# DEPARTMENT OF
# MATHEMATICS

Curriculum and Syllabus for
Postgraduate Programme in
Mathematics
Under Credit Semester System
(with effect from 2019 admissions)

St Berchmans College
Founded 1922
AUTONOMOUS | College with Potential for Excellence | Reaccredited by NAAC with A Grade
Affiliated to Mahatma Gandhi University, Kottayam, Kerala
Changanassery, Kottayam, Kerala, India-686101

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# PREFACE

"The *study of Mathematics, like the Nile, begins in minuteness but ends in magnificence*"

- Charles Caleb Colton.

Mathematics education has been a focus of attention around the world over the last few decades. New standards for instruction and curriculum have been developed and as a result, the discourses among the international fraternity of Mathematics scholars help to maintain the academic standards of the hour. The need for new scholars and teachers in Mathematics is great. This syllabus helps the postgraduate students to go for research leading to PhD and MPhil and facilitate them to become the best mathematicians.

We gave utmost attention in keeping the balance between pure and applied, classical and recent topics.

I hope this curriculum and restructured syllabus would enrich the understanding of students in various fields of Mathematics.

Dr. Antony Mathews
Chairman, Board of Studies

# BOARD OF STUDIES IN MATHEMATICS

1. Dr Antony Mathews, Associate Professor and Head, Department of Mathematics St Berchmans College Changanassery (Chairman)
2. Dr Viji Z Thomas, Assistant Professor, Department of Mathematics, IISER, Thiruvananthapuram.
3. Dr Vishnu Namboothiri, Assistant Professor, Department of Mathematics, Government College, Ambalapuzha.
4. Dr J P Mohandas, Assistant Professor, Department of Mathematics, University College, Thiruvananthapuram.
5. Dr A K Anilkumar, Director, Directorate of Space Situational Awareness and Management (DSSAM), ISRO Head Quarters, New BEL Road, Bangalore, 560231.
6. Prof Zachariah Varkey, Managing Director, Havist Technologies Pvt Ltd., Bangalore
7. Dr Shine C Mathew, Assistant Professor, Department of Mathematics, St Berchmans College, Changanassery.
8. Dr Ullas Thomas, Assistant Professor, Department of Mathematics, St Berchmans College, Changanassery.
9. Mr M C Jose, Associate Professor, Department of Mathematics, St Berchmans College, Changanassery.
10. Rev Fr John J Chavara, Assistant Professor, Department of Mathematics, St Berchmans College, Changanassery
11. Mr Tibin Thomas, Assistant Professor, Department of Mathematics, St Berchmans College, Changanassery.
12. Ms Treesa Maria Kuriakose, Assistant Professor, Department of Mathematics, St Berchmans College, Changanassery.
13. Ms Jinu Mary Jameson, Assistant Professor, Department of Mathematics, St Berchmans College Changanassery.

## PROGRAMME OBJECTIVES

- To develop a spirit of inquiry in the student.
- To improve the perspective of students on Mathematics as per current requirement.
- To initiate students to use abstraction to perceive relationships and structure and to understand the basic structure of Mathematics.
- To provide greater scope for individual participation in the process of learning and becoming autonomous learners.
- To help the student build interest and confidence in learning the subject.
- To enable the students to appreciate the power of abstraction and rigor in Mathematics.
- To make students ready to pursue a career in Mathematics

### PROGRAMME OUTCOME

- Set comprehensive knowledge in mathematical theory at an advanced level.
- Exposure to various quantitative techniques, which are essential to analyze mathematical issues.
- Build up the ability to do research in Mathematics.
- Planning and carrying out research projects in mathematics.
- Acquire deep knowledge in mathematical and computational discipline so that they can qualify CSIR UGC NET/JRF, GATE etc.

**REGULATIONS FOR POST GRADUATE (PG) PROGRAMMES UNDER CREDIT SEMESTER SYSTEM (SB-CSS-PG) 2019**

## 1. SHORT TITLE

1.1 These Regulations shall be called St. Berchmans College (Autonomous) Regulations (2019) governing postgraduate programmes under Credit Semester System (SB-CSS-PG).

1.2 These Regulations shall come into force with effect from the academic year 2019-20 onwards.

## 2. SCOPE

2.1 The regulation provided herein shall apply to all regular postgraduate programmes, MA/MSc/MCom, conducted by St. Berchmans College (Autonomous) with effect from the academic year 2019-20.

## 3. DEFINITIONS

3.1 'University' means Mahatma Gandhi University, Kottayam, Kerala.

3.2 'College' means St. Berchmans College (Autonomous).

3.3 There shall be an Academic Committee nominated by the Principal to look after the matters relating to the SB-CSS-PG system.

3.4 'Academic Council' means the Committee consisting of members as provided under section 107 of the University Act 2014, Government of Kerala.

3.5 'Parent Department' means the Department, which offers a particular postgraduate programme.

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

3.7 'Faculty Mentor' is a teacher nominated by a Department Council to coordinate the continuous evaluation and other academic activities of the Postgraduate programme undertaken in the Department.

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

3.9 'Duration of Programme' means the period of time required for the conduct of the programme. The duration of a postgraduate programme shall be four (4) semesters.

3.10 'Semester' means a term consisting of a minimum 90 working days, inclusive of tutorials, examination days and other academic activities within a period of six months.

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

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

3.13 '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.

3.14 'Elective Course' means a course, which can be substituted, by equivalent course from the same subject and the number of courses required to complete the programme shall be decided by the respective Board of Studies.

3.15 The elective course shall be either in the fourth semester or be distributed among third and fourth semesters.

3.16 'Audit Course' means a course opted by the students, in addition to the compulsory courses, in order to develop their skills and social responsibility.

3.17 'Extra Credit Course' means a course opted by the students, in addition to the compulsory courses, in order to gain additional credit that would boost the performance level and additional skills.

3.17.1 Extra credit and audit courses shall be completed by working outside the regular teaching hours.

3.17.2 There will be optional extra credit courses and mandatory audit courses. The details of the extra credit and audit courses are given below.

| Semester | Course | Type |
|---|---|---|
| I | Course on Mendely Reference Management Software | Optional, Extra credit<br>Grades shall be given |
| | Course on Basic Life Support System and Disaster Management | Compulsory, Audit<br>Grades shall be given |
| First summer vacation | Internship/Skill Training | Optional, Extra credit<br>Grades shall be given |
| Any time during the programme | Oral Presentation in National/International seminar | Optional, Extra credit |
| | Publication in a recognized journal with ISSN number | |

3.18 'Project' means a regular research work with stated credits on which the student conducts research under the supervision of a teacher in the parent department/any appropriate research centre in order to submit a report on the project work as specified.

3.19 'Dissertation' means a minor thesis to be submitted at the end of a research work carried out by each student on a specific area.

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

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

3.22 '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.

3.23 'Improvement Examination' is an examination conducted to improve the performance of students in the courses of a particular semester.

3.24 'Supplementary Examination' is an examination conducted for students who fail in the courses of a particular semester.

3.25 The minimum credits, required for completing a postgraduate programme is eighty (80).

3.26 'Credit' (C) of a course is a measure of the weekly unit of work assigned for that course in a semester.

3.27 'Course Credit': One credit of the course is defined as a minimum of one (1) hour lecture/minimum of two (2) hours lab/field work per week for eighteen (18) weeks in a semester. The course will be considered as completed only by conducting the final examination.

3.28 'Grade' means a letter symbol (A,B,C etc.) which indicates the broad level of performance of a student in a course/semester/programme.

3.29 'Grade Point' (GP) is the numerical indicator of the percentage of marks awarded to a student in a course.

3.30 'Credit Point' (CP) of a course is the value obtained by multiplying the grade point (GP) by the credit (C) of the course.

3.31 'Semester Grade Point Average' (SGPA) of a semester is calculated by dividing total credit points obtained by the student in a semester by total credits of that semester and shall be rounded off to two decimal places.

3.32 'Cumulative Grade Point Average' (CGPA) is the value obtained by dividing the sum of credit points in all the courses obtained by the student for the entire programme by the total credits of the whole programme and shall be rounded off to two decimal places.

3.33 'Institution average' is the value obtained by dividing the sum of the marks obtained by all students in a particular course by the number of students in respective course.

3.34 'Weighted Average Score' means the score obtained by dividing sum of the products of marks secured and credit of each course by the total credits of that semester/programme and shall be rounded off to two decimal places.

3.35 'Grace Marks' means marks awarded to course/courses, in recognition of meritorious achievements of a student in NCC/NSS/Sports/Arts and cultural activities.

3.36 First, Second and Third position shall be awarded to students who come in the first three places based on the overall CGPA secured in the programme in the first chance itself.

## 4. PROGRAMME STRUCTURE

4.1 The programme shall include two types of courses; Core Courses and Elective Courses. There shall be a project/research work to be undertaken by all students. The programme will also include assignments, seminars, practical, viva-voce etc., if they are specified in the curriculum.

4.2 Total credits for a programme is eighty (80). No course shall have more than four (4) credits.

### 4.3 Project/dissertation

Project/research work shall be completed by working outside the regular teaching hours except for MSc Computer Science programme. Project/research work shall be carried out under the supervision of a teacher in the concerned department. A student may, however, in certain cases be permitted to work in an industrial/research organization on the recommendation of the supervisor. There shall be an internal assessment and external assessment for the project/dissertation. The external evaluation of the Project/Dissertation shall be based on the individual presentation in front of the expert panel.

### 4.4 Evaluations

The evaluation of each course shall contain two parts.

i Internal or In-Semester Assessment (ISA)

ii External or End-Semester Assessment (ESA)

Both ISA and ESA shall be carried out using indirect grading. The ISA:ESA ratio is 1:3. Marks for ISA is 25 and ESA is 75 for all courses.

### 4.5 In-semester assessment of theory courses

The components for ISA are given below.

| Component | Marks |
|---|---|
| Attendance | 2 |
| Viva | 3 |
| Assignment | 4 |
| Seminar | 4 |
| Class test | 4 |
| Model Exam | 8 |
| **Total** | **25** |

4.6 Attendance evaluation of students for each course shall be as follows:

| % of Attendance | Marks |
|---|---|
| Above 90 | 2 |
| 75 - 90 | 1 |

4.7 **Assignments**

Every student shall submit one assignment as an internal component for every course.

4.8 **Seminar**

Every student shall deliver one seminar as an internal component for every course. The seminar is expected to train the student in self-study, collection of relevant matter from the books and internet resources, editing, document writing, typing and presentation.

4.9 **In-semester examination**

Every student shall undergo at least two in-semester examinations one as class test and second as model examination as internal component for every theory course.

4.10 To ensure transparency of the evaluation process, the ISA mark awarded to the students in each course in a semester shall be published on the notice board according to the schedule in the academic calendar published by the College. There shall not be any chance for improvement for ISA. The course teacher and the faculty mentor shall maintain the academic record of each student registered for the course which shall be forwarded to the office of the Controller of Examinations through the Head of the Department and a copy shall be kept in the office of the Head of the Department for at least two years for verification.

4.11 **In-semester assessment of practical courses**

The internal assessment of practical courses shall be conducted either annually or in each semester. There shall be one in-semester examination for practical courses. The examination shall be conducted annually or in each semester.

The components for internal assessment is given below.

| **Component** | **Marks** |
|---|---|
| Attendance | 2 |
| Lab Test | 15 |
| Viva-Voce | 5 |
| Record | 3 |
| **Total** | **25** |

Attendance evaluation of students for each course shall be as follows:

| **% of Attendance** | **Marks** |
|---|---|
| Above 90 | 2 |
| 75 - 90 | 1 |

4.12 **End-semester assessment**

The end-semester examination in theory and practical courses shall be conducted by the College.

4.13 The end-semester examinations for theory courses shall be conducted at the end of each semester. There shall be one end-semester examination of three (3) hours duration in each lecture based course.

4.14 The question paper should be strictly on the basis of model question paper set by Board of Studies.

4.15 A question paper may contain short answer type/annotation, short essay type questions/problems and long essay type questions. Marks for each type of question can vary from programme to programme, but a general pattern may be followed by the Board of Studies.

4.16 Question Pattern for external theory examination shall be,

| Section | Total No. of Questions | Questions to be Answered | Marks | Total Marks for the Section |
|---|---|---|---|---|
| A | 18 | 15 | 1 | 15 |
| B | 4 | Four question sets, one from each module. Each set consists of two questions out of which one is to be answered. | 15 | 60 |
| | | | **Maximum** | **75** |

4.17 Photocopies of the answer scripts of the external examination shall be made available to the students for scrutiny as per the regulations in the examination manual.

4.18 Practical examination shall be conducted annually or in each semester. Practical examination shall be conducted by one external examiner and one internal examiner. The question paper setting and evaluation of answer scripts shall be done as per the directions in the examination manual of the College. The duration of practical examination shall be decided by the Board of Studies.

4.19 Project/Dissertation evaluation shall be conducted at the end of the programme. Project/Dissertation evaluation shall be conducted by one external examiner and one internal examiner. The components and mark division for internal and external assessment shall be decided by the respective Board of Studies.

| Components of Project Evaluation | Marks |
|---|---|
| Internal Evaluation | 25 |
| Dissertation (External) | 50 |
| Viva-Voce (External) | 25 |
| **Total** | **100** |

4.20 Comprehensive viva-voce shall be conducted at the end of the programme. Viva-voce shall be conducted by one external examiner and one internal examiner. The viva-voce shall cover questions from all courses in the programme.There shall be no internal assessment for comprehensive viva-voce. The maximum marks for viva-voce is one hundred (100).

