear Difference equations, Solution of Difference equations, Linear First-Order Difference equations with constant coefficients, Behaviour of the solution sequence, Equilibrium and Stability, Applications of Difference equations in Economic Models, The Harrod Model, The General Cobweb Model, Consumption Model, Income – Consumption – Investment Model.

( Chapter 6 Sections 6.1 to 6.5 of text 2)

(20 hours)

### Question paper pattern

	Part A	Part B	Part C
	Short questions	Short essays	Long essays
Module I	2	2	1
Module II	2	3	2
Module III	2	1	2
Module IV	2	2	1
Total	8	8	6

#### References:-

1. Allen.R.G.D, Mathematical Economics, 1959.
2. Alpha C Chiang, Fundamental methods of Mathematical Economics.
3. Koutsoyiannis. A, Modern Microeconomics, Macmillan.
4. Samuelson. P.A, Foundation of Economic Analysis.
5. Josef Hadar, Mathematical theory of economic behaviour, Addison-Wesley

PE 6

MT04E06

### COMPUTING FOR MATHEMATICS

#### Textbooks

**Text 1: E. Balagurusamy, Object Oriented Programming With C++, 4<sup>th</sup> Edition, Tata Mc Graw Hill, 2008.**

**Text 2: Leslie Lamport, LaTeX: A document preparation system, 2<sup>nd</sup> Edition, Addison-Wesley, 1994.**

**Module 1.** Principles of Object Oriented Programming, Beginning with C++, Tokens, expressions and control structures, Functions in C++.

- (Chapters 1-4 of text 1) (25 hours)
- Module 2.** Classes and Objects, Constructors and Destructors, Operator overloading and type conversions  
(Chapters 5-7 of text 1) (25 hours)
- Module 3.** Inheritance: Extending classes, Managing console I/O operation  
(Chapters 8 and 10 of text 1) (20 hours)
- Module 4.** Introduction to LaTeX: Getting started-Preparing an input file-The input Changing the type style-Symbols from other languages -Mathematical formulas Defining commands and environments. Other document classes-Books-Slides-Letter  
(Chapter 2,3,and 5 of Text 2) (20 hours)

**For this course a record book of the practical work is to be kept. A maximum of 3 weightage is to be awarded for the record and it is to be awarded by a committee of the HOD and the teacher in charge of the course. These 3 weightage is the weightages of the assignment, seminar and the internal viva.**

**If this paper is offered by the SDE or for private candidates the same is to be maintained and shall be produced before the viva board. The viva board can reserve a maximum of 10 marks for this record book.**

### Question paper Pattern

	Part A Short questions	Part B Short essays	Part C Long essays
Module I	2	2	2
Module II	2	2	2
Module III	2	2	1
Module IV	2	2	1
Total	8	8	6

### References

1. Stephen Prata, C++ Primer Plus, 5<sup>th</sup> Edition, Sams, 2004.
2. R. LaFore, Object Oriented Programming in C++, 4<sup>th</sup> Edition, Sams, 2011.
3. Deitel, and Deitel, C++ How to Program, 6<sup>th</sup> Edition, Prentice-Hall, 2008.
4. F. Mittelbach, M. Goossens The LaTeX Companion: 2<sup>nd</sup> Edition, *et.al.*, 2004.
5. Stroustup ,The C++ Programming Language, 3<sup>rd</sup> Edition, Addison-Wesley, 1997.

**Text -1- Ravindran. A, Don T Philips and James J Solberg., Operations Research Principle and Practice, 2<sup>nd</sup> edition, John Wiley and Sons.**

**Text – 2- Hamdy A. Thaha, Operations Research – An Introduction, 6<sup>th</sup> edition, Prentice Hall of India Pvt. Ltd.**

**Text – 3- K.V. Mital and C. Mohan, Optimization Methods in Operation Research and Systems Analysis, 3<sup>rd</sup> 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**

Introduction – Variables in an inventory problem – Objectives of inventory control – The classical E.O.Q. without shortages – The classical E.O.Q. with shortages – The Production Lot size (P.L.S) models – Nonzero Lead time – The Newsboy Problem (a single period model) – Lot size reorder point model – Variable lead times – The importance of selecting the right model.

