CENTRAL UNIVERSITY OF SOUTH BIHAR

ORDINANCE AND REGULATIONS GOVERNING

Master of Arts/Science in Mathematics (M.A./M.Sc. in Mathematics)

(Effective from the Academic Session 2018-2019)

Department of Mathematics

School of Mathematics, Statistics and Computer Science

15/12/2018

15/12/2018

15/12/18

15/12/18

15/12/2018

15/12/18

15.12.2018

TABLE OF CONTENTS

ORDINANCE AND REGULATIONS GOVERNING

MASTER OF ARTS/SCIENCE IN MATHEMATICS PROGRAMME OF CENTRAL UNIVERSITY OF SOUTH BIHAR UNDER CHOICE BASED CREDIT SYSTEM

(Effective from Academic Session 2018-19)

Under the powers conferred by The Central Universities Act, 2009- section 28(1) (b)], as amended, Central University of South Bihar, hereby, institutes the four semester Post Graduate Degree Programme for the Award of Master of Arts/Science in Mathematics (M.A./M.Sc. in Mathematics) Degree by the Department of Mathematics under the School of Mathematics, Statistics and Computer Science of the University under the choice based credit system. The following ordinance for governing admission, course of study, examinations and other matters relating to M.A./M.Sc. in Mathematics Degree under Department of Mathematics of the Central University of South Bihar are hereby laid to come in force w.e.f. the Academic Session 2018-19 onwards till further amended.

1. Definitions of Key Words:

1.1 **'Choice-Based Credit System (CBCS)':** The CBCS provides choice for the students to select course from the prescribed courses (Elective or Soft-skill courses). It provides a 'cafeteria' approach in which the students can take courses of their choice, learn at their own pace, study additional courses and acquire more than the minimum required credits, and adopt an inter-disciplinary approach to learning.

1.2 **'Academic Year':** Two consecutive (one odd + one even) semesters shall constitute one academic year.

1.3 **'Course':** Course, usually referred to as paper having specific title and code number, is a component of a Programme. It consists of a list of topics /points /concepts /theories /principles etc. which a student has to learn and master during the Programme of study. Each Course generally shall be of 04 credits. Each course should define the learning objectives/ learning outcomes. A course may be designed to be delivered through lectures/tutorials/laboratory work/field work/outreach activities/project work/vocational training/viva/seminars/ term papers/assignments /presentations / self-study work etc., or a combination of some of these.

1.4 **'Course Teacher':** The course teacher generally will be the teacher who has primarily conceived the course, developed its contents, taken up the responsibility of teaching it and evaluating the performance of the students in that course.

1.5 **'Credit':** A unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work/field work per week.

1.6 **'Credit Point':** It is the product of the grade point and the number of credits for a course.

1.7 **'Grade Point':** It is a numerical weight allotted to each letter grade on a 10-point scale.

1.8 **'Letter Grade':** It is an index of the performance of students in a said course. Grades are denoted by letters O, A+, A, B+, B, C, P and F. A letter grade is assigned to a student on the basis of evaluation of her/his performance in a course on a ten point scale.

1.9 **'Programme':** An educational Programme leading to the award of a Degree, Diploma or Certificate.

1.10 **'Credit-Based Semester System (CBSS)':** Under the CBSS, the requirement for awarding a degree or diploma or certificate is prescribed in terms of number of credits to be completed by the students.

1.11 **'Semester':** Each Semester shall consist of 15-18 weeks of academic work equivalent to 90 actual teaching days. The odd semester may be scheduled from July to December and even semester from January to June. The credit-based semester system provides flexibility in designing curriculum and assigning credits based on the course content and hours of teaching.

1.12 **'Semester Grade- Point Average (SGPA)':** It is a measure of performance of the work done in a semester. It is ratio of total credit points secured by a student in various courses registered in a semester and the total course credits taken during that semester. It shall be expressed up to two decimal places.

1.13 **'Cumulative Grade Point Average (CGPA)':** It is a measure of overall cumulative performance of a student over all semesters. The CGPA is the ratio of total credit points secured by a student in various courses in all semesters and the sum of the total credits of all courses in all the semesters. It shall be expressed up to two decimal places.

1.14 **'Transcript'/ 'Grade Card' 'or Certificate':** Based on the grades earned, a grade certificate shall be issued to all the registered students after every semester. The grade certificate will display the course details (code, title, number of credits, grade and/or marks secured) along with SGPA of that semester.

1.15 **'The University':** 'The University' in this Ordinance means the Central University of South Bihar.

2. Admission and Other General Provisions:

2.1 The Programme of study leading to Master of Arts/Science in Mathematics (M.A./M.Sc. in Mathematics.) Degree of Central University of South Bihar shall be of two year (Four Semesters) duration which may be completed in a maximum duration of four years (Eight Semesters). Admission to the M.A./M.Sc. in Mathematics Programme in Department of Mathematics (School of Mathematics, Statistics and Computer Science) shall be made on merit in the admission test conducted for this purpose.

2.2 The intake to the said PG Programme (M.A./M.Sc. in Mathematics) shall be as notified in the University Admission Prospectus.

2.3 The admission to the (M.A./M.Sc. in Mathematics) Programme shall be governed by the provisions as laid down in the University Admission Prospectus issued each year for admissions to the said Programme of the University.

2.4 After the declaration of the admission test results, the admission to the (M.A./M.Sc. in Mathematics) Programme shall be done by the Admission Committee, constituted as per the University rules.

2.5 Reservation rules as per the Government of India (GOI) and/or adopted by the University shall be applicable in admission to the (M.A./M.Sc. in Mathematics) Degree Programme as follows:

S. No.	Category	Reservation
1	SC Candidates	15 % of the intake
2	ST Candidates	7.5% of the intake
3	OBC Candidates	27% of the intake
4	Divyang Candidates	5% of the intake *(on horizontal reservation basis)*
5	Widows/Wards of Defence Personnel and Kashmiri Migrants	As per the GOI rules

(a) The candidates seeking admission under the above categories must fulfill the minimum eligibility conditions, qualifying requirements and submit requisite documents in support of their claim, as prescribed by the GOI from time to time.

(b) The SC/ ST/OBC candidates must enclose attested copy of the latest caste certificate as per GOI norms along with their Admission Form/Enrolment form stating that the candidate belongs to SC/ST/OBC Category.

The following are empowered to issue SC/ST/OBC Certificates:

(i) District magistrate/ Additional District Magistrate/ Collector/ Deputy Commissioner/ Addl. Deputy Commissioner/Deputy Collector /Ist Class Stipendiary Magistrate/City Magistrate/Sub Divisional magistrate/ Taluka Magistrate/ Executive Magistrate /Extra Assistant Commissioner.

(ii) Chief Presidency Magistrate/ Addl. Chief Presidency Magistrate/ Presidency Magistrate.

(iii) Revenue Officer not below the rank of Tehsildar.

(iv) Sub - Divisional Officer of the area where the candidate and/or his family normally resides.

(v) Administrator/Secretary to the Administrator/ Development Officer (Lakshadweep Islands).

(vi) Candidate must note that certificate from any other person/authority shall not be accepted generally.

(c) 5% seats on horizontal reservation basis shall be reserved for Divyang Candidates (Benchmark Category) and shall be further sub-divided into different categories of Divyangs as per the GOI rules.

A candidate applying under Divyang category must attach a certificate by CMO, District Hospital. However, she/he shall be considered under Divyang category only after verification from the University Medical Board, if any.

(d) Vacant seats reserved for SC/ST/OBC candidates, if any, may be filled up as per the GOI rules. In case in any one of the two categories of candidates viz., SC/ST, the required number of candidates for admission is not available (i.e., the list of respective category has been exhausted), then candidates belonging to the other category (SC or ST as the case may be, if available), shall be called for admission in order of merit so as to make up the deficiency in the required number in any of the aforesaid two categories. This provision shall be applicable to candidates belonging to SC & ST categories only.

(e) If sufficient number of candidates are not available in OBC category (i.e., OBC category list has been exhausted), such vacant seats shall be transferred to the general category.

2.6 Mere appearance in the admission test shall not entitle a candidate to be considered for admission to the Programme unless she/he fulfills the eligibility conditions. Applicants must fully satisfy themselves about their eligibility before filling the application form.

2.7 Provisional admission shall be offered to the candidates in order of merit list and the availability of seat in the Programme on the date of admission.

2.8 In case there is more than one candidate securing equal ranks as obtained by the last candidate in order of merit in the list of candidates to be called for admission, the following *inter-se* ranking rules of the University shall be applicable.

In case the candidates have equal/tie ranks then the marks obtained in the qualifying examination shall be the deciding factor and if, that is also same or result of both the candidates is not declared, then a senior candidate on the basis of date of birth shall be given preference. However, in a case of tie rank, if the result of qualifying examination of one candidate is declared then she/he will be given preference, provided she/he fulfills other eligibility conditions. In case of any dispute the decision of the Chairman, UATEC shall be final.

2.9 If the result of the qualifying examination is not declared by a university/board till the date of admission, the mark-sheet of the qualifying examination by a candidate can be submitted on or before 30th September of the admission year. In exceptional cases, further extension may be given by the Competent Authority on cogent reason(s). However, it may be noted that this clause cannot be extended to the candidate(s) whose result is being withheld or not declared by the university/board due to some specific reasons particularly related to the candidate(s). Furthermore, if the result of qualifying examination is not declared by a university/board in general then the aggregate percentage of marks/grades of the completed semesters/years of the qualifying examination must be not less than the required percentage of marks/grades in the qualifying examination.

2.10 At the time of reporting for admission, the candidates are required to be present in person and bring the documents in original as well as a set of photocopy duly attested as notified by the Admission Committee/Controller of Examinations (CoE) from time to time.

2.11 A candidate provisionally selected for admission shall be required to fill the prescribed form, submit the required documents, collect her/his admit card or any other equivalent document for admission to the Programme from the office of the Department/School/University after paying the fees on or before a date fixed for the purpose, otherwise the offer made to her/him will automatically stand cancelled.

2.12 In case any provisionally selected candidate fails to deposit the fee by the date prescribed, her/his provisional admission shall be cancelled and the seat thus falling vacant shall be offered to the next candidate in order of merit under the specified category.

2.13 Notwithstanding anything contained in this ordinance, a candidate who is qualified under the foregoing ordinance for admission to the University, and who is a student of some other Indian University/Institution, shall not be admitted to the University without the production of a leaving or transfer certificate and/or migration certificate (as the case may be) issued by the last college/university attended and certifying to the satisfactory conduct of the student mentioning the highest examination she/he has passed. However, in certain cases if the candidates are not in position to submit the Transfer Certificate and/or Migration Certificate and the character certificate at the time of admission, they should submit the same as early as possible, but not later than 30th September of the year of admission in M.A./M.Sc. in Mathematics failing which the University reserves the right to cancel their admission. In exceptional cases, further extension may be given by the Competent Authority on cogent reason(s). However, it may be noted that this clause cannot be extended to the candidate(s) whose result is being withheld or not declared by the university/board due to some specific reasons particularly related to the candidate(s).