4.21 For all courses (theory and practical) an indirect grading system based on a seven (7) point scale according to the percentage of marks (ISA + ESA) is used to evaluate the performance of the student in that course. The percentage shall be rounded mathematically to the nearest whole number.

| Percentage of Marks | Grade | Performance | Grade Point |
|---|---|---|---|
| 95 and above | S | Outstanding | 10 |
| 85 to below 95 | A+ | Excellent | 9 |
| 75 to below 85 | A | Very Good | 8 |
| 65 to below 75 | B+ | Good | 7 |
| 55 to below 65 | B | Above Average | 6 |
| 45 to below 55 | C | Satisfactory | 5 |
| 40 to below 45 | D | Pass | 4 |
| Below 40 | F | Failure | 0 |

4.22 **Credit Point**

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

$$\mathbf{CP = C \times GP}$$

where C is the credit and GP is the grade point

4.23 **Semester Grade Point Average**

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

$$\mathbf{SGPA = TCP/TCS}$$

where TCP is the total credit point of all the courses in the semester and TCS is the total credits in the semester

GPA shall be rounded off to two decimal places.

4.24 **Cumulative Grade Point Average**

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

$$\mathbf{CGPA = TCP/TC}$$

where TCP is the total credit point of all the courses in the whole programme and TC is the total credit in the whole programme

GPA shall be rounded off to two decimal places.

Grades for the different courses, semesters, Semester Grade Point Average (SGPA) and grades for overall programme, Cumulative Grade Point Average (CGPA) are given based on the corresponding Grade Point Average (GPA) as shown below:

| GPA | Grade | Performance |
|---|---|---|
| 9.5 and above | S | Outstanding |
| 8.5 to below 9.5 | A+ | Excellent |
| 7.5 to below 8.5 | A | Very Good |
| 6.5 to below 7.5 | B+ | Good |
| 5.5 to below 6.5 | B | Above Average |
| 4.5 to below 5.5 | C | Satisfactory |
| 4 to below 4.5 | D | Pass |
| Below 4 | F | Failure |

4.25 A separate minimum of 40% marks each in ISA and ESA (for theory and practical) and aggregate minimum of 40% are required for a pass in a course. For a pass in a programme, a separate minimum of grade 'D' is required for all the individual courses.

## 5. SUPPLEMENTARY/IMPROVEMENT EXAMINATION

5.1 There will be supplementary examinations and chance for improvement. Only one chance will be given for improving the marks of a course.

5.2 There shall not be any improvement examination for practical courses and examinations of the final year.

## 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 ten (10) days in a semester subject to a maximum of two times during the whole period of postgraduate programme may be granted by the College. This condonation shall not be counted for internal assessment.

6.2 Benefit of attendance may be granted to students representing the College, University, State or Nation in Sports, NCC, NSS or Cultural or any other officially sponsored activities such as

College union/University union activities etc., on production of participation/attendance certificates, within one week from competent authorities, for the actual number of days participated, subject to a maximum of ten (10) days in a semester, on the specific recommendations of the Faculty Mentor and Head of the Department.

6.3 A student who does not satisfy the requirements of attendance shall not be permitted to appear in the end-semester examinations.

6.4 Those students who are not eligible even with condonation of shortage of attendance shall repeat the course along with the next batch after readmission.

## 7. BOARD OF STUDIES AND COURSES

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

7.2 The syllabus of a programme shall contain programme objectives and programme outcome.

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

7.4 Each course shall have an alpha numeric code which includes abbreviation of the course in two letters, semester number, course code and serial number of the course.

7.5 Every programme conducted under Credit Semester System shall be monitored by the Academic Council.

## 8. REGISTRATION

8.1 A student who registers his/her name for the external exam for a semester will be eligible for promotion to the next semester.

8.2 A student who has completed the entire curriculum requirement, but could not register for the Semester examination can register notionally, for getting eligibility for promotion to the next semester.

8.3 A student may be permitted to complete the programme, on valid reasons, within a period of eight (8) continuous semesters from the date of commencement of the first semester of the programme

## 9. ADMISSION

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

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

9.3 Separate rank lists shall be drawn up for seats under reservation quota as per the existing rules.

9.4 There shall be an academic and examination calendar prepared by the College for the conduct of the programmes.

## 10. ADMISSION REQUIREMENTS

10.1 Candidates for admission to the first semester of the PG programme through SB-CSS-PG shall be required to have passed an appropriate degree examination of Mahatma Gandhi University or any University or authority, duly recognized by the Academic council of Mahatma Gandhi University as equivalent thereto.

## 11. MARK CUM GRADE CARD

11.1 The College under its seal shall issue to the students, a Mark cum Grade Card on completion of each semester, which shall contain the following information.

i. Name of the Student
ii. Register Number
iii. Photo of the Student
iv. Degree
v. Programme
vi. Semester and Name of the Examination
vii. Month and Year of Examination
viii. Faculty
ix. Course Code, Title and Credits of each course opted in the semester
x. Marks for ISA, ESA, Total Marks (ISA + ESA), Maximum Marks, Letter Grade, Grade Point (GP), Credit Point (CP) and Institution Average in each course opted in the semester
xi. Total Credits, Marks Awarded, Credit Point, SGPA and Letter Grade in the semester
xii. Weighted Average Score
xiii. Result
xiv. Credits/Grade of Extra Credit and Audit Courses

11.2 The final Mark cum 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 Mark cum Grade Card shall show the CGPA and the overall letter grade of a student for the entire programme.

11.3 A separate grade card shall be issued at the end of the final semester showing the extra credit and audit courses attended by the student, grade and credits acquired.

## 12. AWARD OF DEGREE

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

## 13. MONITORING COMMITTEE

There shall be a Monitoring Committee constituted by the Principal to monitor the internal evaluation conducted by the College. The Course Teacher, Faculty Mentor, and the College Coordinator should keep all the records of the continuous evaluation, for at least a period of two years, for verification.

## 14. GRIEVANCE REDRESS COMMITTEE

14.1 In order to address the grievance of students relating to ISA, a two-level grievance redress mechanism is envisaged.

14.2 A student can approach the upper level only if grievance is not addressed at the lower level.

14.3 Department level: The Principal 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 of the students.

14.4 College level: There shall be a College level Grievance Redress Committee comprising of Faculty Mentor, two senior teachers and two staff council members (one shall be an elected member) and the Principal as Chairman. The Committee shall address all grievances relating to the internal assessment of the students.

## 15. TRANSITORY PROVISION

Notwithstanding anything contained in these regulations, the Principal shall, for a period of three years 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.

# REGULATIONS FOR EXTRACURRICULAR COURSES, INTERNSHIP AND SKILL TRAINING

## COURSE ON BASIC LIFE SUPPORT SYSTEM AND DISASTER MANAGEMENT (BLS & DM)

i. The course on BLS & DM shall be conducted by a nodal centre created in the college.
ii. The nodal centre shall include at least one teacher from each department. A teacher shall be nominated as the Director of BLS & DM.
iii. The team of teachers under BLS & DM shall function as the trainers for BLS & DM.
iv. The team of teachers under BLS & DM shall be given intensive training on Basic Life Support System and Disaster Management and the team shall be equipped with adequate numbers of mannequins and kits for imparting the training to students.
v. Each student shall under go five (5) hours of hands on training in BLS & DM organised by the Centre for BLS & DM.
vi. The training sessions shall be organised on weekends/holidays/vacation during the first semester of the programme.
vii. After the completion of the training, the skills acquired shall be evaluated using an online test and grades shall be awarded.
viii. Nodal centre for BLS & DM shall conduct online test and publish the results.
ix. Students who could not complete the requirements of the BLS & DM training shall appear for the same along with the next batch. There shall be two redo opportunity.
x. For redressing the complaints in connection with the conduct of BLS & DM students shall approach the Grievance Redress Committee functioning in the college.

## COURSE ON MENDELY REFERENCE MANAGEMENT SOFTWARE

i. College shall arrange workshop with hands on training in Mendely reference management software during the first semester.
ii. Students completing the course can enrol for an evaluation and those who pass the evaluation shall be given one credit.

## INTERNSHIP/SKILL TRAINING PROGRAMME

i. Postgraduate student can undergo an internship for a minimum period of five days (25 hours) at a centre identified by the concerned department. In the case of disciplines where internship opportunities are scanty (e.g. Mathematics) special skill training programmes with duration of five days (25 hours) shall be organised.
ii. Each department shall identify a teacher in charge for internship/skill training programme.
iii. The department shall select institutions for internship/organising skill training programme.
iv. Internship/skill training programme shall be carried out preferably during the summer vacation following the second semester or during the Christmas vacation falling in the second semester or holidays falling in the semester.
v. At the end of the stipulated period of internship each student shall produce an internship completion cum attendance certificate and an illustrated report of the training he/she has underwent, duly certified by the tutor and Head of the institution where the internship has been undertaken.
vi. Students undergoing skill training programme shall submit a training completion cum attendance certificate and a report of the training he/she has underwent, duly certified by the trainer, teacher co-ordinator of the programme from the concerned department and the head of the department concerned.
vii. Upon receipt of the internship completion cum attendance certificate and illustrated report of the training or a training completion cum attendance certificate and a report of the training, the teacher in charge of internship/skill training programme shall prepare a list of students who have completed the internship/skill training programme and a list of students who failed to complete the programme. Head of the department shall verify the lists and forward the lists to the Controller of Examinations.

## PAPER PRESENTATION

i. During the period of the programme students shall be encouraged to write and publish research/review papers.
ii. One research/review paper published in a UGC approved journal or oral presentation in an international/national seminar which is later published in the proceedings shall fetch one credit.

## VIRTUAL LAB EXPERIMENTS/MOOC COURSES

i. During the tenure of the programme, students shall be encouraged to take up Virtual Lab Experiments and/or MOOC Courses.

ii. College shall arrange dedicated infrastructure for taking up Virtual Lab experiments and/or MOOC courses.

iii. There shall be a Nodal Officer and a team of teachers to coordinate the logistics for conducting Virtual Lab experiments and MOOC courses and to authenticate the claims of the students regarding the successful completion of the Virtual Lab experiments and or MOOC courses.

iv. Students who are desirous to do Virtual Lab experiments and or MOOC courses shall register with the Nodal Officer at the beginning of the experiment session/MOOC course. Students also shall submit proof of successful completion of the same to the Nodal officer.

v. Upon receipt of valid proof, the Nodal Officer shall recommend, to the Controller of Examinations, the award of extra credits. In the case of Virtual Lab experiments, 36 hours of virtual experimentation shall equal one credit and in the case of MOOC courses 18 hours of course work shall equal one credit.

**<u>Model Mark cum Grade Card</u>**

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# MARK CUM GRADE CARD

Date:

Name of the Candidate :

Permanent Register Number (PRN) :

Degree :

Programme :

Name of Examination :

Faculty :

Photo

| Course Code | Course Title | Credits (C) | Marks | | | | | | Grade Awarded (G) | Grade Point (GP) | Credit Point (CP) | Institution Average | Result |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ISA | | ESA | | Total | | | | | | |
| | | | Awarded | Maximum | Awarded | Maximum | Awarded | Maximum | | | | | |
| | Total<br>SGPA: SG: WAS:<br>***End of Statement*** | | | | | | | | | | | | |

***WAS: Weighted Average Score**

**Entered by:**

**Verified by:**

**Controller of Examinations** **Principal**

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Affiliated to Mahatma Gandhi University, Kottayam, Kerala
Changanassery, Kottayam, Kerala, India - 686101, Tel: 91-481-2420025, 9961231314
E-mail: sbc@sbcollege.org Web: www.sbcollege.ac.in

# CONSOLIDATED MARK CUM GRADE CARD

**Name of the Candidate :**

**Permanent Register Number (PRN) :**

**Degree :**

**Programme :**

**Faculty :**

**Date :**

Photo

| Course Code | Course Title | Credits (C) | Marks | | | | | | Grade Awarded (G) | Grade Point (GP) | Credit Point (CP) | Institution Average | Result |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ISA | | ESA | | Total | | | | | | |
| | | | Awarded | Maximum | Awarded | Maximum | Awarded | Maximum | | | | | |
| **SEMESTER I** | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| **SEMESTER II** | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| **SEMESTER III** | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

| SEMESTER IV | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ***End of Statement*** | | | | | | | | | | | | |

**PROGRAMME RESULT**

| Semester | Marks Awarded | Maximum Marks | Credit | Credit Point | SGPA | Grade | WAS | Month & Year of Passing | Result |
|---|---|---|---|---|---|---|---|---|---|
| I<br>II<br>III<br>IV | | | | | | | | | |
| **Total** | | | | | **FINAL RESULT: CGPA = ; GRADE = ;WAS =** | | | | |

*** Separate grade card is issued for Audit and Extra Credit courses.**
**** Grace Mark awarded.**

**Entered by:**

**Verified by:**

**Controller of Examinations** **Principal**

## Reverse side of the Mark cum Grade Card (COMMON FOR ALL SEMESTERS)
## Description of the Evaluation Process

**Grade and Grade Point**
The evaluation of each course comprises of internal and external components in the ratio 1:3 for all Courses. Grades and Grade Points are given on a seven (7) point scale based on the percentage of Total Marks (ISA + ESA) as given in Table 1. Decimals are corrected to the nearest whole number.