(Chapter 8; Sections: 8.1 – 8.14 of text 1) (20 hours)

### **Module 2: QUEUEING SYSTEMS**

Why study queues? – Elements of a queueing model – Role of exponential distribution (Derivation of exponential distribution; forgetfulness property) – Pure Birth and Death models – Relationship between the exponential and Poisson distributions – Generalized Queueing Models – Kendall notation – Poisson Queueing Models – Single server models and multiple server models – Machine servicing models – (M/M/R) : (GD/K/K) Model – (M/G/1) : (GD/) model – Pollaczek-Khintchine (P - K) formula.

(Chapter 17; Sections: 17.1 – 17.9 of text – 2) (25 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 – Computational economy in DP – Serial multistage models – Examples of failure – Decomposition – backward and forward recursions – Systems with more than one constraint – Applications of D.P to continuous systems.

(Chapter: 10; Sections: 10.1 – 10.12 of text – 3) (20 hours)

### **Module 4: NETWORK SEQUENCING; SIMULATION MODELING**

Problem of sequencing – Basic assumptions – Processing n jobs through two machines – Optimum Sequence (Johnson Bellman) Algorithm - Processing n jobs through k machines – Processing of two jobs through k machines – Maintenance crew scheduling.

Simulation – Generation of random variables – Monte Carlo simulation – Sampling from probability distributions: 1. Inverse method, 2. Convolution method (&Box-Muller method), 3. Acceptance-Rejection method – Generic definition of events.

(Chapter: 12; Sections: 12.1 – 12.7 of text – 4

Chapter: 18- Sections: 18.1 – 18.6 of text – 2) (25 hours)

## Question Paper Pattern

	Part A	Part B	Part C
	Short questions	Short essays	Long essays
Module I	2	2	1
Module II	2	2	2
Module III	2	2	1
Module IV	2	2	2
<b>Total</b>	<b>8</b>	<b>8</b>	<b>6</b>

### References:-

1. Thomas L Satty, Elementary Queuing Theory, McGraw Hill Publishing Company.
2. Narasingh Deo, System Simulation with digital Computers, 7<sup>th</sup> edition, Prentice Hall India Pvt. Ltd., 1997.
3. Geoffrey Gordon, System Simulation, 2<sup>nd</sup> edition Prentice Hall India Pvt. Ltd, 1998.

**PE 8**

**MT04E08**

## SPECIAL FUNCTIONS

**Text Book:- Earl. D. Rainville, Special functions, Chelsa Publishing Company, New York, 1960.**

### Module – 1

Infinite products:- Introduction, definition of an infinite product, a necessary condition for convergence, the associated series of logarithms, absolute convergence, uniform convergence.

The Gamma and Beta functions:- The Euler and Mascheroni constant  $\gamma$ , the Gamma function, a series for  $\Gamma^1(z) / \Gamma(z)$ , evaluation of  $\Gamma(1)$  and  $\Gamma^1(1)$ , the Euler product for  $\Gamma(z)$ , the difference equation  $\Gamma(z + 1) = z\Gamma(z)$  the order symbols  $o$  and  $0$ , evaluation of certain infinite products, Euler's integral for  $\Gamma(z)$ , the Beta function, the value of  $\Gamma(z) \Gamma(1 - z)$ , the factorial function, Legendre's duplication formulae, Gauss' multiplication theorem, a summation formula due to Euler, the behavior of  $\log \Gamma(z)$  for large  $|z|$

(Chapter 1 & 2 of text – Sections 1 to 22)

### Module – 2

The hypergeometric function:- The function  $F(a,b,c,z)$ , a simple integral form,  $F(a,b,c,1)$  as a function of the parameters, evaluation of  $F(a,b,c,1)$ , the contiguous function relations, the hypergeometric differential equation, logarithmic solution of the hypergeometric equation,  $F(a,b,c,z)$  as a function of its parameters, elementary series multiplications, simple transformations, relation between functions of  $z$  and  $1 - z$ .

(Chapter 4 of the text – Sections 29 to 39)

**Module – 3**

Generalized Hypergeometric Functions: The function  ${}_pF_q$ , the exponential and binomial functions, a differential equation, other solutions of the differential equation, the contiguous function relations, a simple integral, the  ${}_pF_q$  with unit argument.