2.14 Waitlisted candidate shall be offered admissions strictly on the basis of ranking, provided there is a vacancy in the Programme. Such waitlisted candidates shall have to deposit their fees latest by the date fixed by the Admission Committee/ Competent Authority.

2.15 The candidates enjoying employed status and selected for admission to M.A./M.Sc. in Mathematics Programme in the University, are required to produce Leave Sanction /Relieving Order at the time of Admission/Registration from their employer for the duration of the Programme permitting them to pursue their studies at the University, failing which the offer of admission may stand withdrawn. In case of any dispute the decision of the competent authority shall be final.

2.16 The admission of any candidate is liable to be cancelled without giving any further notice forthwith or at any time during the period of the concerned Programme of Study, if it is detected that the candidate has /had produced fake / forged certificate(s) /document(s), indulged in any act of misconduct/indiscipline and has /had concealed any other relevant information at the time of seeking admission.

2.17 The admission of the candidate to the M.A./M.Sc. in Mathematics. Programme shall be subject to such ordinances, rules and regulations as may be framed from time to time by the University.

2.18 Foreign students shall be admitted as per the rules of the University.

2.18 Only the High Court of Patna shall have jurisdiction in case of any dispute relating to the provisional admission in the Programme.

3. Eligibility Conditions

The eligibility conditions for admission into the M.A./M.Sc. in Mathematics Degree Programme shall be as follows:
Bachelor Degree with Mathematics/Statistics but shoult have studied Mathematics as a subject in all the 3 years with a minimum of 55% marks for General / OBC candidates and 50% marks for SC / ST candidates in the qualifying degree.

However, the eligibility conditions for admission into M.A./M.Sc. in Mathematics Programme of the University may be recommended by the University Admission, Teaching and Evaluation Committee (UATEC) from time to time which shall be notified in the admission prospectus each year before admission.

4. Medium of Instruction of the Programme:

The medium of instruction and examination shall be English for M.A./M.Sc. in Mathematics Programme.

5. Programme Fee:

5.1 The fee structure for each semester of M.A./M.Sc. in Mathematics Programme is given below:

	Semester Fee	
1	Tuitions Fee	2500/-
2	Computer Lab	500/-
3	Evaluation	500/-
	Annual Fee	
1	Vidyarthi Medi-claim Policy Premium (VMCPP)	Rs.524/- +Applicable Service Tax

5.2 The mode and schedule of payment of fees shall be decided by the university from time to time.

5.3 The fee structure of M.A./M.Sc. in Mathematics Programme under Department of Mathematics may be changed by the University prospectively. Such changed fee structure shall be declared in the admission prospectus of the concerned academic session.

6. Conduct of the Programme:

6.1 To qualify for the M.A./M.Sc. in Mathematics Degree, a candidate must earn 96 credits as contained in the Programme structure/Syllabus of M.A./M.Sc. in Mathematics Degree and annexed with this ordinance. This Programme structure/syllabus is subject to update/change/modify from time to time as prescribed by the Board of Studies (BoS) of the Department and need not to follow the procedure prescribed for updating the ordinances.

6.2 A student of the M.A./M.Sc. in Mathematics Programme shall not be permitted to seek admission concurrently to any other equivalent or higher degree or diploma examination in this University or any other University, subject to rules/regulations of UGC or equivalent body in this regard and adoption of the same by the University.

6.3 The maximum period allowed to complete the M.A./M.Sc. in Mathematics Programme will be four years (Eight Semesters).

6.4 The Department shall offer courses as per its schedule and available resources and can decide to offer or not to offer a particular course from time to time. To earn additional or lesser credits in a semester from the Department other than the prescribed in the syllabus and to earn credits from other Departments/Schools shall be the sole responsibility of the student. S/he has to choose the courses in such a way that it becomes feasible for her/him to earn the credits.

7. Type of Courses:

The M.A./M.Sc. in Mathematics Programme of the University has three types of courses, viz,. Core courses, Elective courses, and Self-study/Skill-based courses.

7.1 Core courses:

7.1.1. The core courses are those courses whose knowledge is deemed essential for the students registered for the M.A./M.Sc. in Mathematics Programme.

Where feasible and necessary, two or more Programmes (like, degree, diploma and certificate etc.) may prescribe one or more common core courses.

7.1.2 All the core courses prescribed for M.A./M.Sc. in Mathematics Degree Programme offered by the Department of Mathematics under the School of Mathematics, Statistics and Computer Science shall be mandatory for all the students registered in the M.A./M.Sc. in Mathematics Programme.

7.1.3 A core course of the Programme may be an elective course for any other Programme.

7.2 Elective courses:

7.2.1 The elective courses can be chosen from a pool of courses (papers). These courses are intended to:

- allow the student to specialize in one or more branches of the broad subject area;
- help the student to acquire knowledge and skills in a related area that may have applications in the broad subject area;
- help the student to bridge any gap in the curriculum and enable acquisition of essential skills (e.g. statistical, computational, language or communication skills etc.); and
- help the student to pursue an area of interest.

7.2.2 Along with the elective courses prescribed for the M.A./M.Sc. in Mathematics Degree Programme offered by the Department of Mathematics, a student has to register herself/himself in different elective courses in such a way that she/he ensures earning of minimum eight credits as elective from the other Departments/Schools.

7.2.3 The student may also choose additional elective courses offered by the University to enable her/him to acquire extra credits from the discipline, or across the disciplines. However, up to only 16 credit courses with best grades completed from the other Departments/Schools shall be considered for calculating CGPA of the Programme of study.

7.3 Self-study/Skill-based Courses:

The self-study/skill-based courses are optional, not mandatory. Being non-credit courses, the performance of students in these courses shall be indicated either as "satisfactory" or as "unsatisfactory", instead of the Letter Grade and this shall not be counted for the computation of SGPA/CGPA. These courses may also be taken by a student from other

Departments/Schools.

Moreover, if the BoS of the Department feels that the Programme of study of M.A./M.Sc. in Mathematics requires certain academic backgrounds to pursue the Programme effectively, it may recommend some course(s) without credit(s) to meet the purpose as compulsory part of the syllabus.

Note: A course (Core/Elective/Self-study/Skill-based) may also be offered by the department in the form of a Dissertation, Project work, Practical training, Field work or Internship/Seminar etc.

8. Mobility Options and Credit Transfers:

The students shall be permitted to opt inter-disciplinary and horizontal mobility and can take courses of their choice, learn at their paces, enroll for additional courses, acquire more than the required credits, and adopt an interdisciplinary approach to learning, subject to the provisions made in this ordinance.

8.1. A student may be allowed to take course/courses of any other University/Organization/Institution, the courses of whom are duly accredited by the Department of Mathematics/School of Mathematics, Statistics and Computer Science under MoU or otherwise and approved by the Academic Council. (Note: The Department of Mathematics/School of Mathematics, Statistics and Computer Science shall try to ensure accreditation of relevant courses of other Universities/Organizations/Institutions including MOOCs and increase the choice basket of M.A./M.Sc. in Mathematics Programme).

8.2. A student availing inter-university mobility shall continue to be a bonafide-student of the University where she/he initially got admission and in case she/he earns credits from a different university, the credits so earned shall be transferred to her/his parent University.

8.3. It shall be the responsibility of the student to assess the feasibility and practicality of vertical mobility (across universities), as it doesn't entitle a student to be exempted or relaxed from any of the requisites (sessional, attendance, assignments, end-semester examinations and Programme duration etc.) for the completion of the Programme.

8.4. The mobility option should not be interpreted as inter-university migration.

8.5. The mobility across the disciplines is also subject to availability of desired elective course, faculty, infrastructure and number of students (as fixed by the University/Department from time to time) opting for that elective course.

8.6. The mobility shall be permissible from the Regular Mode Programme to the Regular Mode Programme of learning only, and cannot be replaced by Open/Distance/Online Programme.

8.7 A student of some other University shall in any case be admitted only at the beginning of the particular Programme/Course which she/he proposes to take in the University subject to the fulfillment of other conditions.

9. Credits:

A credit defines the quantum of contents/syllabus prescribed for a course and determines the number of hours of instruction required per week. Thus, in each course, credits are assigned on the basis of the number of lectures/tutorials/laboratory work/field work and other forms of learning required for completing the contents in 15-18 week schedule. 2 hours of laboratory work/field work is generally considered equivalent to 1 hour of lecture.

(i) 1 credit = 1 hour of instruction per week (1 credit course = 15 contact hours of instruction per semester)

(ii) 4 credits = 4 hours of instruction per week (4 credit course = 60 contact hours of instruction per Semester)

(iii) 1 credit = 1 hour of tutorial per week (1 credit course = 15 contact hours of instruction per semester)

(iv) 1 credit = 2 hours of laboratory work/field work per week (1 credit course = 30 hours of laboratory work/field)

Number(s) of credit(s) assigned to a particular course are mentioned in the detailed syllabus of the courses.

10. Course Coding:

Each course offered by the Department of Mathematics is identified by a unique course code comprising of twelve letters/numbers indicating Programme/level of Programme (first two letters in uppercase), Discipline/Subject (Next three letters in uppercase), Semester (next digit ranging from 1 to 4), Course Number (next three digits starting from 001 for each semester), Nature of Course for the Programme (next letter in uppercase i.e. C = Core Course; E = Elective Course, S = Self-study/Skill course), total number of credits for the course (next two digits starting from 00), respectively.

For example, the course code for second core course of the M.A./M.Sc. in Mathematics Programme in the Third semester in the Department carrying 4 credits shall be ***MSMTH3002C04***.

Every time when a new course is prepared by the BoS of the Department (merely changing minor content and not the course title shall also be considered as a new course) it shall be assigned a new course code.

However, the University may decide a different course codification pattern for any Programme in future as per the demand of the situation.

11. Duration of the Programme:

The minimum duration for completion of M.A./M.Sc. in Mathematics Programme shall be four consecutive semesters (two odd and two even semesters). *The maximum period for completion shall be eight semesters.*

Provided that (i) a semester or a year may be declared by the Controller of Examinations as a zero semester or a zero year for a student if she/he could not continue with the academic work during that period due to terminal illness and hospitalization of longer duration, or due to accepting a scholarship/fellowship, with due permission of the University, subject to the fulfillment of requirements laid down in this respect by the rules or regulations of the University. Such a zero semester/year shall not be counted for calculation of the duration of the Programme in the case of such a student.