**Credit Point and Grade Point Average**
Credit Point (CP) of a course is calculated using the formula

**CP = C × GP**

where C is the Credit and GP is the Grade Point
Grade Point Average of a Semester (SGPA) or Cumulative Grade Point Average (CGPA)for a Programme is calculated using the formula

**SGPA or CGPA = TCP/TC**

where TCP is the Total Credit Point and TC is the Total Credit
GPA shall be rounded off to two decimal places.

The percentage of marks is calculated using the formula;

$$\% \text{ Marks}= \left(\frac{\text{total marks obtained}}{\text{maximum marks}}\right)\times 100$$

| Percentage of Marks | Grade | Performance | Grade Point |
|---|---|---|---|
| 95 and above | S | Outstanding | 10 |
| 85 to below 95 | A+ | Excellent | 9 |
| 75 to below 85 | A | Very Good | 8 |
| 65 to below 75 | B+ | Good | 7 |
| 55 to below 65 | B | Above Average | 6 |
| 45 to below 55 | C | Satisfactory | 5 |
| 40 to below 45 | D | Pass | 4 |
| Below 40 | F | Failure | 0 |

Table 1

Grades for the different Semesters and overall Programme are given based on the corresponding GPA, as shown in Table 2.

| GPA | Grade | Performance |
|---|---|---|
| 9.5 and above | S | Outstanding |
| 8.5 to below 9.5 | A+ | Excellent |
| 7.5 to below 8.5 | A | Very Good |
| 6.5 to below 7.5 | B+ | Good |
| 5.5 to below 6.5 | B | Above Average |
| 4.5 to below 5.5 | C | Satisfactory |
| 4 to below 4.5 | D | Pass |
| Below 4 | F | Failure |

Table 2

Note: Course title followed by (P) stands for practical course. A separate minimum of 40% marks each for internal and external assessments (for both theory and practical) and an aggregate minimum of 40% marks is required for a pass in each course. For a pass in a programme, a separate minimum of Grade D for all the individual courses and an overall Grade D or above are mandatory. If a candidate secures Grade F for any one of the courses offered in a Semester/Programme, only Grade F will be awarded for that Semester/Programme until the candidate improves this to Grade D or above within the permitted period.

# PROGRAMME STRUCTURE

| | Course Code | Course Title | Hours /Week | Total Hours | Credit | ISA | ESA | Total |
|---|---|---|---|---|---|---|---|---|
| **Semester I** | BMMM101 | Group Theory | 5 | 90 | 4 | 25 | 75 | 100 |
| | BMMM102 | Linear Algebra | 5 | 90 | 4 | 25 | 75 | 100 |
| | BMMM103 | Real Analysis - I | 5 | 90 | 4 | 25 | 75 | 100 |
| | BMMM104 | Topology | 5 | 90 | 4 | 25 | 75 | 100 |
| | BMMM105 | Differential Equations | 5 | 90 | 4 | 25 | 75 | 100 |
| | | **Total** | **25** | **450** | **20** | **125** | **375** | **500** |
| **Semester II** | BMMM206 | Ring Theory | 5 | 90 | 4 | 25 | 75 | 100 |
| | BMMM207 | Real Analysis - II | 5 | 90 | 4 | 25 | 75 | 100 |
| | BMMM208 | Measure and Integration | 5 | 90 | 4 | 25 | 75 | 100 |
| | BMMM209 | Complex Analysis - I | 5 | 90 | 4 | 25 | 75 | 100 |
| | BMMM210 | Optimization Techniques | 5 | 90 | 4 | 25 | 75 | 100 |
| | | **Total** | **25** | **450** | **20** | **125** | **375** | **500** |
| **Semester III** | BMMM311 | Galois Theory | 5 | 90 | 4 | 25 | 75 | 100 |
| | BMMM312 | Complex Analysis - II | 5 | 90 | 4 | 25 | 75 | 100 |
| | BMMM313 | Functional Analysis | 5 | 90 | 4 | 25 | 75 | 100 |
| | BMMM314 | Differential Geometry | 5 | 90 | 4 | 25 | 75 | 100 |
| | BMMM315 | Graph Theory | 5 | 90 | 4 | 25 | 75 | 100 |
| | | **Total** | **25** | **450** | **20** | **125** | **375** | **500** |
| **Semester IV** | | Elective Course | 5 | 90 | 3 | 25 | 75 | 100 |
| | | Elective Course | 5 | 90 | 3 | 25 | 75 | 100 |
| | | Elective Course | 5 | 90 | 3 | 25 | 75 | 100 |
| | | Elective Course | 5 | 90 | 3 | 25 | 75 | 100 |
| | | Elective Course | 5 | 90 | 3 | 25 | 75 | 100 |
| | BMMM4PJ | Project | - | - | 2 | 25 | 75 | 100 |
| | BMMM4VV | Programme Viva Voce | - | - | 3 | - | 100 | 100 |
| | | **Total** | **25** | **450** | **20** | **150** | **550** | **700** |
| | | **Grand Total** | **-** | **-** | **80** | **525** | **1675** | **2200** |

# ELECTIVE COURSES

| Sl. No. | Course Code | Course Title |
|---|---|---|
| 1 | BMMM4E01 | Finite Model Theory |
| 2 | BMMM4E02 | Commutative Algebra |
| 3 | BMMM4E03 | Spectral Theory |
| 4 | BMMM4E04 | Lie Algebra |
| 5 | BMMM4E05 | Coding Theory |
| 6 | BMMM4E06 | Analytic Number Theory |
| 7 | BMMM4E07 | Theory of Wavelets |
| 8 | BMMM4E08 | Algebraic Topology |
| 9 | BMMM4E09 | Fractal Geometry |
| 10 | BMMM4E10 | Calculus of Variations and Integral Equations |
| 11 | BMMM4E11 | Computing for Mathematics |
| 12 | BMMM4E12 | Matlab Programming for Numerical Computation |
| 13 | BMMM4E13 | Representation Theory |
| 14 | BMMM4E14 | Theory of Manifolds |
| 15 | BMMM4E15 | Probability Theory |

# SEMESTER I

## BMMM101: GROUP THEORY

**Total Hours: 90**
**Credit: 4**

**COURSE OBJECTIVES**

- This course deal adequately with the essentials in Abstract Algebra for a postgraduate student in Mathematics.
- Introduce some new techniques of proof and certain procedures which will be useful for future courses in pure mathematics.
- The topic covers the requirements of the CSIR UGC NET syllabus.
- Group Theory will help to learn more about the concept of groups, normal subgroups and homomorphism etc.
- Develop the concepts of normal subgroups, group homomorphisms.

**COURSE OUTCOMES**

- Numerous exercises discussed during this course will enhance the understanding of the material the students studied.
- Compare class equations and normal series.
- Apply normal subgroups to future papers like Field Theory and Galois Theory.

**TEXT BOOK**:

DAVID S DUMMIT, RICHARD M FOOTE, ABSTRACT ALGEBRA, THIRD EDITION, WILEY, 2011.

Quick Review: Chapter 1 and 2 of the Textbook

**MODULE 1**: **QUOTIENT GROUP AND HOMOMORPHISM (20 hours)**

Definitions and Examples, More on Cosets and Lagrange's Theorem, The Isomorphism Theorems, Composition Series and Holder Program, Transpositions and the Alternating Group.

Chapter 3, Sections: 3.1-3.5

**MODULE 2: GROUP ACTIONS (25 hours)**

Group Actions and permutation representations, Group acting on themselves by left multiplication-Cayley's theorem, Group acting on themselves by Conjugation-The class equation, Automorphisms, The Sylow theorems, The simplicity of An.

Chapter 4, Sections: 4.1 - 4.6

**MODULE 3**: **DIRECT PRODUCTS AND SEMIDIRECT PRODUCTS AND ABELIAN GROUPS (25 hours)**

Direct products, The fundamental theorem of finitely generated abelian groups, Table of groups of small order, Recognizing direct products, Semidirect Products.

Chapter 5 – Sections: 5.1 - 5.5

**MODULE 4: FURTHER TOPICS IN GROUP THEORY (20 hours)**

P-groups, nilpotent groups and solvable groups, Applications in groups of medium order, A word on free groups.

Chapter 6 - Sections: 6.1 - 6.3

**REFERENCES**

1. JOHN B FRALEIGH, A FIRST COURSE IN ABSTRACT ALGEBRA, 7TH EDITION, PEARSON EDUCATION, 2002.
2. I N HERSTEIN, TOPICS IN ALGEBRA, 2ND EDITION, WILEY, 2006.
3. S LANG, ALGEBRA, THIRD EDITION, SPRINGER, 2002.

## BMMM102: LINEAR ALGEBRA

**Total Hours: 90**

**Credit: 4**

**COURSE OBJECTIVES**

- This course deal adequately with the essentials in linear algebra for a postgraduate student in Mathematics.
- Introduce some new techniques of proof which will be useful for future courses in pure mathematics.
- The topic covers the requirements of the CSIR UGC NET syllabus
- Linear maps between vector spaces and the interplay between linear maps and matrices are studied in detail.
- Develop the concepts such as eigen values, characteristic polynomials, minimal polynomials and invariant subspaces which are essential in many branches of higher mathematics.
- Familiarized with the canonical forms of the matrices.

**COURSE OUTCOMES**

- Numerous exercises discussed during this course will enhance the understanding of the material the students studied.
- Compare vector spaces using linear transformations and finding the rank, nullity of transformations.
- Computing matrices of linear transformations and vice versa.
- Discriminate between diagonalizable and non diagonalizable linear operators.
- Able to apply diagonalization theorem.
- Computing the Jordan forms of linear operators.

**TEXT BOOK**

P. K. SAIKIA: LINEAR ALGEBRA, PEARSON, 2009.

**QUICK REVIEW**: Vector Spaces-Introduction, Basic Concepts-, Examples, Subspaces, Linear Independence and Dependence, Basis and Dimension, Polynomials over fields.

**MODULE 1: VECTOR SPACES (15 hours)**

Subspaces, Rank of a Matrix, Orthogonality in $R^n$ , Bases of subspaces.

Sections 3.5 - 3.8

**MODULE 2: LINEAR MAPS AND MATRICES (30 hours)**

Basic Concepts, Algebra of Linear Maps, Isomorphism, Matrices of Linear Maps.

Sections 4.1 - 4.5

**MODULE 3: LINEAR OPERATORS (25 hours)**

Polynomials over fields, Characteristic polynomial and Eigenvalues, Minimal Polynomial, Invariant Subspaces, Some basic results.

Sections 5.1 - 5.6

**MODULE 4: CANONICAL FORMS (20 hours)**

Primary Decomposition Theorem, Jordan Forms.

Sections 6.1 - 6.3

**REFERENCES**


1. K.B. DATTA: MATRIX AND LINEAR ALGEBRA, PRENTICE HALL OF INDIA PVT. LTD., NEW DELHI, 2000.
2. PAUL R. HALMOS: LINEAR ALGEBRA PROBLEM BOOK, THE MATHEMATICAL ASSOCIATION OF AMERICA, 1995.
3. KENNETH HOFFMAN, RAY KUNZE (SECOND EDITION): LINEAR ALGEBRA, PRENTICE-HALL OF INDIA PVT. LTD., NEW DELHI, 1992.
4. S. KUMARESAN: LINEAR ALGEBRA, A GEOMETRICAL APPROACH, PRENTICE HALL OF INDIA, 2000.
5. S. LANG: ALGEBRA, THIRD EDITION, ADDISON-WESLEY, 1993.

## BMMM103: REAL ANALYSIS - I

**Total Hours: 90**

**Credit: 4**

**COURSE OBJECTIVES**

- To introduce a class of functions closely related to monotonic functions.
- Give a background to the theory of Riemann Steiltjes integration.
- To deal with sequences and series of functions
- To derive some properties which are represented by power series

**COURSE OUTCOMES**

- More thorough concepts about functions
- Capable to deal with complex valued and vector valued functions
- Transition from elementary calculus to advanced calculus.
- Equips the students to abstract thinking

**TEXT BOOKS**

1. TOM APOSTOL, MATHEMATICAL ANALYSIS (SECOND EDITION), NAROSA PUBLISHING HOUSE, 2002.
2. WALTER RUDIN, PRINCIPLES OF MATHEMATICAL ANALYSIS (THIRD EDITION), INTERNATIONAL STUDENT EDITION, 1976.

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

**MODULE 1: FUNCTIONS OF BOUNDED VARIATION AND RECTIFIABLE CURVES (25 hours)**

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.

Text Book 1 - Chapter 6- Section: 6.1 - 6.12

**MODULE 2**: **THE RIEMANN-STIELTJES INTEGRAL (20 hours)**

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

Text Book 2 - Chapter 6 - Section 6.1 to 6.25.)

**MODULE 3: SEQUENCE AND SERIES OF FUNCTIONS (25 hours)**

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

Text Book 2- Chapter 7 -Sections 7.7 - 7.18

**MODULE 4: SOME SPECIAL FUNCTIONS (20 hours)**

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

Text Book 2- Chapter 8 - Section 8.1 to 8.16

**REFERENCES**


1. ROYDEN H.L, REAL ANALYSIS, 2ND EDITION, MACMILLAN, NEW YORK, 1968.
2. BARTLE R.G, THE ELEMENTS OF REAL ANALYSIS, JOHN WILEY AND SONS, 1975.
3. S.C. MALIK, SAVITHA ARORA, MATHEMATICAL ANALYSIS, NEW AGE INTERNATIONAL LTD, 2010.
4. EDWIN HEWITT, KARL STROMBERG, REAL AND ABSTRACT ANALYSIS, SPRINGER INTERNATIONAL, 1978.
5. GOLDBERG, METHODS OF REAL ANALYSIS, JOHN WILEY & SONS, 2012.
6. ROBERT S. STRICHARTZ, THE WAY OF ANALYSIS, JONES AND BARTLETT BOOKS IN MATHEMATICS, 2000.
7. TERENCE TAO, ANALYSIS I, HINDUSTAN BOOK AGENCY, 2006.