The Confluent Hypergeometric Functions: Basic properties of the  ${}_1F_1$ , Kummer’s first formula, Kummer’s second formula.

(Chapter 5 – Sections 44 to 50, Chapter 7 - Sections – 68, 69, 70)

**Module – 4**

Legendre Polynomials: A generating function, Differential recurrence relations, the pure recurrence relation, Legendre’s differential equation, the Rodrigue’s formula, Bateman’s generating function, additional generating functions, Hypergeometric forms of  $p_n(x)$ , Brafman’s generating function, special properties of  $p_n(x)$ .

Hermite Polynomials: Definition of  $H_n(x)$ , recurrence relations, the Rodrigue’s formula, other generating functions, integrals.

**Question paper pattern**

	Part A Short questions	Part B Short essays	Part C Long essays	
Module I	2	2	1	1
Module II	2	2	1	
Module III	2	2	1	1
Module IV	2	2	1	
Total	8	8	6	

**References:-**

1. M.A. Pathan, V.B.L.Chaurasia, P.K.Banerji, M.C.Goyal ,Special Functions and Calculus of Variations, Ramesh Book Depot, New Delhi, 2007.
2. Z.X. Wang, D.R. Guo, Special Functions, World Scientific Publishing Company, London, 1989.
3. N.M. Temme, Special Functions – An Introduction to the Classical Functions of Mathematical Physics, John Wiley & Sons, New York, 1996.
4. A.M. Mathai, H.J. Haubold, Special Functions for Applied Scientist, Springer, New York, 2008.

5. G.E. Andrews, R. Askey, R. Roy, Special Functions, Encyclopedia of Mathematics and its Applications 71, Cambridge University Press, Cambridge.1999.

PE 9

MT04E09

### THEORY OF WAVELETS

**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  $\mathbf{Z}_N$ : The First Stage.

(Chapter – 3 Section 3.1 of the text) (20 hours)

**Module – 2:-**Construction of Wavelets on  $\mathbf{Z}_N$  : The Iteration Step, Examples – Haar, Shannon and Daubechies).

(Chapter – 3 Section 3.2 & 3.3 of the text) (20 hours)

**Module – 3:-**  $l^2(\mathbf{Z})$ , Complete Orthonormal sets in Hilbert Spaces,  $L^2[-\pi, \pi]$  and Fourier Series.

(Chapter – 4 Section 4.1, 4.2 & 4.3 of the text) (20 hours)

**Module – 4:-** The Fourier Transform and Convolution on  $l^2(\mathbf{Z})$ , First-stage Wavelets on  $\mathbf{Z}$ , The Iteration step for Wave lets on  $\mathbf{Z}$ , Examples- Haar and Daubechies.

(Chapter – 4 Section 4.4, 4.5, 4.6 & 4.7 of the text) (30 hours)

#### Question paper Pattern

	Part A Short questions	Part B Short essays	Part C Long essays	
Module I	2	2	1	1
Module II	2	2	1	
Module III	2	2	1	1
Module IV	2	2	1	
Total	8	8	6	

#### References:-

1. Mayer, Wavelets and Operators, Cambridge University Press, 1993.
2. Chui, An Introduction to Wavelets, Academic Press, Boston, 1992.

PE 10

MT04E10

## SIGNAL THEORY

**Text Book:- Athanasios Papoulis and S. Unnikrishna Pillai, Probability, Random Variables and Stochastic Processes, Fourth edition, Tata McGraw-Hill, New Delhi.**

**Module – 1 General Concepts:**

Definitions, Systems with Stochastic Inputs, The Power Spectrum, Discrete-Time Processes, Simple problems  
(Chapter – 9, Sections 9.1 to 9.4 of the text) (22 hours)

**Module – 2 Random Walks and Other Applications.**

Random Walks, Poisson points and Shot Noise, Modulation.  
(Chapter –10, Sections 10.1 to 10.3 of the text) (22 hours)

**Module – 3 Spectral Representation**

Factorizations and Innovations, Finite-Order Systems and State Variables, Fourier Series and Karhunen-Loeve Expansions, Spectral representation of Random Processes, Simple problems.  
(Chapter – 11, Sections 11.1 to 11.4 of the text) (24 hours)