(ii) Hostel and other related facilities shall not be given to a student after completion of minimum duration, i.e., four semesters required for M.A./M.Sc. in Mathematics Programme.

12. Student Mentor:

The Department shall appoint a Mentor for each student from amongst the faculty members of the Department. All faculty members of the Department shall function as Student Mentors and shall generally have more or less equal number of students. The Student Mentor shall advise the student in choosing courses and render all possible support and guidance to her/him.

13. Course Registration:

13.1. The registration for courses shall be the sole responsibility of the student. No student shall be allowed to do a course without registration, and no student shall be entitled to any credits in the course, unless she/he has been registered for the course by the scheduled date fixed by the Department/School/University.

13.2. Every student has to register in each semester (in consultation with her/his Student Mentor) for the courses she/he intends to undergo in that semester by applying in the prescribed proforma in triplicate (one copy each for student, for the student's file to be maintained in the departmental office and for the office of the Controller of Examinations), duly signed by her/him, the Student Mentor, the concerned Course Teacher and finally approved by the Head/In charge of the Department of Mathematics, within the deadline notified for the purpose by the Department/School/University.

13.3. Registration done in different courses within the stipulated period of time by a student shall not ordinarily be permitted to be changed. However, in exceptional cases, a student may be allowed by the Head/In charge of the Department of Mathematics to add a course, substitute a course for another course of the same type (elective or self-study/skill-based) or withdraw from a course, for valid reasons by applying on prescribed proforma (in triplicate as mentioned above in 13.2) with the consent of the Student Mentor not later than one week from the last date of course registration in a particular semester. Further, withdrawal from a course shall be permitted only if the courses registered after the withdrawal shall enable the student to earn a minimum of 20 credits. This duly approved change/withdrawal shall be notified by the office of the Department of Mathematics to all concerns like Controller of Examinations, both the Course Teachers etc.

13.4. A student shall register for a minimum of 20 credits and can register for a maximum of 32 credits in a semester unless specified otherwise by the University for a Programme of study.

13.5. If a student registers herself/himself for more elective courses than the prescribed in the Programme, while calculating the Cumulative Grade Point Average (CGPA), only the prescribed number of elective courses for the Programme of study shall be included in the descending order of the grades obtained by her/him ensuring the presence of minimum 8 and maximum 16 credits from the electives of other Departments/Schools.

13.6. A student shall have the option of choosing an elective course from other Departments/Schools irrespective of the semester in which the course is offered, other things being the same. For example; a student of odd/even Semester can opt an elective course of other department offered in any odd/even semester respectively.

14. **Examination and Promotion:**

(A) The examination of all the courses required for the M.A./M.Sc. in Mathematics degree shall be internal in nature and generally consisting of Continuous Internal Assessment and End-Semester Examination. For the preparation of final grade in a particular course, the Continuous Internal Assessment (Formative in nature) and the End-Semester Examination (Summative in nature) shall have the weightage of 30% and 70%, respectively.

(B) Each course, irrespective of credits assigned to it, shall be evaluated out of 100 points. These points should not be confused with traditional system of marks. The points obtained by a student in a course are indicator of percentage of marks and not the raw marks. Since, the University has adopted the system of grading, hence, the marks shall not be reflected in a grade sheet of a student. However, for wider uses, and if required, the students or the prospective employer or end user may take the following reference for calculating maximum marks and obtained marks for a Programme/Course:

For Maximum Marks –

1 Credit Course = 25 marks course

2 Credit Course= 50 marks course

3 Credit Course= 75 marks course

4 Credit Course= 100 marks course

and so on.

For obtained marks –

The obtained points may be converted into marks by taking them as percentage of marks. For example:

(i) If a student has obtained 80 points in a 4 Credit Course, then it may be converted as: *80 marks out of 100.*

(ii) If a student has obtained 80 points in a 2 Credit Course, then it may be converted as: *40 marks out of 50.*

(iii) If a student has obtained 80 points in a 1 Credit Course, then it may be converted as: *20 marks out of 25.*

In such course(s), where direct numerical grades are awarded in place of points, these numerical grades shall be converted into marks by using the following formula:

Marks in the Course = Numerical grade in the Course x 10

However, any change may be recommended in this pattern by the UATEC, from time to time.

14.1. Continuous Internal Assessment:

14.1.1 The Continuous Internal Assessment of the students' learning and performance shall be carried out by the Course Teacher(s). Considering the nature of the course, the teacher(s) shall decide the mode of Continuous Internal Assessment, which may include one or more assessment tools, such as student's class performance, assignments, class tests, take-home tests, term paper(s), presentations, oral-quizzes, case studies and laboratory work etc.

14.1.2 Each Course Teacher shall design the Continuous Internal Assessment system for the course she/he offers with the approval of the Departmental Committee (DC). This approved design of Continuous Internal Assessment shall be announced to the students of the respective courses at the beginning of each semester by the concerned teacher.

14.1.3 Generally, each course shall be taught by one teacher only, who shall maintain all the records related to attendance, teaching and assessment in a systematic manner. In an exceptionally rare case, if a teacher is assisted in teaching by other teacher, the teacher (in-charge of the course) shall be responsible for coordinating teaching and assessment, including award of final grade.

14.1.4 In case a student fails to appear in any Continuous Internal Assessment, it will be taken care by the concerned Course Teacher at her/his level.

14.2. End-Semester Examination:

14.2.1 Generally, End-Semester theory question paper shall include a limited number of very short answer type questions followed by short and long questions covering the entire syllabus in such a way that the question paper ensures assessing students' knowledge, understanding, application and analysis-synthesis/reflection of the subject. Thus, a standard model format of the End-Semester Examination paper consisting of 70 points shall be as under –

Section-A: 15 very short questions of 02 points each = 30 points
(Short specific questions covering the entire syllabus to be given which should be answered in approximately 50 words by the examinee).

Section-B: 04 short questions of 05 points each = 20 points
(05 short questions to be given out of which 04 questions are to be attempted in approximately 200 words by the examinee).

Section-C: 02 long questions of 10 points each = 20 points

(03 long questions to be given out of which 02 questions are to be attempted in approximately 500 words by the examinee).

However, a different format of the End-Semester question paper for some particular course (e.g., project, dissertation or laboratory/field work etc.) may be prescribed by the Board of Studies (BoS) of the Department which shall come into force only after the approval of the competent authority of the University.

14.2.2 The duration of the End-Semester theory examination generally shall be of three hours.

14.2.3 The DC shall appoint one or more team(s), as per the need, of preferably three faculty members in each team for moderation of question papers of End-Semester Examinations and communicate the same to the Controller of Examinations. The task of moderation shall be organized by the Controller of Examinations.

The paper setter and the moderator(s) shall ensure and certify that question paper is comprehensive to cover all important topics/themes/course and fit for assessing the mastery of the entire course. They shall also ensure and certify that not more than 10% questions from the previous year question paper have been repeated.

14.3 In exceptional cases, depending upon the nature of a particular course, a totally different mode of assessment and evaluation may be prescribed by the BoS of the Department for the course, which shall come into force only after the approval of the competent authority of the University. However, it must be reflected in the detailed syllabus of the course and be available to the students at the beginning of the semester.

14.4 Any partial or complete change in the system of examination (Assessment & Evaluation) may be recommended by the UATEC which shall be implemented only after the approval of the competent authority.

14.5 A student is required to secure a minimum of 'P' grade in the Continuous Internal Assessment and in the End-Semester Examination, taking together, in a course.

14.6 Making Evaluated Answer-scripts Available to the Students:

14.6.1 All the examination answer-scripts shall be made available to the students after evaluation by the respective teachers as per the schedule decided by the concerned teachers or the University. In case of the End-Semester Examination, the evaluated answer scripts shall be made available to the students within 7 days of the last examination for the semester. Thereafter, within a week, all the answer books along with the statement of marks shall be sent by the concerned teacher through her/his Department to the Office of the Controller of Examinations for declaration of the results.

14.6.2 If a student is not satisfied with the evaluation of her/his answer script, s/he must submit a written objection to the concerned Head of the Department (offering the course) within 8 days from the last examination for the semester. Such complaint shall be looked after by a panel of three faculty members, including the concerned teacher, to be nominated by the concerned Head of the Department, whose decision shall be final. The revised points, if any, shall be submitted by the panel to the concerned Head of Department who shall further submit it to the Controller of Examinations. This complete process of grievance redressal by the panel and the further submission of marks by the Head of Department, generally, should not take more than 7 days from the date of receipt of the grievance. However, in case of any controversy, the matter shall be referred to the Vice-Chancellor for final decision and action.

14.6.3 Once evaluated answer books are submitted to the Controller of Examinations, there shall be no re-evaluation/re-totaling thereafter.

14.7 Letter Grades and Grade Points:

An absolute grading system shall be adopted to grade the students.

14.7.1. Under the absolute grading system, points shall be converted to grades based on pre-determined class intervals.

14.7.2. In the End-Semester theory or practical examinations, the examiner shall award the points and these points after adding the points of Continuous

Internal Assessment shall be further converted into Grades/Grade points in accordance with the provisions of this ordinance.

14.7.3. Detail Grade Sheet issued by the Controller of Examinations office at the end of the semester shall carry points /percentage and equivalent grades (numerical and letter) both.

14.7.4. The 10-point Grading System, with the Letter Grades as given under shall be followed:

Letter Grade	**Numerical Grade Point**	**Class Interval (in %)**
O (Outstanding)	10	Above 90 and ≤ 100
A+ (Excellent)	9	Above 80 and ≤ 90
A (Very Good)	8	Above 70 and ≤ 80
B+ (Good)	7	Above 60 and ≤ 70
B (Above Average)	6	Above 50 and ≤ 60
C (Average)	5	Above 45 and ≤ 50
P (Pass)	4.5	40 to 45
F (Fail)	0	< 40
Ab (Absent)	0	Absent

Note:

(i) F= Fail, and the students graded with 'F' in a Programme or Course shall be required to re-appear in the examination.

(ii) The minimum qualifying points for a course shall be 45% (i.e., 'P' grade).

(iii) The students shall have to qualify in the Continuous Internal Assessment and the End-Semester examinations taking together.

(iv) Before awarding numerical grade to the points obtained in a course, only the total of Continuous Internal Assessment and End-Semester Examination shall be rounded off to remove the decimal point. Thus, no separate rounding off shall be done of the points obtained in different components of Continuous Internal Assessment and End-Semester Examination.

(v) There shall be rounding off of SGPA/CGPA up to two decimal points.

(vi) The SGPA/CGPA obtained by a student shall be out of a maximum of 10 points.