## BMMM104: TOPOLOGY

**Total Hours: 90**

**Credit: 4**

**COURSE OBJECTIVE**

- To have an abstract reasoning about topological spaces and continuity and to analyse the properties of examples provided.
- To describe and work with relevant topological models for various concrete applications.
- To understand more about subspaces product and quotient topologies and how their definitions are related to continuous functions.
- To understand various notions of compactness and know the relations with other topological and metric properties and be familiar with various compactification constructions.

**COURSE OUTCOMES**

- Able to apply him/her knowledge of general topology to formulate and solve problems of a topological nature in mathematics and other fields where topological issues arises.
- Apply theoretical concepts in topology to understand real world applications.

**TEXT BOOK**

FRED H CROOM, PRINCIPLES OF TOPOLOGY, CENGAGE LEARNING, 2016.

**MODULE 1: TOPOLOGICAL SPACES (20 hours)**

The definition and some examples, Interior, Closure and Boundary, Basis and sub basis, continuity and topological equivalence.

Sections 4.1 - 4.5

**MODULE 2: CONNECTEDNESS (25 hours)**

Connected and disconnected spaces, Theorems on connectedness, connected subsets of the real line, Applications of Connectedness, Path connected spaces, locally connected and locally path connected spaces.

Sections 5.1 - 5.6

**MODULE 3: COMPACTNESS (20 hours)**

Compact spaces and subspaces, Compactness and continuity, Properties related to compactness, One-point compactification.

Sections 6.1 -6.4

**MODULE 4: PRODUCT AND QUOTIENT SPACES (25 hours)**

Finite Products, Arbitrary products, Comparison of topologies, Quotient spaces, Separation Properties, $T_0$; $T_1$ and $T_2$ spaces, Regular spaces, Normal Spaces, Separation by continuous functions.

Sections 7.1 -7.5 ; 8.1-8.4

**REFERENCES**


1. K.D. JOSHI, INTRODUCTION TO GENERAL TOPOLOGY, WILEY EASTERN LTD, 1984
2. MUNKRES J.R, TOPOLOGY-A FIRST COURSE, PRENTICE HALL OF INDIA PVT. LTD., NEW DELHI, 2000.
3. STEPHEN WILLARD, GENERAL TOPOLOGY, ADDISON-WESLEY, 2004.

## BMMM105: DIFFERENTIAL EQUATIONS

**Total Hours: 90**

**Credit: 4**

**COURSE OBJECTIVE**

- Introduce modern theory and methods on ordinary and partial differential equations.
- Develop the skills to find the solutions of ordinary and partial differential equations.
- Distinguish between types of PDE and solutions.
- Discussion of heat equations, wave equations, Laplace equations.

**COURSE OUTCOMES**

- Have a deep overview on ordinary and partial differential equations.
- Understand the concepts of linear differential equations, solutions, Sturm's theorem, ordinary and singular points and Picard's theorem.
- Understand the key concepts and definition of PDE and also mathematical models representing stretched strings, vibrating membrane, heat conduction rod.
- Demonstrate initial and final value problems of PDE.

**TEXT BOOK**

1. G F SIMMONS - DIFFERENTIAL EQUATIONS WITH APPLICATIONS AND HISTORICAL NOTES (THIRD EDITION), 1974.
2. T AMARNATH - AN ELEMENTARY COURSE IN PARTIAL DIFFERENTIAL EQUATIONS NAROSA PUBLICATIONS**, 1997.**

**MODULE 1 (25 hours)**

Second order linear equations: Introduction, The general Solution of Homogeneous equations, the use of a known solution to find another ,the homogeneous equation with constant coefficients, the method of undetermined Coefficients, Operator method for finding Particular solutions, Oscillations and the sturm separation theorem, The sturm comparison theorem

Text Book 1 - Sections: 14-19; 23- 25

**MODULE 2 (25 hours)**

Power series solutions and special functions: Series solution of first order equations. Second order equations linear equations, ordinary points, regular singular points, regular singular points (continued), Gauss Hypergeometric equations, the point at infinity, The method of successive approximations, Picard's theorem

Text Book 1 - Sections: 27 - 32 ; 69,70

**MODULE 3 (20 hours)**

Curves and surfaces, Genesis of first order P.D.E, Classification of Integrals, Linear Equations of the First Order, Pfaffian Differential Equations, Compatible Systems, Charpit's Method, Jacobi's Method, Integral Surfaces Through a given curve, Quasi Linear equations, Non linear pde of first order.

Text Book 2 - Sections: 1.1 - 1.11

**MODULE 4 (20 hours)**

Genesis of second order PDE, classification of second order pde, one dimensional wave equation: Vibrations of infinite string, Vibrations of Semi infinite string, Vibrations of Finite length Laplace equation: maximum and minimum principles, the Cauchy principles, the dirichlet problem for the upper half plane, the Neumann problem for the upper half plane, the Dirichlet exterior problem for a circle, the Neumann problem for a circle, The dirichlet problem for a Rectangle, Heat conduction Problem: Heat conduction -infinite rode case, heat conduction- finite rod case, Families of equipotential Surfaces

Text Book 2 - Sections: 2.1 , 2,2 ; 2.3.1 - 2.3.3 ; 2.4.1 - 2.4.9; 2.5, 2.8

**REFERENCES**


1. EARL A CODDINGTON, NORMAN LEVINSON: THEORY OF ORDINARY DIFFERENTIAL EQUATIONS, TATA MC GRAW HILL, 1955.
2. G.BIRKOFF AND G.C ROTA : ORDINARY DIFFERENTIAL EQUATIONS, WILEY AND SONS- 3RD EDN (1978)
3. M.RAM MOHAN RAO: ORDINARY DIFFERENTIAL EQUATIONS AND APPLICATIONS, 1980.
4. IAN SNEDDON: PARTIAL DIFFERENTIAL EQUATIONS, MCGRAW-HILL BOOK COMPANY, 1957.
5. E.T COPSON, PARTIAL DIFFERENTIAL EQUATIONS, S .CHAND & CO, 1975.
6. K SANKARA RAO, INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATIONS, PRENTICE-HALL OF INDIA, 2010.

# SEMESTER II

## BMMM206: RING THEORY

**Total Hours: 90**

**Credit: 4**

**COURSE OBJECTIVES**

- This course deal adequately with the essentials in Abstract Algebra for a postgraduate student in Mathematics.
- Introduce some new techniques of proof and certain procedures, which will be useful for future courses in pure mathematics.
- The topic covers the requirements of the CSIR UGC NET syllabus.
- Field Theory will help to learn more about the concept of rings, integral domain and fields etc.
- Develop the concepts of Ideals through normal subgroups.
- Develop the concepts of prime and maximal ideals through the integers.
- Apply Rings, integral domain and fields to Gaussian integers.

**COURSE OUTCOMES**

- Numerous exercises discussed during this course will enhance the understanding of the material the students studied.
- Compare Unique Factorization Domain, Principal Ideal Domain and Euclidean Domains.
- Compare ideals, prime ideals, maximal ideals and principal ideals.

**TEXT BOOK:**

DAVID S DUMMIT, RICHARD M FOOTE: ABSTRACT ALGEBRA, THIRD EDITION, WILEY, 2011.

**MODULE 1: INTRODUCTION TO RINGS (25 hours)**

Rings; definition and examples, Polynomial rings, Matrix rings and Group rings, Ring homomorphisms and Quotient Rings, Ideals, Properties of ideals, Rings of fractions, The Chinese remainder theorem.

Chapter 7 – Sections: 7.1 - 7.6

**MODULE 2: EUCLIDEAN DOMAINS (20 hours)**

Euclidean Domains, Principal Ideal Domains and Unique Factorization Domains Euclidean Domains, Principal Ideal Domains, Unique Factorization Domains

Chapter 8 – Sections: 8.1 - 8.3

**MODULE 3**: **POLYNOMIAL RINGS (20 hours)**

Polynomial rings: Definition and properties, Polynomial rings over fields I, Polynomial rings that are Unique Factorization Domains, Irreducibility criteria, Polynomial rings over fields II.

Chapter 9 – Sections : 9.1 - 9.5

**MODULE 4: INTRODUCTION TO MODULE THEORY (25 hours)**

Basic Definitions and Examples, Quotient Modules and Module Homomorphisms, Generations of modules, Direct sums and Free Modules

Chapter 10-Sections: 10.1 - 10.3

**REFERENCES**


1. 1.JOHN B FRALEIGH: A FIRST COURSE IN ABSTRACT ALGEBRA, 7TH EDITION, PEARSON EDUCATION, 2002.
2. I N HERSTEIN: TOPICS IN ALGEBRA, SECOND EDITION, WILEY, 2006.
3. S LANG: ALGEBRA, THIRD EDITION, SPRINGER, 2002.

# BMMM207: REAL ANALYSIS - II

**Total Hours: 90**

**Credit: 4**

**COURSE OBJECTIVES**

- To introduce an indispensable tool in the analysis of certain periodic phenomena
- Introduce multivariable calculus.
- Understand Inverse function theorem and Implicit function theorem
- To study integration at a different level.

**COURSE OUTCOMES**

- Transition from elementary analysis to advanced analysis.
- Equips the students to abstract thinking
- Understand mathematical techniques needed to work in advanced analysis

**TEXTBOOKS:**

1. TOM APOSTOL, MATHEMATICAL ANALYSIS, SECOND EDITION, NAROSA PUBLISHING HOUSE, 2002.
2. WALTER RUDIN, PRINCIPLES OF MATHEMATICAL ANALYSIS, THIRD EDITION – INTERNATIONAL STUDENT EDITION, 1976.

**MODULE 1: INTEGRAL TRANSFORMS (20 hours)**

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.

Text Book 1 -Chapter 11- Sections 11.15 - 11.21

**MODULE 2: MULTIVARIABLE DIFFERENTIAL CALCULUS (20 hours)**

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.

Text Book 1 -Chapter 12 - Sections. 12.1 - 12.10

**MODULE 3: IMPLICIT FUNCTIONS (25 hours)**

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.

Text Book 1 - Chapter 12- Sections 12.11 - 12.13

Text Book 1 - Chapter 13 -Sections 13.1 - 13.6

**MODULE 4: INTEGRATION OF DIFFERENTIAL FORMS (25 hours)**

Integration, primitive mappings, partitions of unity, change of variables, differential forms, Stokes theorem (without proof)

Text Book 2 - Chapter 10: Sections - 10.1 - 10.25, 10.33

**REFERENCES**

1. LIMAYE BALMOHAN VISHNU, MULTIVARIATE ANALYSIS, SPRINGER, 2010.
2. SATISH SHIRALI AND HARIKRISHNAN, MULTIVARIABLE ANALYSIS, SPRINGER, 2010.
3. SUDHIR R. GHORPADE AND BALMOHAN V. LIMAYE, A COURSE IN MULTIVARIABLE CALCULUS AND ANALYSIS SPRINGER, 2010.
4. TERENCE TAO, ANALYSIS II , HINDUSTAN BOOK AGENCY, 2016.

# BMMM208: MEASURE AND INTEGRATION

**Total Hours: 90**

**Credit: 4**

**COURSE OBJECTIVES**

- This course deal adequately with the essentials in real analysis for a postgraduate student in Mathematics.
- Introduce some new techniques of proof which will be useful for future courses in pure mathematics.
- The topic covers the requirements of the CSIR UGC NET syllabus.
- Measure Theory will help to learn more about the concept of integration.
- Develop the concepts of differentiation through the approach of measure.
- It will help to realize the concept of integration as a reverse process of differentiation.
- We have to apply the concept of measure on real line to general spaces.

**COURSE OUTCOMES**

- Numerous exercises discussed during this course will enhance the understanding of the material the students studied.
- Compare integration and differentiation in the aspect of measure.
- Discriminate probability space and certain other measure spaces with Lebesgue outer measure.
- Able to apply Radon Nikodym Theorem.

**TEXT BOOK:**

H.L. ROYDEN, REAL ANALYSIS, THIRD EDITION, PRENTICE HALL OF INDIA PRIVATE LIMITED, 1963.

**MODULE 1: LEBESGUE MEASURE (20 hours)**

Outer measure, measurable sets and Lebesgue measure, A non-measurable set, Measurable functions.

Chapter 3 - Sec. 1 - 5

**MODULE 2: THE LEBESGUE INTEGRAL (25 hours)**

The Riemann integral (a quick review), the Lebesgue integral of a bounded function over a set of finite measures, the integral of a non-negative function, the general Lebesgue integral.

Chapter 4 - Sec. 1 - 5

**MODULE 3: DIFFERENTIATION AND INTEGRATION (20 hours)**

Differentiation of monotone functions, Functions of bounded variations, Differentiation of an integral, absolute continuity.

Chapter 5-sections 1 - 4

**MODULE 4: GENERAL MEASURE AND INTEGRATION (25 hours)**

Theory Measurable spaces, measurable function, integration, signed measure, The Radon Nikodym Theorem, Outer measure and measurability, the extension theorem, product measures.