**Module – 4 Entropy**

Introduction, Basic Concepts, Coding, Channel Capacity, Simple Problems.  
(Proof of the channel Capacity theorem excluded)  
(Chapter – 14, Sections 14.1, 14.2, 14.5 & 14.6 of the text) (22 hours)

### Question paper Pattern

	Part A	Part B	Part C	
	Short questions	Short essays	Long essays	
Module I	2	2	1	1
Module II	2	2	1	
Module III	2	2	1	1
Module IV	2	2	1	
<b>Total</b>	<b>8</b>	<b>8</b>	<b>6</b>	

**References:-**

1. Meldhi.J, Stochastic Process, Wiley Eastern, 1987
2. Srinivasan. C.K, Stochastic Processes, 2<sup>nd</sup> edition, Tata McGraw-Hill.
3. Karlin and Taylor, A First Course in Stochastic Processes.
4. Karlin and Taylor, A Second Course in Stochastic Processes.

**Text Book :- Gregor Kemper, A Course in Commutative Algebra, Springer, ISSN0072-5285, ISBN978-3-642-03544-6**

**Module :- 1 The Algebra-Geometry Lexicon – Hilbert’s Nullstellensatz**  
 Maximal ideals, Jacobson Rings, Coordinate Rings, Simple problems.  
 (Chapter1 Sections 1.1, 1.2 & 1.3 of the text) (25 hours)

**Module: -2 Noetherian and Artinian Rings.**  
 The Noether and Artin Properties for Rings and Modules, Noetherian Rings and Modules, Simple problems  
 (Chapter2 Sections 2.1 & 2.2, of the text) (20 hours)

**Module: - 3 The Zariski Topology**  
 Affine Varieties, Spectra, Noetherian and Irreducible Spaces, Simple problems.  
 (Chapter3 Sections 3.1, 3.2 & 3.3 of the text) (25 hours)

**Module: -4 A Summary of the Lexicon**  
 True Geometry: Affine Varieties, Abstract Geometry : Spectra , Simple problems  
 (Chapter4 Sections 4.1 & 4.2, of the text). (20 hours)

**Question paper Pattern**

	Part A Short questions	Part B Short essays	Part C Long essays	
Module I	2	2	1	1
Module II	2	2	1	
Module III	2	2	1	1
Module IV	2	2	1	
Total	8	8	6	

**References: -**

1. William W. Adams, Phillippe Loustanaou, An Introduction to Grobner bases, Graduate Studies in Mathematics 3, American Mathematical Society, 1994, [117]
2. Michael F Atiyah, Ian Grant Macdonald, Introduction to Commutative Algebra, Addison- Wesley, Reading, 1969[174]
3. Nicolas Bourbaki, General Topology, Chapters – 1 – 4, Springer, Berlin, 1993, [117, 118, 161].

**Text Book:** Mathai A.M., Saxena R.K., H.J. Houbold, The H-Function: Theory and Applications, Springer, 2010.

**Module-1**

**Introduction**

**A Brief Historical Background**

**Fractional Integrals:** Riemann-Liouville Fractional Integrals, Basic properties of Fractional Integrals, Illustrative Examples.

**Riemann-Liouville Fractional Derivatives,** Illustrative Examples.

(3.1, 3.2, 3.3 -3.3.1, 3.3.2, 3.3.3 - 3.4 - 3.4.1 of the text)

**Module-2**

**The Weyl Integral:** Basic properties of Weyl Integrals, Illustrative examples.

**Laplace Transform:** Laplace Transform of Fractional Integrals, Laplace Transform of Fractional Derivatives, Laplace Transform of Caputo Derivative.

(3.5 - 3.5.1, 3.5.2, 3.6 - 3.6.1, 3.6.2, 3.6.3 of the text)

**Module-3**

**Mellin Transforms:** Mellin Transform of the  $n^{\text{th}}$  Derivative, Illustrative Examples

**Kober Operators:** Erdelyi-Kober Operators

**Generalized Kober Operators**

(3.7 - 3.7.1, 3.7.2, 3.8 - 3.8.1, 3.9 of the text)

**Module-4**

**Saigo Operators:** Relations among the Operators, Power Function Formulae, Mellin Transform of Saigo Operators, Representation of Saigo Operators.