(vii) In order to be eligible for the award of the M.A./M.Sc. in Mathematics Degree of the University, a student must obtain CGPA of 4.50 at the end of the Programme.x

(viii) Provided that the student who is otherwise eligible for the award of the M.A./M.Sc. in Mathematics Degree but has secured a CGPA of less than 4.50 at the end of the minimum permissible period of semesters may be allowed by the Department to repeat the same course(s) or other courses of the same type in lieu thereof in the extra semesters provided in Clause 11 related to the duration of Programme.

(ix) The Cumulative Grade Point Average (CGPA) obtained by a student shall be classified into the following division/Class:

CGPA	Class/ Division
Above 9	Outstanding
Above 8 to 9	First Class (With Distinction)
6 to 8	First Class
5.5 to < 6	High-Second Class
5 to < 5.5	Second Class
4.5 to < 5	Third Class

14.8. Re-appear in the End-Semester Examination:

14.8.1 Once a student has fulfilled the attendance requirements in a course as per the provisions mentioned in this ordinance but has failed to score minimum grade required to qualify the Course or failed to appear in the End-Semester Examination of the course, may be allowed to re-appear in the End-Semester Examination, in such course, in the extra semesters provided under the Clause 11 on duration of Programme.

14.8.2. Such student may avail the chance to re-appear only within the maximum duration of the Programme. The re-appearance shall be permitted only in the End-Semester Examination of the concerned course(s) and the marks obtained by the student in the Continuous Internal Assessment conducted earlier for the particular course(s) shall be carried forward to be added with the marks obtained by her/him in the latest End-Semester Examination of the respective course(s).

14.8.3. The re-appear examination of even semesters shall be conducted along with the End-Semester Examinations of even semesters. Similarly, the re-appear examinations of odd semesters shall be conducted along with the End-Semester Examinations of odd semesters.

14.8.4. The re-appear examination shall be based on the syllabi of the course in force at the time of initial registration to the course.

14.8.5 A student who is re-appearing for the End-Semester Examination as per the clause 14.8.1 above; can re-appear in the subsequent semester(s), whenever the examination of a particular course is held, on payment of Rs. 2000/- (may be revised time to time by the University) per course in addition to the prescribed semester fee of the semester in which she/he has been promoted/provisionally promoted, if applicable, within the maximum permissible duration for the Programme.

14.8.6 A student who has got the Migration/Transfer Certificate issued from the University shall not be allowed to re-appear in the End-Semester Examination.

14.9 Re-appear in the End-Semester Examination for Improvement of Grade(s):

14.9.1 If a student wishes to improve her/his grade(s) in any course (s), s/he can re-appear in the End-Semester Examination in the subsequent odd/even semester(s), whenever the examination of the particular course(s) is held, on payment of Rs. 2000/- (may be revised time to time by the University) per course in addition to the prescribed semester fee of the semester in which she/he has been promoted/provisionally promoted, if applicable, within the maximum permissible duration for the Programme of study of the student.

14.9.2 A student may improve her/his points/grade by reappearing in the End-Semester Examination of a course as per the provisions of reappearing mentioned above. In such cases points obtained by the student in the Continuous Internal Assessment of the particular course shall be carried forward to the subsequent End-Semester Examination of the course. However, in such case, the points/grades obtained on the basis of latest appeared End-Semester Examination shall be considered for calculation of final CGPA of the Programme.

14.9.3 The re-appear examination of a course for improvement of grade shall be based on the syllabi of the course in force at the time of initial registration to the course.

14.9.4 A student who has got the Migration/Transfer Certificate issued from the University shall not be allowed to re-appear in any examination for improvement of grade.

14.10 Repeating course(s):

14.10.1 A student having attendance shortage in any course may repeat the course by taking re-admission in that course in subsequent odd/even semester(s), whenever the course is being offered, within the maximum permissible duration of the Programme.

14.10.2 If a student repeats a course she/he has to fulfill all the desired requirements afresh including attendance, Continuous Internal Assessment and the End-Semester Examination. In such case the course content shall be based on the syllabi of the course in force at the time of repeat of the course. However, at the time of repeating, if the same course is not being offered by the Department due to any reason, the student may choose any other course of similar nature and credits from the available courses on recommendation of the Mentor and approval of the concerned Head of Department.

14.10.3 If a student repeats a course, she/he has to submit a fee of Rs. 3000/- (may be revised time to time by the University) per course in addition to the prescribed semester fee of the semester in which she/he has been promoted/provisionally promoted, if applicable.

14.11 Promotion Rules:

14.11.1 A student shall be declared as **'Promoted'** to the next semester when s/he earns 'P' Grade or above in the last concluded semester examination, maintaining the spirit and pattern of semester system and covering the mandatory components, such as Continuous Internal Assessment and End-Semester Examinations in all the courses for which s/he was registered till date.

14.11.2 A student shall be **'Provisionally Promoted'** to the next semester if she/he secures less than 'P' grade in **maximum three courses** out of the total courses registered by her/him till date.

14.11.3 A student shall be deemed as **'Failed'** in a semester when she/he gets below 'P' Grade in **more than three courses** or does not appear in the End-Semester Examination of **more than three courses**, after fulfilling the attendance requirements as per this ordinance, out of the total courses registered by her/him till date. In such case(s), a student has to re-appear in the End-Semester Examination of the course(s) in subsequent odd/even semester(s) within the maximum permissible duration of the Programme on payment of Rs. 2000/- (may be revised time to time by the University) per course. Since, such student does not need to attend the classes of the course(s) again; the marks of Continuous Internal Assessment obtained by her/him in the course(s) earlier shall be carried forward to be added with the marks obtained by her/him in the latest End-Semester Examination of the respective course(s).

14.11.4 A student shall also be deemed as **'Failed'** in a semester when she/he failed to appear in the End-Semester Examinations of more than three courses due to the attendance criteria mentioned in 18.4 of this ordinance. Such student has to repeat the courses in the subsequent odd/even semester(s), whenever the courses are being offered, within the maximum permissible duration of the Programme, on payment of the prescribed fees as per the clause 14.10.3.

14.11.5 Under no circumstances, any student shall be permitted to register in a new course if she/he is having less than 'P' Grade in more than three courses.

14.11.6 A student shall be declared to have passed the Programme of study and award of the degree if she/he has secured the required credits with at least 'P' grade.

14.11.7 The re-examination of End-Semester Examination of the failed or provisionally promoted students shall be as per the clauses/sub-clauses under 14.8 above. However, only in a case where a student of final semester (within the minimum prescribed duration of the Programme) fails to appear or to achieve 'P' grade in maximum three courses including all backlogs after the result declaration of final semester, the Department may ask the concerned course Teacher(s) to conduct re-examination of End-Semester Examinations of such course(s) within a month from commencement of the next semester relaxing the condition of odd/even semester as given in 14.8.3 the student shall have to pay a fee of Rs. 2000/- per course.

14.11.8 If a candidate is repeating a course in an academic session, whatever may be the reason, it shall not be counted in the total number of seats and shall not affect the fresh intake of the M.A./M.Sc. in Mathematics Programme in that academic session.

14.12 **Minimum Credit Requirements:**

For a two-year M.A./M.Sc. in Mathematics Degree Programme, the credit requirements shall be 96 credits, including core and elective courses as prescribed in the detailed syllabus attached with this ordinance and regulations. A minimum of 8 credits and maximum of 16 credits shall be from elective courses offered by other Department(s).

15. Computation of SGPA and CGPA:

The University shall follow the following procedure to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

15.1. The SGPA is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student in a particular semester and sum of the number of credits of all the courses undergone by a student in that semester, i.e.,

SGPA (Si) = $\sum (Ci \times Gi)/\sum Ci$

Where, Ci is the number of credits of the i^{th} course and Gi is the grade point scored by the student in the i^{th} course.

15.2. The CGPA is also calculated in the same manner taking into account all the considerable courses as per the provision laid down in this ordinance out of the total courses undergone by a student over all the semesters of a Programme, i.e.,

CGPA = $\sum (Ci \times Gi)/\sum Ci$

Where, Ci is the number of credits of the i^{th} course (which is to be considered for the award of the PG Degree) and Gi is the grade point scored by the student in the i^{th} course.

15.3. The SGPA and CGPA shall be rounded off to 2 decimal points.

15.4 Since, the calculation of CGPA is not based on all the courses undergone by student, rather it is governed by other provisions laid down in this ordinance like, clause 7.2.3, 13.5 etc., the CGPA may differ from the corresponding calculations based on SGPA only.

16. **Illustration of Computation of SGPA and CGPA:**

16.1. Illustration for computing SGPA:

Course	**Credit**	**Grade Letter**	**Grade Point**	**Credit Point**
Course I	3	A	8	3 x 8 = 24
Course II	4	B+	7	4 x 7 = 28
Course III	3	B	6	3 x 6 = 18
Course IV	3	O	10	3 x 10 =30
	Total credits for the semester = 13			Total Credit points Earned = 100

Thus, SGPA = 100/13 = 7.69

16.2 Illustrations for computing CGPA:

Courses Considered for the Award of the Degree	**Completed in the month (Year)**	**Credit**	**Grade Letter**	**Grade Point**	**Credit Point**
Course I	Dec 2018	4	A	8	4 x 8 = 32

Course II	Dec 2018	4	B+	7	4 x 7 = 28
Course III	June 2019	4	B	6	4 x 6 = 24
Course IV	June 2020	4	o	10	4 x 10 = 40
		Total credits for the semester =16			Total Credit points earned= 124

Thus, CGPA= 124/16= 7.75

Note: Formula to calculate percentage from CGPA/SGPA= CGPA or SGPA x 10; and formula to calculate percentage to CGPA or SGPA = Percentage/10,

e.g., In case of example mentioned in Table 16.2, the percentage of CGPA = 7.75 x 10 = 77.50%

16.3. Transcript (Format): Based on the above, letter grades, grade points, and the SGPA, the Transcripts/Detail Grades Certificates (DGCs) shall be issued to the candidates for each semester and a consolidated transcript on completion of the Programme indicating the performance in all the courses considered for calculating the CGPA. Along with the CGPA, the percentage of marks obtained in the Programme shall be reflected in this consolidated transcript on the basis of the CGPA. However, this system may be changed by the University at any point of time without prior notice to the stakeholders as per the need.

17. Removal of Student Name from the Programme:

The name of a student falling under any one of the following categories shall automatically stand removed from the rolls of the University:

(a) A student who has failed to fulfill the minimum grade point requirements prescribed for the Programme during the maximum duration of the Programme.

(b) A student who has already exhausted the maximum duration allowed for completion of the Programme and has not fulfilled the requirements for the award of the degree.

(c) A student who is found to be involved in misconduct, forgery, indiscipline or any other objectionable conduct, upon recommendation of the Disciplinary Committee/ Proctorial Board or any other procedure deemed fit by the University.