Chapter 11-sections 1, 3, 5, 6

Chapter 12-sections 1, 2, 3

**REFERENCES**


1. G. DE BARRA, MEASURE THEORY AND INTEGRATION, NEW AGE INTERNATIONAL (P) LINNILECT PUBLISHERS, 1981.
2. FRANK BURK, LEBESGUE MEASURE AND INTEGRATION, AN INTRODUCTION, JOHN WILEY AND SONS, 1998
3. INDER K RANA, AN INTRODUCTION TO MEASURE AND INTEGRATION, NAROSA PUBLISHING HOUSE, 1997.
4. P.K. JAIN AND V.P. GUPTA, LEBESGUE MEASURE AND INTEGRATION, NEW AGE INTERNATIONAL (P) LTD., NEW DELHI, 1986(REPRINT 2000)

# BMMM209: COMPLEX ANALYSIS - I

**Total Hours: 90**

**Credit: 4**

**COURSE OBJECTIVES**

- To give a better understanding on complex analysis.
- It is a very good tool to study wot dimensional physical systems.
- .A detailed study on analytic functions

**COURSE OUTCOMES**

- Study conformality and linear transformation.
- Complex integrations
- Cauchy's integral formula, properties of analytic functions
- Residue theorems and some practical methods to solve integrals
- An introductory study on harmonic functions.

**TEXT BOOK**

LARS V. AHLFORS: COMPLEX ANALYSIS, THIRD EDITION, MCGRAW HILL, 1953.

**MODULE 1: ANALYTIC FUNCTIONS (20 hours)**

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 2-4

**MODULE 2: COMPLEX INTEGRATION (20 hours)**

Complex Integration, Fundamental theorem: line integrals, rectifiable arcs, line integrals as functions of arcs, Cauchy's theorem for a rectangle, Cauchy's theorem in a disk, Cauchy's integral formula: the index of a point with respect to a cloud curve, the integral formula, higher derivatives.

Chapter 4- Sections 1-2

**MODULE 3: LOCAL PROPERTIES OF ANALYTICAL FUNCTIONS (25 hours)**

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 3-4

**MODULE 4: RESIDUES (25 hours)**

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 5-6

**REFERENCES**


1. CARTAN. H ELEMENTARY THEORY OF ANALYTIC FUNCTIONS OF ONE OR SEVERAL VARIABLE, ADDISON WESLEY, 1973.
2. CHAUDHARY. B, THE ELEMENTS OF COMPLEX ANALYSIS, WILEY EASTERN, 1983.
3. CONWAY .J.B, FUNCTIONS OF ONE COMPLEX VARIABLE, NAROSA PUBLISHING, 1978.
4. LANG. S, COMPLEX ANALYSIS, SPRINGER, 1977.
5. S PONNUSAMY, HERB SILVERMAN, COMPLEX VARIABLES WITH APPLICATIONS, 2011.
6. H.A. PRIESTLY, INTRODUCTION TO COMPLEX ANALYSIS, CLARENDON PRESS, OXFORD, 1990.

# BMMM210: OPTIMIZATION TECHNIQUES

**Total Hours: 90**

**Credit: 4**

**COURSE OBJECTIVES**

- To understand the theory of optimization methods and algorithms developed for solving various types of linear and non linear programming problems.
- To understand the strength and weakness of queuing models.

**COURSE OUTCOME**

- Able to formulate optimization problems. Achieve knowledge about techniques that can be used to solve such problems
- Able to model and analyze the real world queuing systems.

**TEXTBOOKS**

1. K.V. MITAL AND C. MOHAN, OPTIMIZATION METHODS IN OPERATION RESEARCH AND SYSTEMS ANALYSIS, $3^{RD}$ EDITION, 1996.
2. DONALD GROSS, JOHN F SHORTLE, JAMES M THOMPSON AND CARL M HARRIS, FUNDAMENTALS OF QUEUEING THEORY ,$4^{TH}$ EDITIONS, JOHN WILEY & SONS, 2012.

**MODULE 1: LINEAR PROGRAMMING (20 hours)**

Introduction, LP in 2-dimensional space, General LP Problem, Feasible solutions, Basic solutions, Basic feasible solutions, Optimum solutions, Simplex method, Canonical form of equations, Simplex method (numerical example), Simplex tableau, Finding the first bfs, artificial variables, Degeneracy, Duality in LP problems, Duality theorems, Applications of duality, Dual simplex method, Summary of simplex methods, Applications of LP

Text Book 1 - Chapter 3 - Sec. 3.1 - 3.22 (excluding 3.15 & 3.16)

**MODULE 2: TRANSPORTATION AND ASSIGNMENT PROBLEMS (20 hours)**

Introduction, Transportation problem, Transportation array, Transportation matrix, Triangular basis, Finding a basic feasible solution, Testing for optimality, Loop in transportation array, Changing the basis, Degeneracy, Unbalanced problem, Transportation with Transhipment, Caterer problem, Assignment problem, Generalized transportation problem, Summary of transportation algorithm.

Text Book 1 - Chapter 4

**MODULE 3: NON-LINEAR PROGRAMMING (25 hours)**

Introduction, Lagrangian function, saddle point, relation between saddle point of F(X,Y) and minimal point of F(X), Kuhn Tucker conditions, primal and dual problems, Quadratic programming, unimodal functions, search plans, Fibonacci search plan, Golden section plan, method of axial directions, method of steepest descent, Newton – Raphson Method, Constrained problem: gradient projection.

Text Book 1 - Chapter 8 – Sec. 8.1 - 8.6, Chapter 11 – Sec. 11.1 - 11.5, 11.9 - 11.11, 11.16

**MODULE 4: QUEUEING THEORY (25 hours)**

Description of queueing problem, Characteristics of Queueing process, Notations, Measuring system performance, Some general results, Simple data book keeping for queues, Poisson process and the exponential distribution, Markovian property of exponential distribution. Birth-death process, Single server queues (M/M/1), Multi server queues (M/M/c), Queues with truncations (M/M/c/K).

Text Book 2 - Chapter 1 - Sections: 1.1 - 1.8, Chapter 2 – Sections 2.1 - 2.3,2.5

**REFERENCES**


1. S.S. RAO, OPTIMIZATION THEORY AND APPLICATIONS, 2ND EDITION, NEW AGE INTERNATIONAL PVT, 1984.
2. J.K. SHARMA, OPERATIONS RESEARCH: THEORY AND APPLICATIONS, THIRD EDITION, MACMILLAN INDIA LTD, 2006.
3. RAVINDRAN, PHILIPS AND SOLBERG, OPERATIONS RESEARCH PRINCIPLE AND PRACTICE, 2ND EDITION, JOHN WILEY AND SONS, 1987.
4. R. B. COOPER, INTRODUCTION TO QUEUEING THEORY, 2ND EDITION, 1972.

# SEMESTER III

## BMMM311: GALOIS THEORY

**Total Hours: 90**

**Credit: 4**

**COURSE OBJECTIVES**

- This course deal adequately with the essentials in Abstract Algebra for a postgraduate student in Mathematics.
- Introduce some new techniques of proof and certain procedures which will be useful for future courses in pure mathematics.
- The topic covers the requirements of the CSIR UGC NET syllabus.
- Galois Theory will help to learn more about the concept of finite fields, cyclotomic polynomials, splitting fields, normal fields, separable polynomials, etc.
- Develop the concepts of Galois fields through the separable polynomials.
- Develop the concepts of Galois fields through the splitting fields.
- Apply finite fields to Number theory and Complex analysis.
- We have to apply the concept of Galois theory to topology.

**COURSE OUTCOMES**

- Numerous exercises discussed during this course will enhance the understanding of the material the students studied.
- Compare splitting fields and Galois fields.
- Compare normal extension and separable extensions.
- Concreting the concept of Galois extension.
- Able to apply Galois Theory to other branches of mathematics.

**TEXT BOOK**

DAVID S DUMMIT, RICHARD M FOOTE: ABSTRACT ALGEBRA, THIRD EDITION, WILEY, 2011.

**MODULE 1: FIELD THEORY (20 hours)**

Basic theory of field extensions, Algebraic extensions, Classical straightedge and compass constructions.

Chapter 13 - Sections. 13.1 - 13.3

**MODULE 2: FIELD THEORY- Contd; (25 hours)**

Splitting fields and Algebraic closures, Separable and inseparable extensions, cyclotomic polynomials and extensions.

Chapter 13- Sections. 13.4 - 13.6

**MODULE 3: GALOIS THEORY (20 hours)**

Galois theory: Basic definitions, The fundamental theorem of Galois theory, Finite fields.

Chapter 14- Sections. 14.1 - 14.3

**MODULE 4: GALOIS THEORY-Contd; (25 hours)**

Composite extensions and simple extensions, Cyclotomic extensions and abelian extensions over Q, Galois group of polynomials.

Chapter 14-Sections. 14.4 - 14.6

**REFERENCES**


1. JOHN B FRALEIGH, A FIRST COURSE IN ABSTRACT ALGEBRA, 7TH EDITION, PEARSON EDUCATION, 2002.
2. I N HERSTEIN, TOPICS IN ALGEBRA, 2ND EDITION, WILEY, 2006.
3. S LANG, ALGEBRA, THIRD EDITION, SPRINGER, 2002.

## BMMM312: COMPLEX ANALYSIS - II

**Total Hours: 90**

**Credit: 4**

**COURSE OBJECTIVES**

- To give a better understanding on complex analysis
- It is a very good tool to study 2 dimensional physical systems.
- A detailed study on analytic functions, entire functions, elliptic functions
- Study global analytic function

**COURSE OUTCOMES**

- Study properties analytic functions through power series representations
- Study some Important theorems on entire functions
- Riemann zeta functions and it's both complex analytic part and number theoretic part are discussed.
- Study Riemann mapping theorem, solution for Dirichlet problems through sub-harmonic functions.
- Study properties of doubly periodic functions.
- Study global analytic functions.

**TEXT BOOK**

LARS V. AHLFORS: COMPLEX ANALYSIS, THIRD EDITION, MCGRAW HILL INTERNATIONALS, 1953.

**MODULE 1: POWER SERIES (25 hours)**

Elementary theory of power series: sequences, series, uniform convergence, power series, Abels limit theorem. Power series expansions: Weierstrass theorem, the Taylors series, the Laurents series. Partial fractions and factorisation: partial fractions, infinite products, canonical products, the gamma functions.

Chapter 2, Section 2; Chapter 5 - Sections 1, 2.1 - 2.4

**MODULE 2: ENTIRE FUNCTIONS (25 hours)**

Entire functions: Jensons formula, Hadamards theorem (without proof) the Riemann zeta function: the product development, extension to the whole plane, the functional equation, the zeroes of zeta function. Normal families: Equi continuity, normality and compactness, Arzelas theorem (without proof)

Chapter 5 - Sections 3, 4, 5.1, 5.2, & 5.3

**MODULE 3:HARMONIC FUNCTIONS (20 hours)**

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, Harnacks 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

**MODULE 4: ELLIPTIC FUNCTIONS (20 hours)**

Elliptic functions: simply periodic functions, representation of exponentials, the Fourier development, functions of finite order, Doubly periodic functions: The period module, unimodular transformations, the canonical basis, general properties of elliptic functions. The Weirstrass theory: the Weierstrass function, the functions (y) and (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 - 1.5

**REFERENCES**


1. CHAUDHARY. B, THE ELEMENTS OF COMPLEX ANALYSIS, WILEY EASTERN, 1983.
2. CARTAN. H, ELEMENTARY THEORY OF ANALYTIC FUNCTIONS OF ONE OR SEVERAL VARIABLE, ADDISON WESLEY, 1973.
3. CONWAY .J.B, FUNCTIONS OF ONE COMPLEX VARIABLE, NAROSA PUBLISHING, 1978.
4. LANG. S, COMPLEX ANALYSIS, SPRINGER, 1977.
5. H.A. PRIESTLY, INTRODUCTION TO COMPLEX ANALYSIS, CLARENDON PRESS, OXFORD, 1990.

## BMMM313: FUNCTIONAL ANALYSIS

**Total Hours: 90**
**Credit: 4**

**COURSE OBJECTIVES**

- Introduce the key notions in functional analysis such as Normed spaces, Banach space, bounded linear operators, Hilbert spaces etc
- Comprehend the role of functional analysis in modern Mathematics and in applied context.
- Introduce the relationship between analysis and linear algebra.

**COURSE OUTCOME**

- Understanding the topological terminology of continuity, completeness on linear operators, Vector spaces.
- Understanding the concepts of linear operators, dual spaces, the theory of Hahn Banach.
- Ability to pursue further studies in the field.

**TEXT BOOK**

ERWIN KREYSZIG: INTRODUCTORY FUNCTIONAL ANALYSIS WITH APPLICATIONS, JOHN WILEY AND SONS, NEW YORK, 1978.

**MODULE 1: NORMED SPACE, BANACH SPACE (20 hours)**

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

Sections 2.1-2.7

**MODULE 2: HILBERT SPACES (20 hours)**

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

Sections 2.8-2.10 ; 3.1-3.2

**MODULE 3: HILBERT SPACES – contd (25 hours)**

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.