(3.10 - 3.10.1, 3.10.2, 3.10.3, 3.10.4 of the text)

**Question paper pattern**

	Part A	Part B	Part C
	Short questions	Short essays	Long essays
Module I	2	3	2
Module II	2	2	2
Module III	2	1	1
Module IV	2	2	1
Total	8	8	6

**References:-**

- (1) Dold.A, Eckmann. B, Fractional Calculus and its Applications, Springer Verlag, 1975.
- (2) Miller.K.S, Rose.B, An Introduction to Fractional Calculus and Fractional Differential Equation, John Wiley and Sons, 1993.
- (3) Nishimoto k, Fractional Calculus Integration and Differentiation of arbitrary order, Descartes press, Koriyama, 1991.

- (4) Oldham K.B, Spanier .J, Fractional Calculus theory and Applications of Differentiation and Integration to arbitrary order, Academic press, 1974.
- (5) Ian N Sneddon, The use of operators of Fractional Integration in Applied Mathematics,(Applied mechanic series), Polish Scientific publishers, 1979.
- (6) Lecture notes on Multivariable and Matrix variable calculus and Applications, Stochastic models, Edited by A.M. Mathai, Publication number – 40, SERC School notes, CMS, pala, Kerala.(phone- 04822-216317)

**PE 13**

**MT04E13**

## ALGORITHMIC GRAPH THEORY

**Text Book:- Gray Chartrand and O.R Oellermann , Applied and Algorithmic Graph Theory, Tata McGraw- Hill Companies Inc**

### **Module 1 : Introduction to Graphs and Algorithms**

What is graph? The degree of a vertex. isomorphic graphs. subgraphs, degree sequences. connected graphs. cutvertices and blocks. special graphs. digraphs. algorithmic complexity. Search algorithms, sorting algorithms. greedy algorithms., representing graphs in a computer.

( Capter 1 Sections 1.1 to 1.9, Chapter 2 Sections 2.1, 2.2 , 2.3, 2.5 and 2.6 of the text)  
(24 hours)

### **Module 2: Trees, paths and distances**

Properties of trees, rooted trees. Depth-first search: a tool for finding blocks,. breadth – first search, . the minimum spanning tree problem

Distance in a graphs, distance in weighted graphs, .the centre and median of a graph. activity digraphs and critical paths.

(Chapter 3 sections 3.1 to 3.6 , Chapter 4 sections 4.1 to 4.4 of the text )  
(22 hours)

### **Module 3: Networks**

An introduction to networks. the max-flow min-cut theorem. the max-flow min-cut algorithm . connectivity and edge connectivity . Mengers theorem.

( Chapter 5 sections 5.1 , 5.2 , 5.3 , 5.5 and 5.6 of the text ) (22 hours)

### **Module 4 : Matchings and Factorizations**

An introduction to matchings . maximum matchings in a bipartite graph,. Factorizations. Block Designs.

(Chapter 6 sections 6.1 , 6.2 , 6.4 and 6.5 of the text) (22 hours)

### Question paper pattern

	Part A	Part B	Part C	
	Short questions	Short essays	Long essays	
Module I	2	2	1	1
Module II	2	2	1	

Module III	2	2	1	1
Module IV	2	2	1	
Total	8	8	6	

**Reference:-**

1. Alan Gibbons, Algorithmic Graph Theory, Cambridge University Press, 1985
2. Mchugh. J.A, Algorithmic Graph Theory, Prentice-Hall, 1990
3. Golumbic. M, Algorithmic Graph Theory and Perfect Graphs, Academic press.

**PE 14**

**MT04E14**

**CODING THEORY**

**Text :- Vera Pless 3<sup>rd</sup> Edition , Introduction to the theory of error coding codes, Wiley Inter Science**

**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) (25 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) (20 hours)

**Module:- 3** Finite fields

(Chapter 4 of the text) (20 hours)

**Module:- 4** Cyclic Codes, BCH codes)

(Chapter 5 & Chapter 7 of the text) (25 hours)

**Question paper Pattern**

	Part A Short questions	Part B Short essays	Part C Long essays
Module I	2	2	2
Module II	2	2	1
Module III	2	2	1
Module IV	2	2	2
Total	8	8	6

**References:-**

1. R-Lidi, G. Pliz, Applied Abstract Algebra, Springer Verlag.
2. J.H.Van Lint, Introduction to Coding Theory, Springer Verlag
3. R.E.Blahut, Error- Control Codes, Addison Wesley.