(d) A student who has failed to attend the classes as stipulated under the clause of attendance requirements in this ordinance.

18. Attendance Rules:

18.1 A student is required to attend 100% of the classes held in a course in the specific semester in order to be eligible to appear in the End-semester examination of that particular course.

18.2 Waiving of attendance-deficit up to a maximum of 25% is permissible to accommodate following situations:

(a) Representing the University in any inter-collegiate, inter-University, local, national or international events; (b) Participating in an activity of the University with prior permission of the Competent Authority; (c) Participation in NCC/NSC/NSS Camps duly supported by certificate. (d) Participation in Educational Excursions, which form a part of teaching in any subject, conducted on working days duly certified by the concern Course Teacher/ Head of Department /Dean; and (e) to cover all unforeseen reasons like illness, hospitalization, personal engagements elsewhere or other personal reasons which compel a student to absent herself/himself from attending the classes.

18.3 Hence, it shall be mandatory/compulsory to every student to have attendance in 75% classes held in particular course. No waiver, for whatsoever reason, shall be given. Accordingly, no application requesting waiver below 75% attendance shall be entertained by the University. However, a further relaxation up to 10% or the days spent (whichever is lesser) on the basis of situations mentioned under a, b & c of Clause 18.2 above (not on the basis of d of Clause 18.2) may be considered by the Vice-Chancellor on the recommendation of the Head/In charge of the Department. In any other situation no appeal can be made for this purpose even to the Vice-Chancellor.

18.4 A student, however, shall not be allowed to appear in the End-Semester Examination of the courses which are not covered under above mentioned clauses 18.1, 18.2 and 18.3. Such a student shall be permitted to repeat the courses in the subsequent odd/even semester(s), whenever the courses are being offered, within the maximum permissible duration of the Programme, on payment of the prescribed fees as per the clause 14.10.3. However, in the first semester, for repeating the courses, it shall be mandatory for a student to have minimum 40% attendance in aggregate (taken together all the courses registered by her/him in the semester). If a student does not put in at least 40% of aggregate attendance in the first semester, she/he shall have to leave the Programme without claiming refund of any fees, and her/his admission shall be treated as cancelled.

18.5 The attendance of a newly admitted candidate shall be counted from the date of her/his admission/registration or date of beginning of classes, whichever is later. In the case of promoted candidates, attendance shall be counted from the date on which respective class begins. However, if a new student is admitted late after the commencement of the classes, s/he must get herself/himself registered in the desired courses following the due procedure within 5 working days after the admission failing which her/his attendance shall be counted after 5 working days from the date of admission.

18.6 In a case of changed registration as per the clause 13.3 of this ordinance the total classes held for calculating percentage of attendance in the newly registered course for a particular student shall be counted from the fresh registration in that particular course.

18.7 Monthly records of attendance of students in each of the courses taught by a teacher is to be prepared and submitted by the concerned teacher to the Office of the Head/In charge of the Department (HoD) and the Controller of Examinations' (CoE) office by the 10^{th} day of the next month after displaying it to the students in the course and taking their signatures. The teacher will keep the original record of attendance with her/him and submit it finally to both the offices with her/his remarks regarding the eligibility of a student for appearing in the end semester examination within three working days after the last class or teaching day in the semester, whichever is later. Any failure in compliance in this matter must be informed by the concerned teacher to the Head of Department and the Controller of Examinations with justification.

x

18.8 There shall be an Attendance Monitoring Committee in the Department under the Chairmanship of the Head or her/his nominee for proper monitoring of attendance records and taking suitable action(s) as per the requirements.

19. Programme Structure:

The M.A./M.Sc. in Mathematics Programme shall be of two year duration divided into four semesters. A student is required to earn at least 96 credits within the stipulated time as per the details given in Annexure-1.

20. Power to Relax and Amendments

20.1 All the above clauses are subject to the amendments, as and when required, as per the decisions pertaining to rules, regulations and norms of the University Statutory Bodies and other Regulatory Bodies etc. from time to time.

20.1.1 Notwithstanding what is contained in the foregoing clauses of this ordinance, the Academic Council may, in exceptional circumstances consider at its discretion and for reasons to be recorded, relax any of the provisions except those prescribing CGPA requirements.

20.2 Notwithstanding anything stated in this ordinance, for any unforeseen issues arising, and not covered by this ordinance, or in the event of differences of interpretation, the Vice-Chancellor may take a decision, after obtaining the opinion/advice, if required, of UATEC. The decision of the Vice-Chancellor shall be final.

Diary No - 2376 (Admin. Patna)
dt:- 13/7/18

Date: 13.07.2018

To
The Controller of Examinations
Central University of South Bihar,
Panchanpur, Gaya
Through: proper channel

Subject: **Submission of Minutes of BoS meeting, approved Ordinance, CBCS based Syllabus of M.Sc. (Mathematics) and syllabus of Mathematics courses of B.Sc.-B.Ed. programme.**

Madam,

Please find enclosed, herewith, copies of Minutes of BoS meeting held on July 11-12, 2018 (Wednesday-Thursday), approved Ordinance, Syllabus of M.Sc. (Mathematics) under CBCS and syllabus of Mathematics courses of B.Sc.-B.Ed. programme.

Yours faithfully,
13-07-2018

(H. K. Nigam)
Head,
Department of Mathematics

Encl:

1. Minutes of BoS meeting
2. Ordinance and Regulations Governing
3. Syllabus of M.Sc. (Mathematics)
4. Courses of B.Sc.-B.Ed. programme

5
16.07.18

Forwarded
13-07-2018

13/7/18

Minutes of the Board of Studies Meeting

Department of Mathematics

July 11-12, 2018 (Wednesday-Tuesday)

A meeting of the Board of Studies of Department of Mathematics was held under the Convenorship of Dr. H. K. Nigam Head (Department of Mathematics) in the old VC's Chamber of the Central University of South Bihar, Patna Campus.

The following persons were present:

1.	Dr. H. K. Nigam	(Convenor)
2.	Prof. P. D. Srivastava	(External member)
3.	Prof. N. K. Singh	(External member)
4.	Mr. N. C. Rathore	(Cognate Member)
5.	Dr. Mukesh Kumar	(Cognate Member)
6.	Dr. Rajesh Pratap Singh	(Member)
7.	Dr. Vivek Kumar Jain	(Member)
8.	Dr. Roushan Kumar	(Member)
9.	Dr. Shubh Narayan Singh	(Member)
10.	Dr. Pankaj Mishra	(Member)

The Ordinance and Regulations Governing M.Sc. (Mathematics) Degree programme effective from the Academic Session 2018-2019, has been discussed and approved. **(Annexure-A, page no. 1-29)**

The proposed course structure and the syllabi of M.Sc. (Mathematics) programme according to choice based credit system (CBCS) were discussed and the corresponding core courses, elective courses, SWAYAM courses and skill based/self-study courses (Non-credit) have been approved. **(Annexure-1, Page no. 1-84)**

Some Mathematics courses of the B.Sc.-B.Ed. programme have been discussed and revised and finally the syllabi of all the courses have approved. **(Annexure-2, page no. 1-9)**

The meeting ended with vote of thanks to the Chair.

12-7-2018
Dr. Pankaj Mishra

12.07.2018
Dr. Shubh Narayan Singh

Dr. Roushan Kumar

Dr. Vivek Kumar Jain

12/07/2018
Dr. Rajesh Pratap Singh

12/07/2018
Dr. Mukesh Kumar

12/07/18
Mr. N. C. Rathore

12/07/2018
Prof. N. K. Singh

12/07/2018
Prof. P. D. Srivastava

Dr. H. K. Nigam

CENTRAL UNIVERSITY OF SOUTH BIHAR

ORDINANCE AND REGULATIONS GOVERNING

Master of Science in Mathematics (M.Sc.)

(Effective from the Academic Session 2018-2019)

Department of Mathematics

School of Mathematics, Statistics and Computer Science

TABLE OF CONTENTS

ORDINANCE AND REGULATIONS GOVERNING

MASTER OF SCIENCE IN MATHEMATICS PROGRAMME OF CENTRAL UNIVERSITY OF SOUTH BIHAR UNDER CHOICE BASED CREDIT SYSTEM

(Effective from Academic Session 2018-19)

Under the powers conferred by The Central Universities Act, 2009- section 28(1) (b)], as amended, Central University of South Bihar, hereby, institutes the four semester Post Graduate Degree Programme for the Award of Master of Science in Mathematics (M.Sc.) Degree by the Department of Mathematics under the School Mathematics, Statistics and Computer Science of the University under the choice based credit system. The following ordinance for governing admission, course of study, examinations and other matters relating to M.Sc. Degree under Department of Mathematics of the Central University of South Bihar are hereby laid to come in force w.e.f. the Academic Session 2018-19 onwards till further amended.

1. Definitions of Key Words:

1.1 **'Choice-Based Credit System (CBCS)':** The CBCS provides choice for the students to select course from the prescribed courses (Elective or Soft-skill courses). It provides a 'cafeteria' approach in which the students can take courses of their choice, learn at their own pace, study additional courses and acquire more than the minimum required credits, and adopt an inter-disciplinary approach to learning.

1.2 **'Academic Year':** Two consecutive (one odd + one even) semesters shall constitute one academic year.

1.3 **'Course':** Course, usually referred to as paper having specific title and code number, is a component of a Programme. It consists of a list of topics /points /concepts /theories /principles etc. which a student has to learn and master during the Programme of study. Each Course generally shall be of 04 credits. Each course should define the learning objectives/ learning outcomes. A course may be designed to be delivered through lectures/tutorials/laboratory work/field work/outreach activities/project work/vocational training/viva/seminars/ term papers/assignments /presentations / self-study work etc., or a combination of some of these.

1.4 **'Course Teacher':** The course teacher generally will be the teacher who has primarily conceived the course, developed its contents, taken up the responsibility of teaching it and evaluating the performance of the students in that course.

1.5 **'Credit':** A unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work/field work per week.

1.6 **'Credit Point':** It is the product of the grade point and the number of credits for a course.

1.7 **'Grade Point':** It is a numerical weight allotted to each letter grade on a 10-point scale.

1.8 **'Letter Grade':** It is an index of the performance of students in a said course. Grades are denoted by letters O, A+, A, B+, B, C, P and F. A letter grade is assigned to a student on the basis of evaluation of her/his performance in a course on a ten point scale.

1.9 **'Programme':** An educational Programme leading to the award of a Degree, Diploma or Certificate.

1.10 **'Credit-Based Semester System (CBSS)':** Under the CBSS, the requirement for awarding a degree or diploma or certificate is prescribed in terms of number of credits to be completed by the students.