Sections 3.3-3.6; 3.8-3.10

**MODULE 4: FUNDAMENTAL THEOREMS ON NORMED AND BANACH SPACES (25 hours)**

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

Sections 4.1-4.3; 4.5-4.7

**REFERENCES**


1. M. THAMBAN NAIR, FUNCTIONAL ANALYSIS, A FIRST COURSE, PRENTICE HALL OF INDIA PVT. LTD, 2008.
2. WALTER RUDIN, FUNCTIONAL ANALYSIS, TMH EDITION, 1974.
3. SIDDIQI, A.H, FUNCTIONAL ANALYSIS WITH APPLICATIONS, TATA MCGRAW HILL, NEW DELHI, 1989
4. SIMMONS, G.F, INTRODUCTION TO TOPOLOGY AND MODERN ANALYSIS, MCGRAW HILL, NEW YORK, 1963.
5. SOMASUNDARAM. D, FUNCTIONAL ANALYSIS, S. VISWANATHAN PVT. LTD, MADRAS, 1994.
6. VASISTHA, A.R AND SHARMA I.N, FUNCTIONAL ANALYSIS, KRISHNAN PRAKASAN MEDIA (P) LTD, MEERUT, 1995-96.

## BMMM314: DIFFERENTIAL GEOMETRY

**Total Hours: 90**

**Credit: 4**

**COURSE OBJECTIVE**

- To get introduced to the concept of regular parameterized curves**.**
- To get introduced to geodesics on a surface and their characterization.
- To understand the Weingarten equations, mean curvature and Gaussian curvature.

**COURSE OUTCOMES**

- To explain the concepts and language of differential geometry and its role in modern mathematics.
- Analyse and solve complex problems using ideas from differential geometry.

**TEXT BOOK**

JOHN A. THORPE: ELEMENTARY TOPICS IN DIFFERENTIAL GEOMETRY, SPRINGER; 1ST ED. 1979.

**MODULE 1: VECTOR FIELDS ON SURFACES (15 hours)**

Graphs and level sets, vector fields, the tangent space, surfaces, vector fields on surfaces, orientation.

Chapters 1 - 5

**MODULE 2: GEODESICS (20 hours)**

The Gauss map, geodesics, Parallel transport.

Chapters 6, 7 & 8

**MODULE 3: WEINGARTEN MAP (25 hours)**

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

Chapters 9, 10 & 11

**MODULE 4: PARAMETERIZED SURFACES (30 hours)**

Curvature of surfaces, Parametrized surfaces, local equivalence of surfaces and Parametrized surfaces.

Chapters 12, 14 & 15

**REFERENCES**

1. SERGE LANG, DIFFERENTIAL MANIFOLDS, SPRINGER, 2ND ED. 1985.
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. MANFREDO P. DO CARMO, DIFFERENTIAL GEOMETRY OF CURVES AND SURFACES, PEARSON; 1st EDITION (FEBRUARY 11, 1976.
5. A COURSE IN MATHEMATICAL ANALYSIS, BY EDOUARD GOURSAT TRANSLATED BY EARLE RAYMOND HEDRICK, VOL 1(LAST TWO CHAPTERS), UNIVERSITY OF MICHIGAN LI, 1904.

# BMMM315: GRAPH THEORY

**Total Hours: 90**
**Credit: 4**

**COURSE OBJECTIVES**

- Learn Graph Theory which has been witnessing an unprecedented growth due to its applications in various other disciplines.
- To provide a good background in some of the core topics in Graph Theory

**COURSE OUTCOME**

- As student of Mathematics, experience Graph theory both for its own sake and to enhance the application of Mathematics as a whole and if possible further to explore the subject.

**TEXT BOOK**

R BALAKRISHNAN AND K RANGANATHAN: A TEXTBOOK OF GRAPH THEORY, SECOND EDITION, SPRINGER, 2000.

**Quick Review:** Graph, Degrees of vertices, Paths and connectedness, Vertex cuts and edge cuts, Connectivity and edge connectivity, Trees - characterization and simple properties.
**(4 hours)**

**MODULE 1: INDEPENDENT SETS AND MATCHINGS, EULERIAN AND HAMILTONIAN GRAPHS (24 hours)**

Introduction, Vertex-independent sets and vertex coverings, Edge-independent sets, Matchings and factors, Matchings in bipartite graphs, Eulerian graphs, Hamiltonian graphs.
Chapter 5 Sections 5.1 - 5.5, Chapter 6 Sections 6.1 - 6.3

**MODULE 2: GRAPH COLOURINGS (22 hours)**

Vertex colourings, Critical graphs, Brooks' theorem, Edge colourings of graphs, Vizing's theorem.
Chapter 7, Sections 7.2.1, 7.3, 7.3.1, 7.6.1, 7.6.2

**MODULE 3: PLANARITY (20 hours)**

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 the Heawood Five - colour theorem, Kuratowski's theorem, Hamiltonian plane graphs.

Chapter 8, Sections 8.1 - 8.8 (Theorems 8.7.4 and 8.7.5 - statements only)

**MODULE 4: DOMINATION IN GRAPHS (20 hours)**

Introduction, Domination in graphs, Bounds for the domination number, Bound for the size m in terms of order n and domination number $\gamma(G)$, Independent domination and Irredundance.

Chapter 10, Sections 10.1 - 10.6

**REFERENCES**


1. FRANK HARARY, GRAPH THEORY, ADDISON-WESLEY PUBLISHING COMPANY, INC 1969.
2. TERESA W HAYNES, STEPHEN HEDETNIEMI, PETER SLATER, FUNDAMENTALS OF DOMINATION IN GRAPHS, CRC PRESS, 1998.

# SEMESTER IV

# ELECTIVE COURSES

## BMMM4E01: FINITE MODEL THEORY

**Total Hours: 90**

**Credit: 3**

**COURSE OBJECTIVES**

- Introduction to an area of mathematical logic that grew out of computer science applications.
- Study of logic on finite structures
- Provides a conceptual and methodological framework for exploring the connections between logic and several key areas of computer science.
- Discuss first order logic and introduce second order logic.

**COURSE OUTCOMES**

- Able to study the behavior of logics on finite structures.
- Develop skills in answering many questions about complexity theory, databases, formal languages, etc.

**TEXT BOOK:**

LEONID LIBKIN: ELEMENTS OF FINITE MODEL THEORY, SPRINGER, 2012

**MODULE 1: INTRODUCTION (25 hours)**

Background from Mathematical logic, Background from Automata and computability Theory, Background from Complexity Theory, First inexpressibility Proofs, Definition and examples of Ehrenfeucht-Fraisse Games, Games and expressive power of FO, Rank-k types, Proof of Ehrenfeucht-Fraisse Theorem, More Inexpressibility Results.

Chapter 2, 3

**MODULE 2: LOCALITY OF FIRST ORDER LOGIC (20 hours)**

Neighborhoods, Hanf-locality and Gaifman-locality, Combinatorics of Neighborhoods, Locality of FO, structures of Small degree, Locality of FO Revisited.

Chapters 4

**MODULE 3: ORDER INVARIANT FO (20 hours)**

Invariant Queries, The power of Order-Invariant FO, Locality of Order-Invariant FO.

Chapters 5

**MODULE 4: FO QUERIES AND SECOND ORDER LOGIC (25 hours)**

Data, Expression, and combined Complexity, Circuits and FO Queries, Expressive power with Arbitrary Predicates, Uniformity and AC0, Combined Complexity of FO, Parametric Complexity and Locality, Conjunctive Queries, Second-Order Logic and it Fragments, MSO Games and Types, Existential and Universal MSO on Graphs.

Chapter 6

Chapter 7, 7.1-7.3

**REFERENCES**


1. PHOKION G KOLAITIS, ON THE EXPRESSIVE POWER OF LOGICS ON FINITE MODELS, FINITE MODEL THEORY AND ITS APPLICATIONS (PP 27-123), SPRINGER, 2003.
2. HEINZ-DIETER EBBINGHAUS, JORG FLUM, FINITE MODEL THEORY, SPRINGER 1995.

# BMMM4E02: COMMUTATIVE ALGEBRA

**Total Hours: 90**

**Credit: 3**

**COURSE OBJECTIVE**

The course develops the theory of commutative rings mainly

- To study ideals in commutative rings, chain conditions for ideals and localization of commutative rings.
- Discuss important results concerning noetherian rings and Hilbert basis theorem, Nullstellensatz, Noether normalization, and primary decomposition of ideals.

**COURSE OUTCOME**

- Knows basic definitions concerning elements in rings, classes of rings, and ideals in commutative rings.
- Know constructions like tensor product and localization, and the basic theory for this.
- Know basic theory for noetherian rings and Hilbert basis theorem.
- Know dimension theory of local rings.

**TEXT BOOK**

GREGOR KEMPER: A COURSE IN COMMUTATIVE ALGEBRA, SPRINGER, 2010.

**MODULE 1: HILBERT'S NULLSTELLENSATZ (25 hours)**

Maximal Ideals, Jacobson Rings, Coordinate Rings

Chapter 1

**MODULE 2: NOETHERIAN AND ARTINIAN RINGS (25 hours)**

The Noether and Artin properties for rings and modules, Noetherian rings and modules, The Zariski Topology, Affine varieties and spectra, Noetherian and Irreducible spaces

Chapter 2

Chapter 3

**MODULE 3: KRULL DIMENSION AND TRANSCENDENCE DEGREE (20 hours)**

Definition and Examples, Dimension of algebras and polynomial ring, 0-dimensional affine algebras and sets, dimension of a product variety

Chapters 5

**MODULE 4: LOCALIZATION (20 hours)**

Properties of localization, Spectrum and dimension of a localized ring, Height of a prime ideal.

Chapter 6

**REFERENCES**


1. M ATIYAH AND I G MACDONALD, INTRODUCTION TO COMMUTATIVE ALGEBRA, ADDISON WESLEY, 1994.
2. MILES RIED, UNDERGRADUATE COMMUTATIVE ALGEBRA, CAMBRIDGE UNIVERSITY PRESS, 1995.
3. ZARISKI AND SAMUEL, COMMUTATIVE ALGEBRA VOL II, D VAN NOSTRAND COMPANY, 1975 & I.

## BMMM4E03: SPECTRAL THEORY

**Total Hours: 90**

**Credit: 3**

**COURSE OBJECTIVE**

- Teach the students the theory of operators and their spectrum.
- Introduce compact linear operators on normed spaces.
- Study the spectral properties of bounded self adjoint linear operators.

**COURSE OUTCOMES**

Students will have the knowledge and skills to

- Explain the fundamental concepts of spectral theory and their role in modern mathematics.
- Demonstrate accurate and efficient use of functional analysis techniques.
- Apply problem-solving using functional analysis techniques.

**TEXT BOOK:**

ERWIN KREYSZIG: INTRODUCTORY FUNCTIONAL ANALYSIS WITH APPLICATIONS, JOHN WILEY AND SONS, NEW YORK, 1989.

**MODULE 1: FUNDAMENTAL THEOREMS FOR NORMED AND BANACH SPACES (25 hours)**

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

**MODULE 2: SPECTRAL THEORY OF LINEAR OPERATORS IN NORMED SPACES (25 hours)**

Spectral theory infinite 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 - 7.7

**MODULE 3: COMPACT LINEAR OPERATORS ON NORMED SPACES AND THEIR SPECTRUM (20 hours)**

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 - 8.4

Chapter 10 Sections 10.1 & 10.2

**MODULE 4: SPECTRAL THEORY OF BOUNDED SELF-ADJOINT OPERATORS (20 hours)**

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

**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 WALTER RUDIN, FUNCTIONAL ANALYSIS, TMH EDITION, 1974.

# BMMM4E04: LIE ALGEBRA

**Total Hours: 90**

**Credit: 3**

**COURSE OBJECTIVE**

- To introduce students to some more sophisticated concepts and results of Lie theory as an essential part of general mathematical culture and as a basis for further study of more advanced mathematics.
- To provide an introduction to Lie groups, Lie algebras and their representations.
- It focuses on matrix Lie groups, representations of semi simple Lie groups and Lie algebras.

**COURSE OUTCOMES**

- Define the killing form of a finite dimensional Lie algebra.
- Define what is meant by a nilpotent and solvable Lie algebra and provide examples of nilpotent and non-solvable Lie algebras.
- Get acquainted with more advanced areas of mathematics.

**TEXT BOOK:**

JAMES E. HUMPHREYS, INTRODUCTION TO LIE ALGEBRAS AND REPRESENTATION THEORY, SPRINGER, 1994.

**MODULE 1: BASIC CONCEPTS (25 hours)**

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

Chapter 1 - Sections 1, 2 & 3

**MODULE 2: SEMI SIMPLE LIE ALGEBRAS (20 hours)**

Theorems of Lie and Cartan, Killing form, complete reducibility of representations

Chapter 2 - Sections 4, 5, & 6

**MODULE 3: ROOT SYSTEMS (25 hours)**

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

Chapter 3 Sections 9, 10 & 11

**MODULE 4: ISOMORPHISM AND CONJUGACY THEOREMS (20 hours)**

Isomorphism theorem, Cartan Algebras, Conjugacy theorems.

Chapter 4 - Sections 14, 15, & 16 -16.1 to 16.3

**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 INTER SCIENCE, 1962.
3. H. SAMUELSON, NOTES ON LIE ALGEBRAS, VAN NOSTRAND REINHOLD MATHEMATICAL STUDIES NO. 23, NEW YORK: VAN NOSTRAND REINHOLD, 1969.