PE 15

MT04E15

**COMPLEX ALGEBRAIC CURVES**

**Text:- Frances Kirwan, Complex Algebraic Curves, London Mathematical Society Student Texts 23, Cambridge University Press, Cambridge.**

**Module:- 1** Introduction and background - Relationship with other parts of Mathematics – Number theory, Singularities and the theory of knots, Complex analysis, Abelian Integrals – Real Algebraic Curves – Hilbert’s Nullstellensatz, Techniques for drawing real algebraic curves, Real algebraic curves inside complex real algebraic curves, Important examples of real algebraic curves.  
(Chapter 1 of the text) (25 hours)

**Module:- 2** Foundations - Complex real algebraic curves in  $\mathbb{C}^2$ , Complex projective spaces, Complex projective curves in  $\mathbb{P}^2$ , Affine and Projective curves, Exercises (Simple problems.).  
(Chapter 2 of the text) (20 hours)

**Module:- 3** Algebraic Properties – Bezout’s theorem, Points of inflection and cubic curves, Exercises(simple problems)  
(Chapter 3 of the text) (25 hours)

**Module:- 4** Topological Properties –The degree – genes formula, Branched curves of  $\mathbb{P}^1$ , Proof of degree-genus formula, Exercises (Simple problems)  
(Chapter 4 of the text – 4.1.1 & 4.1.2 excluded) (20 hours)

**Question paper Pattern**

	Part A Short questions	Part B Short essays	Part C Long essays	
Module I	2	2	1	1
Module II	2	2	1	
Module III	2	2	1	1
Module IV	2	2	1	
Total	8	8	6	

**References:-**

1. E.Arbarello, M.Cornalba, P.Griffiths and J.Harris, Topics in the theory of algebraic curves, Springer-Verlag(1985)
2. E.Brieskorn and H.Knorrer, Plane Algebraic curves, Birkhauser-Verlag(1986)
3. C.H. Clemens, A scrapbook of Complex curve theory, plenum(1980)
4. J.L.Coolidge, A treatise on algebraic plane curves, Dover(1959)

**PE 16**

**MT04E16**

**ALGEBRAIC GEOMETRY**

**Text:- Brendan Hassett, Intoduction to Algebraic Geometry, Cambridge University Press, 2007.**

**Module:- 1 Guiding problems**

Implicitization, Ideal membership, Interpolation

**Division algorithm and Grobner bases**

3and chain coditions, Buchberger's Criterion.

(Chapter 1 – Sections 1.1 to 1.3, Chapter – 2 Sections 2.1 to 2.5) (30 hours)

**Module:- 2 Affine varieties**

Ideals and varieties, Closed sets and the Zariski topology, Coordinate rings and morphisms, Rational maps, Resolving rational maps, Rational and unirational varities.

(Chapter – 3 Sections 3.1 to 3.6) (22 hours)

**Module:- 3 Elimination**

Projections and graphs, Images of rational maps, Secant varieties, joins, and scrolls.

**Resultants**

Common roots of univariate polynomials, The resultant as a function of the roots, Resultants and elimination theory.

(Chapter – 4 Sections 4.1 to 4.3 Chapter – 5 Sections 5.1 to 5.3)

(23 hours)

**Module:- 4 Irreducible varieties**

Existence of the decomposition, Irreducibility and domains, Doeminant morphisms.

**Nullstellensatz**

Statement of the Nullstellensatz, Classification of maximal ideals, Transcendence bases, Integral elements.

**Primary decomposition**

Irreducible

ideals, Quotient ideals, Primary ideals.