1.11 **'Semester':** Each Semester shall consist of 15-18 weeks of academic work equivalent to 90 actual teaching days. The odd semester may be scheduled from July to December and even semester from January to June. The credit-based semester system provides flexibility in designing curriculum and assigning credits based on the course content and hours of teaching.

1.12 **'Semester Grade- Point Average (SGPA)':** It is a measure of performance of the work done in a semester. It is ratio of total credit points secured by a student in various courses registered in a semester and the total course credits taken during that semester. It shall be expressed up to two decimal places.

1.13 **'Cumulative Grade Point Average (CGPA)':** It is a measure of overall cumulative performance of a student over all semesters. The CGPA is the ratio of total credit points secured by a student in various courses in all semesters and the sum of the total credits of all courses in all the semesters. It shall be expressed up to two decimal places.

1.14 **'Transcript'/ 'Grade Card' 'or Certificate':** Based on the grades earned, a grade certificate shall be issued to all the registered students after every semester. The grade certificate will display the course details (code, title, number of credits, grade and/or marks secured) along with SGPA of that semester.

1.15 **'The University'**: 'The University' in this Ordinance means the Central University of South Bihar.

2. Admission and Other General Provisions:

2.1 The Programme of study leading to Master of Science in Mathematics (M.Sc.) Degree of Central University of South Bihar shall be of two year (Four Semesters) duration which may be completed in a maximum duration of four years (Eight Semesters). Admission to the M.Ed. Programme in Department of Mathematics (School of Mathematics, Statistics and Computer Science) shall be made on merit in the admission test conducted for this purpose.

2.2 The intake to the said PG Programme (M.Sc.) shall be as notified in the University Admission Prospectus.

2.3 The admission to the (M.Sc.) Programme shall be governed by the provisions as laid down in the University Admission Prospectus issued each year for admissions to the said Programme of the University.

2.4 After the declaration of the admission test results, the admission to the (M.Sc.) Programme shall be done by the Admission Committee, constituted as per the University rules.

2.5 Reservation rules as per the Government of India (GOI) and/or adopted by the University shall be applicable in admission to the (M.Sc.) Degree Programme as follows:

S. No.	Category	Reservation
1	SC Candidates	15 % of the intake
2	ST Candidates	7.5% of the intake
3	OBC Candidates	27% of the intake
4	Divyang Candidates	5% of the intake *(on horizontal reservation basis)*
5	Widows/Wards of Defence Personnel and Kashmiri Migrants	As per the GOI rules

(a) The candidates seeking admission under the above categories must fulfill the minimum eligibility conditions, qualifying requirements and submit requisite documents in support of their claim, as prescribed by the GOI from time to time.

(b) The SC/ ST/OBC candidates must enclose attested copy of the latest caste certificate as per GOI norms along with their Admission Form/Enrolment form stating that the candidate belongs to SC/ST/OBC Category.

The following are empowered to issue SC/ST/OBC Certificates:

(i) District magistrate/ Additional District Magistrate/ Collector/ Deputy Commissioner/ Addl. Deputy Commissioner/Deputy Collector /Ist Class Stipendiary Magistrate/City Magistrate/Sub Divisional magistrate/ Taluka Magistrate/ Executive Magistrate /Extra Assistant Commissioner.

(ii) Chief Presidency Magistrate/ Addl. Chief Presidency Magistrate/ Presidency Magistrate.

(iii) Revenue Officer not below the rank of Tehsildar.

(iv) Sub - Divisional Officer of the area where the candidate and/or his family normally resides.

(v) Administrator/Secretary to the Administrator/ Development Officer (Lakshadweep Islands).

(vi) Candidate must note that certificate from any other person/authority shall not be accepted generally.

(c) 5% seats on horizontal reservation basis shall be reserved for Divyang Candidates (Benchmark Category) and shall be further sub-divided into different categories of Divyangs as per the GOI rules.

A candidate applying under Divyang category must attach a certificate by CMO, District Hospital. However, she/he shall be considered under Divyang category only after verification from the University Medical Board, if any.

(d) Vacant seats reserved for SC/ST/OBC candidates, if any, may be filled up as per the GOI rules. In case in any one of the two categories of candidates viz., SC/ST, the required number of candidates for admission is not available (i.e., the list of respective category has been exhausted), then candidates belonging to the other category (SC or ST as the case may be, if available), shall be called for admission in order of merit so as to make up the deficiency in the required number in any of the aforesaid two categories. This provision shall be applicable to candidates belonging to SC & ST categories only.

(e) If sufficient number of candidates are not available in OBC category (i.e., OBC category list has been exhausted), such vacant seats shall be transferred to the general category.

2.6 Mere appearance in the admission test shall not entitle a candidate to be considered for admission to the Programme unless she/he fulfills the eligibility conditions. Applicants must fully satisfy themselves about their eligibility before filling the application form.

2.7 Provisional admission shall be offered to the candidates in order of merit list and the availability of seat in the Programme on the date of admission.

2.8 In case there is more than one candidate securing equal ranks as obtained by the last candidate in order of merit in the list of candidates to be called for admission, the following *inter-se* ranking rules of the University shall be applicable.

In case the candidates have equal/tie ranks then the marks obtained in the qualifying examination shall be the deciding factor and if, that is also same or result of both the candidates is not declared, then a senior candidate on the basis of date of birth shall be given preference. However, in a case of tie rank, if the result of qualifying examination of one candidate is declared then she/he will be given preference, provided she/he fulfills other eligibility conditions. In case of any dispute the decision of the Chairman, UATEC shall be final.

2.9 If the result of the qualifying examination is not declared by a university/board till the date of admission, the mark-sheet of the qualifying examination by a candidate can be submitted on or before 30th September of the admission year. In exceptional cases, further extension may be given by the Competent Authority on cogent reason(s). However, it may be noted that this clause cannot be extended to the candidate(s) whose result is being withheld or not declared by the university/board due to some specific reasons particularly related to the candidate(s). Furthermore, if the result of qualifying examination is not declared by a university/board in general then the aggregate percentage of marks/grades of the completed semesters/years of the qualifying examination must be not less than the required percentage of marks/grades in the qualifying examination.

2.10 At the time of reporting for admission, the candidates are required to be present in person and bring the documents in original as well as a set of photocopy duly attested as notified by the Admission Committee/Controller of Examinations (CoE) from time to time.

2.11 A candidate provisionally selected for admission shall be required to fill the prescribed form, submit the required documents, collect her/his admit card or any other equivalent document for admission to the Programme from the office of the Department/School/University after paying the fees on or before a date fixed for the purpose, otherwise the offer made to her/him will automatically stand cancelled.

2.12 In case any provisionally selected candidate fails to deposit the fee by the date prescribed, her/his provisional admission shall be cancelled and the seat thus falling vacant shall be offered to the next candidate in order of merit under the specified category.

2.13 Notwithstanding anything contained in this ordinance, a candidate who is qualified under the foregoing ordinance for admission to the University, and who is a student of some other Indian University/Institution, shall not be admitted to the University without the production of a leaving or transfer certificate and/or migration certificate (as the case may be) issued by the last college/university attended and certifying to the satisfactory conduct of the student mentioning the highest examination she/he has passed. However, in certain cases if the candidates are not in position to submit the Transfer Certificate and/or Migration Certificate and the character certificate at the time of admission, they should submit the same as early as possible, but not later than 30th September of the year of admission in M.Sc. (Mathematics) failing which the University reserves the right to cancel their admission. In exceptional cases, further extension may be given by the Competent Authority on cogent reason(s). However, it may be noted that this clause cannot be extended to the candidate(s) whose result is being withheld or not declared by the university/board due to some specific reasons particularly related to the candidate(s).

2.14 Waitlisted candidate shall be offered admissions strictly on the basis of ranking, provided there is a vacancy in the Programme. Such waitlisted candidates shall have to deposit their fees latest by the date fixed by the Admission Committee/ Competent Authority.

2.15 The candidates enjoying employed status and selected for admission to M.Sc. (Mathematics) Programme in the University, are required to produce Leave Sanction /Relieving Order at the time of Admission/Registration from their employer for the duration of the Programme permitting them to pursue their studies at the University, failing which the offer of admission may stand withdrawn. In case of any dispute the decision of the competent authority shall be final.

2.16 The admission of any candidate is liable to be cancelled without giving any further notice forthwith or at any time during the period of the concerned Programme of Study, if it is detected that the candidate has /had produced fake / forged certificate(s) /document(s), indulged in any act of misconduct/indiscipline and has /had concealed any other relevant information at the time of seeking admission.

2.17 The admission of the candidate to the M.Sc. (Mathematics) Programme shall be subject to such ordinances, rules and regulations as may be framed from time to time by the University.

2.18 Foreign students shall be admitted as per the rules of the University.

2.18 Only the High Court of Patna shall have jurisdiction in case of any dispute relating to the provisional admission in the Programme.

3. Eligibility Conditions

The eligibility conditions for admission into the M.Sc. (Mathematics) Degree Programme shall be as follows:

Bachelor Degree with Mathematics/ Statistics but should have studied Mathematics as a subject in all the 3 years with a minimum of 55% marks for General / OBC candidates and 50% marks for SC / ST candidates in the qualifying degree.

However, the eligibility conditions for admission into M.Sc. (Mathematics) Programme of the University may be recommended by the University Admission, Teaching and Evaluation Committee (UATEC) from time to time which shall be notified in the admission prospectus each year before admission.

4. Medium of Instruction of the Programme:

The medium of instruction and examination shall be English for M.Sc. (Mathematics) Programme.

5. Programme Fee:

5.1 Fee structure for each semester of M.Sc. (Mathematics) Programme is given below:

	Semester Fee	
1	Tuition Fee	2500/-
2	Computer Lab	500/-
3	Evaluation	500/-
	Annual Fee	
1	Vidyarthi Medi-claim Policy Premium (VMCPP)	Rs. 524/- + Applicable Service Tax

5.2 The mode and schedule of payment of fees shall be decided by the university from time to time.

5.3 The fee structure of M.Sc. (Mathematics) Programme under Department of Mathematics may be changed by the University prospectively. Such changed fee structure shall be declared in the admission prospectus of the concerned academic session.

6. Conduct of the Programme:

6.1 To qualify for the M.Sc. (Mathematics) Degree, a candidate must earn 96 credits as contained in the Programme structure/Syllabus of M.Sc. (Mathematics) Degree and annexed with this ordinance. This Programme structure/Syllabus is subject to update/change/modify from time to time as prescribed by the Board of Studies (BoS) of the Department and need not to follow the procedure prescribed for updating the ordinances.

6.2 A student of the M.Sc. (Mathematics) Programme shall not be permitted to seek admission concurrently to any other equivalent or higher degree or diploma examination in this University or any other University, subject to rules/regulations of UGC or equivalent body in this regard and adoption of the same by the University.