## BMMM4E05: CODING THEORY

**Total Hours: 90**

**Credit: 3**

**COURSE OBJECTIVES**

- To introduce students to a subject of convincing practical relevance that relies heavily on results and techniques from Pure Mathematics.
- To study the techniques which permit the detection of errors and which, if necessary, provide methods to reconstruct the original message. The subject involves some elegant linear and abstract algebra.
- To introduce the linear block codes namely Hamming codes, Reed Muller codes, Golay codes, BCH codes etc.

**COURSE OUTCOMES**

- Able to state and prove fundamental theorems about error-correcting codes given in the course.
- Able to calculate the parameters of given codes and their dual codes using standard matrix and polynomial operations.
- Able to encode and decode information by applying algorithms associated with well-known codes.
- Can design simple linear or cyclic codes with required properties.

**TEXT BOOK:**

VERA PLESS: INTRODUCTION TO THE THEORY OF ERROR CORRECTING CODES, WILEY INTER SCIENCE, 3RD EDITION, 1998.

**MODULE 1: INTRODUCTION TO CODING THEORY-(25 hours)**

Introduction, Basic Definitions, Weight, Minimum weight and Maximum Likelihood decoding, Syndrome decoding, Perfect Codes, Hamming codes, Sphere packing bound, Packing radius, Covering Radius, MDS Code And Some Bounds.

Chapter 1 & Chapter 2 - Sections 2.1, 2.2, 2.3

**MODULE 2: SELF DUAL CODES AND POLYNOMIALS (20 hours)**

Self dual codes, The Golay codes, The problem, polynomials, a finite field of 16 elements, double error correction BCH code.

Chapter 2 - Section 2.4 & Chapter 3

**MODULE 3: FINITE FIELDS (20 hours)**

Finite fields: Groups, structure of a finite field, minimal polynomials, factoring $x^n - 1$

Chapter 4

**MODULE 4: CYCLIC CODES (25 hours)**

Cyclic Codes: Origin and definition of cyclic codes, How to find cyclic codes: the generator polynomial, Generator polynomial of the dual code, Idempotent and minimal ideals for binary cyclic code.

B C H codes: Cyclic codes in terms of roots, Vandermonde determinants, Definition and properties of BCH codes, Reed Solomon codes, More on minimum distance.

Chapter 5 & Chapter 7 –Sections 7.1 to 7.5

**REFERENCES**


1. R-LIDI, G. PLIZ, APPLIED ABSTRACT ALGEBRA, SPRINGER VERLAG, 1997.
2. J.H.VAN LINT, INTRODUCTION TO CODING THEORY, SPRINGER VERLAG, 1998.
3. R.E.BLAHUT, ERROR- CONTROL CODES, ADDISON WESLEY, 1983.

# BMMM4E06: ANALYTIC NUMBER THEORY

**Total Hours: 90**

**Credit: 3**

**COURSE OBJECTIVE**

- To introduce the theory of prime numbers, showing how the irregularities in this elusive sequence can be tamed by the power of complex analysis.
- To understand the the Prime Number Theorem which is the corner-stone of prime number theory, and culminates in a description of the Riemann Hypothesis.
- Learn to handle multiplicative functions, to deal with Dirichlet series as functions of a complex variable, and to prove the Prime Number Theorem and simple variants.

**COURSE OUTCOMES**

Students will demonstrate

- knowledge of the basic definitions and theorems in number theory
- the ability to apply number theory algorithms and procedures to basic problems
- the ability to think and reason about abstract mathematics
- skills at writing mathematical proofs

**TEXT BOOK:**

TOM M APOSTOL: INTRODUCTION TO ANALYTIC NUMBER THEORY, SPRINGER INTERNATIONAL STUDENT EDITION, NAROSA PUBLISHING HOUSE, 1998.

**MODULE 1: ARITHMETIC FUNCTIONS DIRICHLET MULTIPLICATION AND AVERAGES OF ARITHMETICAL FUNCTIONS (30 hours)**

Introduction to Chapter 1 of the text, the Mobius function $\mu(n)$ the Euler totient function j(n), a relation connecting $\mu(n)$ and j(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 Liovillies 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 Chapter 2 of the text, the big oh notation, asymptotic equality of functions, Eulers 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 $\mu$ (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 - 2.17

Chapter 3 - Sections 3.1 - 3.11)

**MODULE 2: SOME ELEMENTARY THEOREMS ON THE DISTRIBUTION OF PRIME NUMBERS (15 hours)**

Introduction to Chapter 4, Chebyshevs functions and, relation connecting , some equivalent forms of prime number theorem, inequalities of and Shapiros Tauberian theorem, applications of Shapiros theorem, an asymptotic formula for the partial sum.

Chapter 4 - Sections 4.1 - 4.8

**MODULE 3: CONGRUENCES (30 hours)**

Definition and basic properties of congruences, residue classes and complete residue systems, liner congruences , reduced residue systems and Euler Fermat theorem, Polynomial congruences modulo , Lagranges theorem, applications of Lagranges theorem, simultaneous linear congruences, the Chinese remainder theorem, applications of Chinese remainder theorem, polynomial congruences with prime power moduli .

Chapter 5 - Sections 5.1 - 5.9

**MODULE 4: PRIMITIVE ROOTS AND PARTITIONS (15 hours)**

The exponent of a number mod m. Primitive roots, Primitive roots and reduced systems, The non existence of Primitive roots mod 2 for 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, Eulers pentagonal- number theorem.

Chapter 10 - Sections 10.1 - 10.5

Chapter 14 - Sections 14.1 - 14.4

**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, G T M VOL. 7, SPRINGER-VERLAG, 1973.

## BMMM4E07: THEORY OF WAVELETS

**Total Hours: 90**

**Credit: 3**

**COURSE OBJECTIVES**

- Introduce a developing area of mathematics, it originated in 1980s..
- Is an applied paper, sharing the boundary of Mathematics and Engineering.
- Very use full in Image compression, numerical solutions of deferential equation, data communication etc.
- It also help the students to apply their knowledge in linear algebra, Fourier Transform, Measure Theory and Functional Analysis.

**COURSE OUTCOMES**

- Get the basics of wavelet theory of finite dimensional and infinite dimensional context.
- Compare Fourier Transform and Wavelets Theory.
- Know some examples for wavelets.
- Cover elementary properties of $l^2(Z)$ and $L^2[-\pi, \pi]$
- Better understanding in Functional Analysis, Measure theory and Linear Algebra.

**TEXT BOOK**

MICHAEL W. FRAZIER: AN INTRODUCTION TO WAVELETS THROUGH LINEAR ALGEBRA, SPRINGER- VERLAG, 2000.

Prerequisites:-Linear Algebra, Discrete Fourier Transforms, Elementary Hilbert Space theorem. (No questions shall be asked from these sections.)

**MODULE 1: INTRODUCTION TO WAVELETS-(20 hours)**

Construction of Wavelets on $Z_N$ : The First Stage.

Chapter 3- Section 3.1

**MODULE 2: CONSTRUCTION OF WAVELETS-(20 hours)**

Construction of Wavelets on $Z_N$ : The Iteration Step, Examples Haar, Shannon and Daubechies

Chapter 3 - Sections 3.2 & 3.3

**MODULE 3: ORTHONORMAL SETS (20 hours)**

$l^2(Z)$, Complete Orthonormal sets in Hilbert Spaces, $L^2[-\pi, \pi]$ and Fourier Series

Chapter 4 Section 4.1, 4.2 & 4.3

**MODULE: WAVELETS ON Z (30 hours)**

The Fourier Transform and Convolution on $l^2(Z)$, First-stage Wavelets on Z, The Iteration step for Wavelets on Z, Examples- Haar and Daubechies.

Chapter 4 - Sections 4.4, 4.5, 4.6 & 4.7

**REFERENCES**


1. MAYER, WAVELETS AND OPERATORS, CAMBRIDGE UNIVERSITY PRESS, 1993.
2. CHUI, AN INTRODUCTION TO WAVELETS, ACADEMIC PRESS, BOSTON, 1992

# BMMM4E08: ALGEBRAIC TOPOLOGY

**Total Hours: 90**

**Credit: 3**

**COURSE OBJECTIVES**

- Covers simplicial homology theory, the fundamental group and covering spaces.
- Emphasizes the geometric approach to algebraic topology.

**COURSE OUTCOMES**

The students learnt:

- techniques to compute the fundamental group of topological spaces, and the proof that it is a topological invariant.
- acquired an understanding of covering spaces and the correspondence with subgroups of the fundamental group.
- learnt how to compute simplicial homology groups of a simplicial complex.

**TEXT BOOK:**

FRED H. CROOM: BASIC CONCEPTS OF ALGEBRAIC TOPOLOGY (SPRINGER VERLAG) NEW YORK. HEIDELBERG, 1978.

**MODULE 1: HOMOLOGY (20 hours)**

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-Pseudo manifolds and the Homology groups of Sn .

Chapter 1 & Chapter 2

**MODULE 2: APPROXIMATIONS (25 hours)**

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

Chapter 3

**MODULE 3: FUNDAMENTAL GROUPS (20 hours)**

The Fundamental group-The covering homotopy property for SI -Examples of fundamental groups-the relation between H1 (K) and π1(|K|).

Chapter 4

**MODULE 4: COVERING SPACES (25 hours)**

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

Chapter 5

**REFERENCES**


1. 1. B. K. LAHIRI, A FIRST COURSE IN ALGEBRAIC TOPOLOGY (SECOND EDITION)-NAROSA PUBLICATIONS, 2005.
2. GLEN E. BREDON, TOPOLOGY AND GEOMETRY (SPRINGER), 1997.
3. JOSEPH J. ROTMAN, AN INTRODUCTION TO ALGEBRAIC TOPOLOGY (SPRINGER), 1998.

# BMMM4E09: FRACTAL GEOMETRY

**Total Hours: 90**

**Credit: 3**

**COURSE OBJECTIVE**

- To know about general theory of fractals and their geometry.
- To introduce various notions of dimension and methods of their calculation.
- To investigate geometrical properties of fractals.

**COURSE OUTCOMES**

- Able to understand the local form of fractals and projections and intersections of fractals.

**TEXT BOOK:**

KENNETH FALCONER: FRACTAL GEOMETRY MATHEMATICAL FOUNDATIONS AND APPLICATIONS, JOHN WILEY & SONS, NEW YORK, 1990.

Prerequisites 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 (30 hours)**

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, Chapter 3 - Sections 3.1 - 3.4

**MODULE 2: TECHNIQUES FOR CALCULATING DIMENSIONS (25 hours)**

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 & Chapter 5

**MODULE 3: PROJECTIONS OF FRACTALS (18 hours)**

Projections of arbitrary sets, Projections of s-sets of integral dimension, Products of fractals Product formulae.

Chapter 6 & Chapter 7

**MODULE 4: INTERSECTIONS OF FRACTALS (12 hours)**

Intersection formula for fractals, Sets with large intersection.

Chapter 8

**REFERENCES**


1. FALCONER K.J, THE GEOMETRY OF FRACTAL SETS, CAMBRIDGE UNIVERSITY PRESS, CAMBRIDGE, 1986.
2. BARNSLEY M.F, (1988), FRACTALS EVERYWHERE, 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. TAMASVICSEK, FRACTAL GROWTH PHENOMENA, SECOND EDITION, WORLD SCIENTI C, 1992.

## BMMM4E10: CALCULUS OF VARIATIONS AND INTEGRAL EQUATIONS

**Total Hours: 90**

**Credit: 3**

**COURSE OBJECTIVE**

- Introduce the ideas and techniques of calculus of variations.
- Discuss the Brachistrochrone problem, problem of geodesics, the problem of minimal surface of revolution, isoperimetric problems
- Develop the mathematical models of some real life problems.
- Be thorough with different types of integral equations.

**COURSE OUTCOME**

- Have a deep overview on Calculus of variation and its application in Mathematics and Physics.
- Methods to determine the extremals of different types of functional.
- Able to solve different types of integral equations.

**TEXT BOOKS:**

1. RAM P KANWAL: LINEAR INTEGRAL EQUATIONS, THEORY AND TECHNIQUES, ACADEMIC PRESS NEW YORK, 1996.
2. A.S GUPTA: CALCULUS OF VARIATIONS WITH APPLICATIONS, PHI, NEW DELHI, 2005.

**MODULE 1: INTEGRAL EQUATIONS (20 hours)**

Introduction, Regularity conditions, special types of Kernels, Eigenvalues and Eigenfunctions, Convolution Integral, The Inner or Scalar Product of Two Functions, Reduction to a System of Algebraic Equations, Fredholm Alternative, An Approximate Method, Fredholm Integral Equation of the First Kind.

Chapter 1 & Chapter 2

**MODULE 2: APPLICATIONS OF INTEGRAL EQUATIONS (25 hours)**

Volterra Integral Equations, Fredholm method of solution, Fredholms First Theorem (proof excluded), Application to ordinary differential equations-Initial value problems and boundary value problems, Symmetric Kernels- Fundamental properties, Hilbert-Schmidts theorem.Solution of symmetric integral equations.

Chapter 3-Sections 3.1 - 3.4, Chapter 4 -sections 4.1 - 4.3 Chapter 5- Sections 5.1 - 5.3 and Chapter 7-Sections 7.2,7.4,7.5,7.6 of text 1

**MODULE 3: CALCULUS OF VARIATIONS (20 hours)**

The concept of Variation and its properties- Euler's equations, Variational problems for functional dependent on higher order derivatives, Functions of several independent variables, some applications to problems of mechanics.