(Chapter:- 6 Sections 6.1 to 6.3) Chapter – 7 Sections 7.1 to 7.4 Chapter – 8 Sections 8.1 to 8.3) (15 hours)

**Question paper Pattern**

	Part A	Part B	Part C	
	Short questions	Short essays	Long essays	
Module I	3	3	1	1
Module II	2	2	1	
Module III	2	2	1	1
Module IV	1	1	1	
Total	8	8	6	

**References:-**

1. William Fulton, Algebraic Curves: An Introduction to Algebraic Geometry, Advanced Book Program, Redwood City, CA: Addison-Wesley, 1989.
2. Phillip Griffiths and Joseph Harris, Principles of Algebraic Geometry, New York: Wiley-Interscience, 1978.
3. Joe Harris, Algebraic Geometry, Graduate Texts in Mathematics, 133. New York: Springer-Verlag, 1992.

**PE 17**

**MT04E17**

**FRACTAL GEOMETRY**

**Text:- Kenneth Falconer, FRACTAL GEOMETRY Mathematical Foundations and Applications, John Wiley & Sons, New York.**

**Pre-requisites** – Mathematical background – A quick revision  
(Chapter 1 of the text).

No questions shall be asked from this section. (5 hours)

**Module:- 1 Hausdorff measure and dimension**

Hausdorff measure, Hausdorff dimension, Calculation of Hausdorff dimension-Simple examples, Equivalent definitions of Hausdorff dimension, Finer definitions of dimension.

**Alternative definitions of dimension**

Box counting dimension, Properties and problems of box counting dimension, Modified box counting dimension, Packing measures and dimension.

(Chapter 2 , 3 Sections 3.1 to 3.4 of the text.) (30 hours)

**Module: 2 Techniques for calculating dimensions**

Basic methods, Subsets of finite measure, Potential theoretic methods, Fourier transform methods.

**Local structure of fractals**

Densities, Structure of 1-sets, Tangents to s-sets.

(Chapter 4 & 5 of the text.) (25 hours)

**Module:- 3 Projections of fractals**

Projections of arbitrary sets, Projections of s-sets of integral dimension,

**Products of fractals** – Product formulae

(Chapter 6 & 7 of the text) (18 hours)

**Module:- 4 Intersections of fractals**

Intersection formulae for fractals, Sets with large intersection.

(chapter 8 of the text) (12 hours)

**Question paper Pattern**

	Part A Short questions	Part B Short essays	Part C Long essays
Module I	3	3	2
Module II	2	2	2
Module III	2	2	1
Module IV	1	1	1
Total	8	8	6

**Reference:-**

1. Falconer K.J, The Geometry of Fractal sets, Cambridge University Press, Cambridge.
2. Barnsley M.F, (1988), Fractals every where, Academic press, Orlando, FL.
3. Mandelbrot B.B, (1982), The Fractal Geometry of Nature, Freeman, San Francisco.
4. Peitgen H.O and Richter P.H, (1986), The Beauty of Fractals, Springer, Berlin.
5. Tamas Vicsek, Fractal Growth Phenomena, Second edition, World Scientific.

## LIE ALGEBRAS

**Text:- James E. Humphreys, Introduction to Lie Algebras and Representation Theory, Springer**

**Module:- 1 Basic Concepts**

Definition and first examples, Ideals and homomorphisms, Solvable and nilpotent Lie Algebras.

(Chapter I Sections 1, 2, & 3 of the text) (25 hours)

**Module:- 2 Semi simple Lie Algebras**

Theorems of Lie and Cartan, Killing form, Complete reducibility of representations.

(Chapter II Sections 4, 5, & 6 of the text) (20 hours)

**Module:- 3 Root Systems**

Axiomatics, Simple roots and Weyl group, Classification.(proof of Classification theorem excluded)

(Chapter III Sections 9, 10 & 11 of the text) (25 hours)

**Module:- 4 Isomorphism and Conjugacy Theorems**

Isomorphism theorem, Cartan Algebras, Conjugacy theorems

(Chapter IV Sections 14, 15, & 16 – 16.1 to 16.3 of the text) (20 hours)

### Question paper Pattern

	Part A	Part B	Part C	
	Short questions	Short essays	Long essays	
Module I	2	2	1	1
Module II	3	2	1	
Module III	2	3	1	1
Module IV	1	1	1	
<b>Total</b>	<b>8</b>	<b>8</b>	<b>6</b>	

**References:-**

1. J.G.F. Belinfante and B. Kolman, A survey of Lie Groups and Lie Algebras with computational methods and Applications, Philadelphia : SIAM, 1972.
2. N. Jacobson, Lie Algebras, New York – London, Wiley interscience, 1962.