6.3 The maximum period allowed to complete the M.Sc. (Mathematics) Programme will be four years (Eight Semesters).

6.4 The Department shall offer courses as per its schedule and available resources and can decide to offer or not to offer a particular course from time to time. To earn additional or lesser credits in a semester from the Department than the prescribed in the syllabus and to earn credits from other Departments/Schools shall be the sole responsibility of the student. S/he has to choose the courses in such a way that it becomes feasible for her/him to earn the credits.

7. Type of Courses:

The M.Sc. (Mathematics) Programme of the University has three types of courses, viz,. Core courses, Elective courses, and Self-study/Skill-based courses.

7.1 Core courses:

7.1.1. The core courses are those courses whose knowledge is deemed essential for the students registered for the M.Sc. (Mathematics) Programme. Where feasible and necessary, two or more Programmes (like, degree, diploma and certificate etc.) may prescribe one or more common core courses.

7.1.2 All the core courses prescribed for M.Sc. (Mathematics) Degree Programme offered by the Department of Mathematics under the School of Mathematics, Statistics and Computer Science shall be mandatory for all the students registered in the M.Ed. Programme.

7.1.3 A core course of the Programme may be an elective course for any other Programme.

7.2 Elective courses:

7.2.1 The elective courses can be chosen from a pool of courses (papers). These courses are intended to:

- allow the student to specialize in one or more branches of the broad subject area;
- help the student to acquire knowledge and skills in a related area that may have applications in the broad subject area;
- help the student to bridge any gap in the curriculum and enable acquisition of essential skills (e.g. statistical, computational, language or communication skills etc.); and
- help the student to pursue an area of interest.

7.2.2 Along with the elective courses prescribed for the M.Sc. (Mathematics) Degree Programme offered by the Department of Mathematics, a student has to register herself/himself in different elective courses in such a way that she/he ensures earning of minimum eight credits as elective from the other Departments/Schools.

7.2.3 The student may also choose additional elective courses offered by the University to enable her/him to acquire extra credits from the discipline, or across the disciplines. However, up to only 16 credit courses with best grades completed from the other Departments/Schools shall be considered for calculating CGPA of the Programme of study.

7.3 Self-study/Skill-based Courses:

The self-study/skill-based courses are optional, not mandatory. Being non-credit courses, the performance of students in these courses shall be indicated either as "satisfactory" or as "unsatisfactory", instead of the Letter Grade and this shall not be counted for the computation of SGPA/CGPA. These courses may also be taken by a student from other

Departments/Schools.
Moreover, if the BoS of the Department feels that the Programme of study of M.Sc. (Mathematics) requires certain academic backgrounds to pursue the Programme effectively, it may recommend some course(s) without credit(s) to meet the purpose as compulsory part of the syllabus.

Note: A course (Core/Elective/Self-study/Skill-based) may also be offered by the department in the form of a Dissertation, Project work, Practical training, Field work or Internship/Seminar etc.

8. Mobility Options and Credit Transfers:

The students shall be permitted to opt inter-disciplinary and horizontal mobility and can take courses of their choice, learn at their paces, enroll for additional courses, acquire more than the required credits, and adopt an interdisciplinary approach to learning, subject to the provisions made in this ordinance.

8.1. A student may be allowed to take course/courses of any other University/Organization/Institution, the courses of whom are duly accredited by the Department of Mathematics/School of Mathematics, Statistics and Computer Science under MoU or otherwise and approved by the Academic Council. (Note: The Department of Mathematics /School of Mathematics, Statistics and Computer Science shall try to ensure accreditation of relevant courses of other Universities/Organizations/Institutions including MOOCs and increase the choice basket of M.Sc. (Mathematics) Programme).

8.2. A student availing inter-university mobility shall continue to be a bonafide-student of the University where she/he initially got admission and in case she/he earns credits from a different university, the credits so earned shall be transferred to her/his parent University.

8.3. It shall be the responsibility of the student to assess the feasibility and practicality of vertical mobility (across universities), as it doesn't entitle a student to be exempted or relaxed from any of the requisites (sessional, attendance, assignments, end-semester examinations and Programme duration etc.) for the completion of the Programme.

8.4. The mobility option should not be interpreted as inter-university migration.

8.5. The mobility across the disciplines is also subject to availability of desired elective course, faculty, infrastructure and number of students (as fixed by the University/Department from time to time) opting for that elective course.

8.6. The mobility shall be permissible from the Regular Mode Programme to the Regular Mode Programme of learning only, and cannot be replaced by Open/Distance/Online Programme.

8.7 A student of some other University shall in any case be admitted only at the beginning of the particular Programme/Course which she/he proposes to take in the University subject to the fulfillment of other conditions.

9. Credits:

A credit defines the quantum of contents/syllabus prescribed for a course and determines the number of hours of instruction required per week. Thus, in each course, credits are assigned on the basis of the number of lectures/tutorials/laboratory work/field work and other forms of learning required for completing the contents in 15-18 week schedule. 2 hours of laboratory work/field work is generally considered equivalent to 1 hour of lecture.

(i) 1 credit = 1 hour of instruction per week (1 credit course = 15 contact hours of instruction per semester)

(ii) 4 credits = 4 hours of instruction per week (4 credit course = 60 contact hours of instruction per Semester)

(iii) 1 credit = 1 hour of tutorial per week (1 credit course = 15 contact hours of instruction per semester)

(iv) 1 credit = 2 hours of laboratory work/field work per week (1 credit course = 30 hours of laboratory work/field)

Number(s) of credit(s) assigned to a particular course are mentioned in the detailed syllabus of the courses.

10. Course Coding:

Each course offered by the Department of Mathematics is identified by a unique course code comprising of twelve letters/numbers indicating Programme/level of Programme (first two letters in uppercase), Discipline/Subject (Next three letters in uppercase), Semester (next digit ranging from 1 to 4), Course Number (next three digits starting from 001 for each semester), Nature of Course for the Programme (next letter in uppercase i.e. C = Core Course; E = Elective Course, S = Self-study/Skill course), total number of credits for the course (next two digits starting from 00), respectively.

For example, the course code for second core course of the M.Sc. (Mathematics) Programme in the Third semester in the Department carrying 4 credits shall be ***MSMTH3002C04***.

Every time when a new course is prepared by the BoS of the Department (merely changing minor content and not the course title shall also be considered as a new course) it shall be assigned a new course code.

However, the University may decide a different course codification pattern for any Programme in future as per the demand of the situation.

11. Duration of the Programme:

The minimum duration for completion of M.Sc. (Mathematics) Programme shall be four consecutive semesters (two odd and two even semesters). *The maximum period for completion shall be eight semesters.*

Provided that (i) a semester or a year may be declared by the Controller of Examinations as a zero semester or a zero year for a student if she/he could not continue with the academic work during that period due to terminal illness and hospitalization of longer duration, or due to accepting a scholarship/fellowship, with due permission of the University, subject to the fulfillment of requirements laid down in this respect by the rules or regulations of the University. Such a zero semester/year shall not be counted for calculation of the duration of the Programme in the case of such a student.

(ii) Hostel and other related facilities shall not be given to a student after completion of minimum duration, i.e., four semesters required for M.Sc. (Mathematics) Programme.

12. Student Mentor:

The Department shall appoint a Mentor for each student from amongst the faculty members of the Department. All faculty members of the Department shall function as Student Mentors and shall generally have more or less equal number of students. The Student Mentor shall advise the student in choosing courses and render all possible support and guidance to her/him.

13. Course Registration:

13.1. The registration for courses shall be the sole responsibility of the student. No student shall be allowed to do a course without registration, and no student shall be entitled to any credits in the course, unless she/he has been registered for the course by the scheduled date fixed by the Department/School/University.

13.2. Every student has to register in each semester (in consultation with her/his Student Mentor) for the courses she/he intends to undergo in that semester by applying in the prescribed proforma in triplicate (one copy each for student, for the student's file to be maintained in the departmental office and for the office of the Controller of Examinations), duly signed by her/him, the Student Mentor, the concerned Course Teacher and finally approved by the Head/In charge of the Department of Mathematics, within the deadline notified for the purpose by the Department/School/University.

13.3. Registration done in different courses within the stipulated period of time by a student shall not ordinarily be permitted to be changed. However, in exceptional cases, a student may be allowed by the Head/In charge of the Department of Mathematics to add a course, substitute a course for another course of the same type (elective or self-study/skill-based) or withdraw from a course, for valid reasons by applying on prescribed proforma (in triplicate as mentioned above in 13.2) with the consent of the Student Mentor not later than one week from the last date of course registration in a particular semester. Further, withdrawal from a course shall be permitted only if the courses registered after the withdrawal shall enable the student to earn a minimum of 20 credits. This duly approved change/withdrawal shall be notified by the office of the Department of Mathematics to all concerns like Controller of Examinations, both the Course Teachers etc.

13.4. A student shall register for a minimum of 20 credits and can register for a maximum of 32 credits in a semester unless specified otherwise by the University for a Programme of study.

13.5. If a student registers herself/himself for more elective courses than the prescribed in the Programme, while calculating the Cumulative Grade Point Average (CGPA), only the prescribed number of elective courses for the Programme of study shall be included in the descending order of the grades obtained by her/him ensuring the presence of minimum 8 and maximum 16 credits from the electives of other Departments/Schools.

13.6. A student shall have the option of choosing an elective course from other Departments/Schools irrespective of the semester in which the course is offered, other things being the same. For example; a student of odd/even Semester can opt an elective course of other department offered in any odd/even semester respectively.

14. **Examination and Promotion:**

(A) The examination of all the courses required for the M.Sc. (Mathematics) degree shall be internal in nature and generally consisting of Continuous Internal Assessment and End-Semester Examination. For the preparation of final grade in a particular course, the Continuous Internal Assessment (Formative in nature) and the End-Semester Examination (Summative in nature) shall have the weightage of 30% and 70%, respectively.

(B) Each course, irrespective of credits assigned to it, shall be evaluated out of 100 points. These points should not be confused with traditional system of marks. The points obtained by a student in a course are indicator of percentage of marks and not the raw marks. Since, the University has adopted the system of grading, hence, the marks shall not be reflected in a grade sheet of a student. However, for wider uses, and if required, the students or the prospective employer or end user may take the following reference for calculating maximum marks and obtained marks for a Programme/Course:

For Maximum Marks –

1 Credit Course = 25 marks course

2 Credit Course= 50 marks course

3 Credit Course= 75 marks course

4 Credit Course= 100 marks course

and so on.