Chapter 1 Sections 1.1 -1.7 of Text 2

**MODULE 4: VARIATIONAL PROBLEMS WITH MOVING BOUNDARIES (25 hours)**

Movable Boundary for a functional dependent on two functions, one sided variations, Reflection and Refraction of extremals.

Chapter 2- Sections 2.1 -2.4 of Text 2

**REFERENCES**


1. F G TRICOMI, INTEGRAL EQUATIONS, INTERSCIENCE, NEW YORK, 1985.
2. L.G CHAMBERS, INTEGRAL EQUATIONS, INTERNATIONAL TEXTBOOK COMPANY LTD. LONDON, 1978.
3. M.D RAISINGHANIA, INTEGRAL EQUATIONS AND BOUNDARY VALUE PROBLEMS, S CHAND AND SONS, NEW YORK, 2010.
4. I. M GELFAND AND S.V FOMIN, CALCULUS OF VARIATIONS, PHI, 2000.
5. ELSGOLC L E, CALCULUS OF VARIATIONS, PERGAMON PRESS LTD, 2007.
6. WEINSTOCK ROBERT, CALCULUS OF VARIATIONS WITH APPLICATIONS TO PHYSICS AND ENGINEERING, DOVER 1974.

## BMMM4E11: COMPUTING FOR MATHEMATICS

**Total Hours: 90**

**Credit: 3**

**COURSE OBJECTIVES**

- Introduction to python programming.
- Explore the power and efficiency of python
- Computation techniques using python for Differential equation and Discrete Mathematics
- Introduce the mathematics typesetting language LaTeX.

**COURSE OUTCOMES**

- Achieve strong foundations for computer-aided problem solving applicable in their later studies.
- Be aware of the variety of computing using python.
- Make documents using LaTeX

**TEXT BOOKS**

1. ROBERT JOHANSSON: NUMERICAL PYTHON, APRESS, 2015
2. IAN. SNEDDON: ELEMENTS OF PDE'S, MCGRAW HILL BOOK COMPANY INC. 2009.
3. C. L. LIU: ELEMENTS OF DISCRETE MATHEMATICS, TATA MCGRAW-HILL, 2000.
4. LESLIE LAMPORT: LATEX: A DOCUMENT PREPARATION SYSTEM, 2ND EDITION, ADDISON-WESLEY, 1994.

**MODULE 1: INTRODUCTION TO PYTHON PROGRAMMING (25 hours)**

Python commands: Comments, Number and other data types, Expressions, Operators, Variables and assignments, Decisions, Loops, Lists, Strings - plotting using "matplotlib" - Basic operations , Simplification, Calculus, Solvers and Matrices using Sympy

**MODULE 2: DIFFERENTIAL EQUATIONS USING PYTHON (25 hours)**

Solving ODE's using Python - Libraries for Differential equations in Python, PDE's using sympy user functions pde_seperate(), pde_seperate_add(). pde_seperate_mul(), pdsolve(), classify_pde(), checkpdesol() , pde_1st_linear_constant_coeff_homogeneous, pde_1st_linear_constant_coeff, pde_1st_linear_variable_coeff.

**MODULE 3: DISCRETE MATHEMATICS USING PYTHON (20 hours)**

Creating and visualizing Graphs, Digraphs, MultiGraphs and MultiDiGraph - Python methods for reporting nodes, edges and neighbours of the given graph / digraph - Python methods for counting nodes, edges and neighbours of the given graph / digraph.

**MODULE 4: LATEX (20 hours)**

Introduction to LaTeX: Getting started-Preparing an input le-The input Changing the type style-Symbols from other languages -Mathematical formulas Defining commands and environments. Other document classes-Books-Slides-Letter.

Chapter 2, Chapter 3 & Chapter 5 of Text 2

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.

**REFERENCES**


1. L DEBNATH, NONLINEAR PDE'S FOR SCIENTISTS AND ENGINEERS, BIRKHAUSER, BOSTON, 2008.
2. F. MITTELBACH, M. GOOSSENS, THE LATEX COMPANION: 2ND EDITION, ET. AL. 2004.

# BMMM4E12: MATLAB PROGRAMMING FOR NUMERICAL COMPUTATION

**Total Hours: 90**

**Credit:3**

**COURSE OBJECTIVES**

- Introduce computational techniques using MATLAB.
- Course lectures, practice problems and assignments will be given using MATLAB.

**COURSE OUTCOMES**

- Learn basics of MATLAB programming.
- Will be able to use MATLAB to solve computational problems.

**TEXTBOOK:**

FAUSETT L.V: APPLIED NUMERICAL ANALYSIS USING MATLAB, 2ND ED., PEARSON EDUCATION, 2007.

**MODULE 1: INTRODUCTION TO MATLAB PROGRAMMING, APPROXIMATIONS AND ERRORS (25 hours)**

Basics of MATLAB programming, Array operations in MATLAB, Loops and execution control, Working with files: Scripts and Functions, Plotting and program output.

Taylor's / Maclaurin series expansion of some functions will be used to introduce approximations and errors in computational methods. Defining errors and precision in numerical methods, Truncation and round-off errors, Error propagation, Global and local truncation errors.

**MODULE 2: NUMERICAL DIFFERENTIATION AND INTEGRATION (20 hours)**

Methods of numerical differentiation and integration, trade-off between truncation and round-off errors, error propagation and MATLAB functions for integration will be discussed.

Numerical Differentiation in single variable, Numerical differentiation: Higher derivatives, Differentiation in multiple variables, Newton-Cotes integration formulae, Multi-step application of Trapezoidal rule, MATLAB functions for integration.

**MODULE 3: LINEAR AND NONLINEAR EQUATIONS (20 hours)**

The focus of this module is to do a quick introduction of most popular numerical methods in linear algebra, and use of MATLAB to solve practical problems.

Linear algebra in MATLAB Gauss Elimination, LU decomposition and partial pivoting, Iterative methods: Gauss Siedel, Special Matrices: Tri-diagonal matrix algorithm

After introduction to bisection rule, this module primarily covers Newton-Raphson method and MATLAB routines fzero and fsolve. Nonlinear equations in single variable, MATLAB function fzero in single variable, Fixed-point iteration in single variable, Newton-Raphson in single variable, MATLAB function fsolve in single and multiple variable, Newton-Raphson in multiple variables

**MODULE 4: ORDINARY DIFFERENTIAL EQUATIONS (ODE) (25 hours)**

Explicit ODE solving techniques in single variable and in multiple variables will be covered in this module.

Introduction to ODEs; Implicit and explicit Euler's method, Second-Order Runge-Kutta Methods, MATLAB ode45 algorithm in single variable, Higher order Runge-Kutta methods, Error analysis of Runge-Kutta method, MATLAB ode45 algorithm in multiple variables, Stiff ODEs and MATLAB ode15s algorithm, Practical example for ODE-IVP, Solving transient PDE using Method of Lines

**REFERENCE BOOK:**


1. CHAPRA S.C. AND CANALE R.P. (2006) NUMERICAL METHODS FOR ENGINEERS, 5TH ED., MCGRAW HILL

## BMMM4E13: REPRESENTATION THEORY

**Total Hours: 90**

**Credit:3**

**COURSE OBJECTIVES**

- To give students a concrete introduction to group theory through their representations.
- To study symmetry by means of linear algebra: it is studied in a way in which a given group or algebra may act on vector spaces, giving rise to the notion of a representation.
- Learn to apply the developed material to group algebras, and classify when group algebras are semisimple.

**COURSE OUTCOME**

- Understand the basics of representation theory of finite groups.
- Have enough knowledge about basic tools of representation theory
- Able to use these tools to determine representations of "Good Enough" groups
- Know pros and cons of these tools and apply suitably

**TEXT BOOK:**

G JAMES AND M LIEBECK: REPRESENTATION AND CHARACTERS OF GROUPS, 2ND ED., CAMBRIDGE UNIVERSITY PRESS, 2001.

**MODULE 1: GROUP REPRESENTATIONS (20 hours)**

Group representations, FG-Modules, FG-submodules and Reducibility.

Chapters 3 - 5

**MODULE 2: GROUP ALGEBRA (20 hours)**

Group Algebras, FG-homomorphisms, Maschke's Theorem.

Chapters 6 - 8

**MODULE 3: MORE ON THE GROUP ALGEBRA (25 hours)**

Schur's Lemma, Irreducible modules and the group algebras, More on the group algebra.

Chapters 9 - 11

**MODULE 4: CONJUGACY CLASSES (25 hours)**

Conjugacy Classes, Characters.

Chapters 12 & chapter 13

## REFERENCES

1. WILLIAM FULTON AND JOE HARRIS, REPRESENTATION THEORY A FIRST COURSE, SPRINGER, 1999.
2. B. STEINBERG. REPRESENTATION THEORY OF FINITE GROUPS, SPRINGER, 2011.

# BMMM4E14: THEORY OF MANIFOLDS

**Total Hours: 90**

**Credit: 3**

**COURSE OBJECTIVES**

- Introduction to the theory of manifolds.
- Learn how to integrate on manifolds.

**COURSE OUTCOME**

- Know why we care about defining manifolds and what we expect to do with them.
- Give examples of manifolds.
- Understand how to construct diffeomorphisms using vector fields.
- Understand geometry of manifolds
- Know how differential calculus can help with distinguishing different objects (through De Rham cohomology).

**TEXT BOOK**

ANANT R SHASTRI: ELEMENTS OF DIFFERENTIAL TOPOLOGY, CRC PRESS, 2011.

**MODULE 1: REVIEW OF DIFFERENTIAL CALCULUS (25 hours)**

Vector Valued Functions, Directional Derivatives and Total Derivative, Linearity of the Derivative, Inverse and Implicit Function Theorems, Lagrange Multiplier Method, Differentiability on Subsets of Euclidean Spaces, Richness of Smooth Maps. Submanifolds of Euclidean Spaces, Basic Notions, Manifolds with Boundary, Tangent Space, Special Types of Smooth Maps, Transversality, Homotopy and Stability.

(Chapters 1 and 3 of the Text)

**MODULE 2: INTEGRATION ON MANIFOLDS (20 hours)**

Orientation on Manifolds, Differential Forms on Manifolds, Integration on Manifolds, De Rham Cohomology.

(Chapter 4 of the Text)

**MODULE 3: ABSTRACT MANIFOLDS (20 hours)**

Topological Manifolds, Abstract Differential Manifolds, Gluing Lemma, Classification of 1-dimensional Manifolds, Tangent

Space and Tangent Bundle, Tangents as Operators

(Chapter 5 Sections 5.1 to 5.6 of the text)

**MODULE 4: ISOTOPY (25 hours)**

Normal Bundle and Tubular Neighbourhoods, Orientation on Normal Bundle, Vector Fields and Isotopies, Patching-up Diffeomorphisms. Geometry of Manifolds - Morse Functions, Morse Lemma, Operations on Manifolds, Further Geometry of Morse Functions.

(Chapter 6 and 8 of the text)

**REFERENCES**


1. JOHN M LEE: INTRODUCTION TO TOPOLOGICAL MANIFOLDS, SPRINGER, 2010.
2. L W TU: AN INTRODUCTION TO MANIFOLDS (SECOND EDITION), SPRINGER, 2010.
3. R L WILDER: TOPOLOGY OF MANIFOLDS, AMS, 1949.

# BMMM4E15: PROBABILITY THEORY

**Total Hours: 90**
**Credit: 3**

**COURSE OBJECTIVES**

- It deals with the fundamental basis for many other areas in the mathematical sciences including statistics, modern optimization methods and risk modelling.
- It provides an introduction to probability theory, random variables and Markov processes. It deals with modelling uncertainty.

**COURSE OUTCOME**

- Students will be able to understand advanced probability models
- Able to analyse and develop such models.

**TEXT BOOKS:**


1. S. C. GUPTA AND V.K. KAPOOR, FUNDAMENTALS OF MATHEMATICAL STATISTICS, 11TH ED., SULTAN CHAND & SONS, 2011.
2. V.K. ROHATAGI, AN INTRODUCTION TO PROBABILITY THEORY AND MATHEMATICAL STATISTICS, 2ND ED. WILEY EASTERN LTD, 1986.
3. T.W. ANDERSON, AN INTRODUCTION TO MULTIVARIATE STATISTICAL ANALYSIS, 3RD ED., WILEY INTERSCIENCE, 2003
4. D.D. JOSHI, LINEAR ESTIMATION AND DESIGN OF EXPERIMENTS, WILEY EASTERN LTD., 1990.


**MODULE 1: DISTRIBUTION FUNCTION (25 hours)**

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 (Khintchines Weak Law, Kolmogrov Strong Law, Bernoulli Strong Law) Central limit theorem (Lindeberg _ Levy theorem).

**MODULE 2: STANDARD DISCRETE AND CONTINUOUS UNIVARIATE DISTRIBUTIONS (20 hours)**

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

**MODULE 3: THEORY OF ESTIMATION- (20 hours)**

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 for hypothesis: most powerful and uniformly most powerful tests (Neyman Pearson Lemma) 45

**MODULE 4: MARKOV MODEL- (25 hours)**

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. C.R. RAO, LINEAR STATISTICAL INFERENCE AND ITS APPLICATIONS, JOHN WILEY, NEW YORK, 1965.
2. W.G. COCHRAN AND G.M. COX, EXPERIMENTAL DESIGNS, 2ND ED., JOHN WILEY, NEW YORK, 1957.

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