3. H. Samuelson, Notes on Lie Algebras, Van Nostrand Reinhold Mathematical studies No. 23, New York: Van Nostrand Reinhold, 1969.

**PE 19**

**MT04E19**

## **ALGEBRAIC TOPOLOGY**

**Text :-** Fred H. Croom - Basic concepts of Algebraic Topology (Springer verlag) ISBN 0-387-90288-0 New York and ISBN 3-540-90288-0 Berlin . Heidelberg

Chapters 1-5 (All sections and Theorems)

### **Module 1**

Geometric complexes and Polyhedra-Introduction-Examples-Orientations of geometric complexes-Chains-Cycles-boundaries and Homology groups-Examples of Homology groups-The structure of Homology groups-The Euler-Poincare Theorem-Pseudomanifolds and the Homology groups of  $S^n$ .

### **Module 2**

Simplicial approximations-Induced homomorphisms on the Homology groups-The Brouwer fixed point Theorem and related results.

### **Module 3**

The Fundamental group-The covering homotopy property for  $S^1$ -Examples of fundamental groups-the relation between  $H_n(K)$  and  $\pi_n(K)$ .

### **Module 4**

Covering spaces -Definition and some examples-Basic properties of covering spaces-Classification of covering spaces-Universal covering spaces.

### **Question paper Pattern**

	Part A	Part B	Part C	
	Short questions	Short essays	Long essays	
Module I	2	2	1	1
Module II	2	2	1	

Module III	2	2	1	1
Module IV	2	2	1	
Total	8	8	6	

### References

1. B.K.Lahiri-A first Course in Algebraic Topology (Second Edition)-Narosa Publications-ISBN 81-7319-635-4
2. Glen E.Bredon-Topology and Geometry (Springer)- ISBN 81-8128-266-3.
3. Joseph J.Rotman-An Introduction to Algebraic Topology (Springer) –ISBN 81-8128-179-9.

**PE 20**

**MT04E20**

## **FINANCIAL MATHEMATICS**

**Text:- Robert J Elliott, P.Ekkehardkopp, Mathematics of Financial Markets, Second edition, Springer**

### **Module:-1 Pricing of Arbitrage**

Introduction: Pricing and Hedging, Single-Period Option Pricing Models, A General Single- Period Model, A Single- Period Binomial Model, Multi-Period Binomial Models, Bounds on Option Prices

(Chapter:- 1 Section 1.1 to 1.6 of the text) (24 hours)

### **Module:- 2 Martingale Measures**

A General Discrete-Time Market Model, Trading Strategies, Martingales and Risk-Neutral Pricing, Arbitrage Pricing: Martingale Measures, Strategies Using Contingent Claims, Example: The Binomial Model, From CRR to Black-Scholes

(Chapter:- 2 Section 2.1 to 2.7 of the text) (22 hours)

### **Module:-3 The First Fundamental Theorem**

The Separating Hyper Plane Theorem in  $\mathbf{R}^n$ , Construction of Martingale Measures, Path wise Description, Examples, General Discrete Models.

(Chapter:- 3 Section 3.1 to 3.5 of the text) (22 hours)

### **Module:- 4 Complete Markets**

Completeness and Matringake Representation, Completeness for Finite Market Models, The CRR Model, The Splitting Index and Completeness, Incomplete Models: The Arbitrage Interval, Characterisation of Complete Models.

(Chapter:- 4 Section 4.1 to 4.6 of the text) (22 hours)

## Question paper Pattern

	Part A	Part B	Part C	
	Short questions	Short essays	Long essays	
Module I	2	2	1	1
Module II	3	2	1	
Module III	2	3	1	1
Module IV	1	1	1	
Total	8	8	6	

### References:-

1. L.U. Dothan, Prices in Financial Markets, Oxford University Press, New York, 1990
2. D.Duffie, Future markets, Prentice-Hall, Englewood cliffs, N.J, 1989.