For obtained marks –

The obtained points may be converted into marks by taking them as percentage of marks. For example:

(i) If a student has obtained 80 points in a 4 Credit Course, then it may be converted as: *80 marks out of 100.*

(ii) If a student has obtained 80 points in a 2 Credit Course, then it may be converted as: *40 marks out of 50.*

(iii) If a student has obtained 80 points in a 1 Credit Course, then it may be converted as: *20 marks out of 25.*

In such course(s), where direct numerical grades are awarded in place of points, these numerical grades shall be converted into marks by using the following formula:

Marks in the Course = Numerical grade in the Course x 10

However, any change may be recommended in this pattern by the UATEC, from time to time.

14.1. Continuous Internal Assessment:

14.1.1 The Continuous Internal Assessment of the students' learning and performance shall be carried out by the Course Teacher(s). Considering the nature of the course, the teacher(s) shall decide the mode of Continuous Internal Assessment, which may include one or more assessment tools, such as student's class performance, assignments, class tests, take-home tests, term paper(s), presentations, oral-quizzes, case studies and laboratory work etc.

14.1.2 Each Course Teacher shall design the Continuous Internal Assessment system for the course she/he offers with the approval of the Departmental Committee (DC). This approved design of Continuous Internal Assessment shall be announced to the students of the respective courses at the beginning of each semester by the concerned teacher.

14.1.3 Generally, each course shall be taught by one teacher only, who shall maintain all the records related to attendance, teaching and assessment in a systematic manner. In an exceptionally rare case, if a teacher is assisted in teaching by other teacher, the teacher (in-charge of the course) shall be responsible for coordinating teaching and assessment, including award of final grade.

14.1.4 In case a student fails to appear in any Continuous Internal Assessment, it will be taken care by the concerned Course Teacher at her/his level.

14.2. End-Semester Examination:

14.2.1 Generally, End-Semester theory question paper shall include a limited number of very short answer type questions followed by short and long questions covering the entire syllabus in such a way that the question paper ensures assessing students' knowledge, understanding, application and analysis-synthesis/reflection of the subject. Thus, a standard model format of the End-Semester Examination paper consisting of 70 points shall be as under –

Section-A: 15 very short questions of 02 points each = 30 points
(Short specific questions covering the entire syllabus to be given which should be answered in approximately 50 words by the examinee).

Section-B: 04 short questions of 05 points each = 20 points
(05 short questions to be given out of which 04 questions are to be attempted in approximately 200 words by the examinee).

Section-C: 02 long questions of 10 points each = 20 points
(03 long questions to be given out of which 02 questions are to be attempted in approximately 500 words by the examinee).

However, a different format of the End-Semester question paper for some particular course (e.g., project, dissertation or laboratory/field work etc.) may be prescribed by the Board of Studies (BoS) of the Department which shall come into force only after the approval of the competent authority of the University.

14.2.2 The duration of the End-Semester theory examination generally shall be of three hours.

14.2.3 The DC shall appoint one or more team(s), as per the need, of preferably three faculty members in each team for moderation of question papers of End-Semester Examinations and communicate the same to the Controller of Examinations. The task of moderation shall be organized by the Controller of Examinations.

The paper setter and the moderator(s) shall ensure and certify that question paper is comprehensive to cover all important topics/themes/course and fit for assessing the mastery of the entire course. They shall also ensure and certify that not more than 10% questions from the previous year question paper have been repeated.

14.3 In exceptional cases, depending upon the nature of a particular course, a totally different mode of assessment and evaluation may be prescribed by the BoS of the Department for the course, which shall come into force only after the approval of the competent authority of the University. However, it must be reflected in the detailed syllabus of the course and be available to the students at the beginning of the semester.

14.4 Any partial or complete change in the system of examination (Assessment & Evaluation) may be recommended by the UATEC which shall be implemented only after the approval of the competent authority.

14.5 A student is required to secure a minimum of 'P' grade in the Continuous Internal Assessment and in the End-Semester Examination, taking together, in a course.

14.6 Making Evaluated Answer-scripts Available to the Students:

14.6.1 All the examination answer-scripts shall be made available to the students after evaluation by the respective teachers as per the schedule decided by the concerned teachers or the University. In case of the End-Semester Examination, the evaluated answer scripts shall be made available to the students within 7 days of the last examination for the semester. Thereafter, within a week, all the answer books along with the statement of marks shall be sent by the concerned teacher through her/his Department to the Office of the Controller of Examinations for declaration of the results.

14.6.2 If a student is not satisfied with the evaluation of her/his answer script, s/he must submit a written objection to the concerned Head of the Department (offering the course) within 8 days from the last examination for the semester. Such complaint shall be looked after by a panel of three faculty members, including the concerned teacher, to be nominated by the concerned Head of the Department, whose decision shall be final. The revised points, if any, shall be submitted by the panel to the concerned Head of Department who shall further submit it to the Controller of Examinations. This complete process of grievance redressal by the panel and the further submission of marks by the Head of Department, generally, should not take more than 7 days from the date of receipt of the grievance. However, in case of any controversy, the matter shall be referred to the Vice-Chancellor for final decision and action.

14.6.3 Once evaluated answer books are submitted to the Controller of Examinations, there shall be no re-evaluation/re-totaling thereafter.

14.7 Letter Grades and Grade Points:

An absolute grading system shall be adopted to grade the students.

14.7.1. Under the absolute grading system, points shall be converted to grades based on pre-determined class intervals.

14.7.2. In the End-Semester theory or practical examinations, the examiner shall award the points and these points after adding the points of Continuous Internal Assessment shall be further converted into Grades/Grade points in accordance with the provisions of this ordinance.

14.7.3. Detail Grade Sheet issued by the Controller of Examinations office at the end of the semester shall carry points /percentage and equivalent grades (numerical and letter) both.

14.7.4. The 10-point Grading System, with the Letter Grades as given under shall be followed:

Letter Grade	Numerical Grade Point	Class Interval (in %)
O (Outstanding)	10	Above 90 and ≤ 100
A+ (Excellent)	9	Above 80 and ≤ 90
A (Very Good)	8	Above 70 and ≤ 80
B+ (Good)	7	Above 60 and ≤ 70
B (Above Average)	6	Above 50 and ≤ 60
C (Average)	5	Above 45 and ≤ 50
P (Pass)	4.5	40 to 45
F (Fail)	0	< 40
Ab (Absent)	0	Absent

Note:

(i) F= Fail, and the students graded with 'F' in a Programme or Course shall be required to re-appear in the examination.

(ii) The minimum qualifying points for a course shall be 45% (i.e., 'P' grade).

(iii) The students shall have to qualify in the Continuous Internal Assessment and the End-Semester examinations taking together.

(iv) Before awarding numerical grade to the points obtained in a course, only the total of Continuous Internal Assessment and End-Semester Examination shall be rounded off to remove the decimal point. Thus, no separate rounding off shall be done of the points obtained in different components of Continuous Internal Assessment and End-Semester Examination.

(v) There shall be rounding off of SGPA/CGPA up to two decimal points.

(vi) The SGPA/CGPA obtained by a student shall be out of a maximum of 10 points.

(vii) In order to be eligible for the award of the M.Sc. (Mathematics) Degree of the University, a student must obtain CGPA of 4.50 at the end of the Programme.x

(viii) Provided that the student who is otherwise eligible for the award of the M.Sc. Degree but has secured a CGPA of less than 4.50 at the end of the minimum permissible period of semesters may be allowed by the Department to repeat the same course(s) or other courses of the same type in lieu thereof in the extra semesters provided in Clause 11 related to the duration of Programme.

(ix) The Cumulative Grade Point Average (CGPA) obtained by a student shall be classified into the following division/Class:

CGPA	Class/ Division
Above 9	Outstanding
Above 8 to 9	First Class (With Distinction)
6 to 8	First Class
5.5 to < 6	High-Second Class
5 to < 5.5	Second Class
4.5 to < 5	Third Class

14.8. Re-appear in the End-Semester Examination:

14.8.1 Once a student has fulfilled the attendance requirements in a course as per the provisions mentioned in this ordinance but has failed to score minimum grade required to qualify the Course or failed to appear in the End-Semester Examination of the course, may be allowed to re-appear in the End-Semester Examination, in such course, in the extra semesters provided under the Clause 11 on duration of Programme.

14.8.2. Such student may avail the chance to re-appear only within the maximum duration of the Programme. The re-appearance shall be permitted only in the End-Semester Examination of the concerned course(s) and the marks obtained by the student in the Continuous Internal Assessment conducted earlier for the particular course(s) shall be carried forward to be added with the marks obtained by her/him in the latest End-Semester Examination of the respective course(s).

14.8.3. The re-appear examination of even semesters shall be conducted along with the End-Semester Examinations of even semesters. Similarly, the re-appear examinations of odd semesters shall be conducted along with the End-Semester Examinations of odd semesters.

14.8.4. The re-appear examination shall be based on the syllabi of the course in force at the time of initial registration to the course.

14.8.5 A student who is re-appearing for the End-Semester Examination as per the clause 14.8.1 above; can re-appear in the subsequent semester(s), whenever the examination of a particular course is held, on payment of Rs. 2000/- (may be revised time to time by the University) per course in addition to the prescribed semester fee of the semester in which she/he has been promoted/provisionally promoted, if applicable, within the maximum permissible duration for the Programme.

14.8.6 A student who has got the Migration/Transfer Certificate issued from the University shall not be allowed to re-appear in the End-Semester Examination.

14.9 Re-appear in the End-Semester Examination for Improvement of Grade(s):

14.9.1 If a student wishes to improve her/his grade(s) in any course (s), s/he can re-appear in the End-Semester Examination in the subsequent odd/even semester(s), whenever the examination of the particular course(s) is held, on payment of Rs. 2000/- (may be revised time to time by the University) per course in addition to the prescribed semester fee of the semester in which she/he has been promoted/provisionally promoted, if applicable, within the maximum permissible duration for the Programme of study of the student.

14.9.2 A student may improve her/his points/grade by reappearing in the End-Semester Examination of a course as per the provisions of reappearing mentioned above. In such cases points obtained by the student in the Continuous Internal Assessment of the particular course shall be carried forward to the subsequent End-Semester Examination of the course. However, in such case, the points/grades obtained on the basis of latest appeared End-Semester Examination shall be considered for calculation of final CGPA of the Programme.

14.9.3 The re-appear examination of a course for improvement of grade shall be based on the syllabi of the course in force at the time of initial registration to the course.

14.9.4 A student who has got the Migration/Transfer Certificate issued from the University shall not be allowed to re-appear in any examination for improvement of grade.

14.10 Repeating course(s):

14.10.1 A student having attendance shortage in any course may repeat the course by taking re-admission in that course in subsequent odd/even semester(s), whenever the course is being offered, within the maximum permissible duration of the Programme.

14.10.2 If a student repeats a course she/he has to fulfill all the desired requirements afresh including attendance, Continuous Internal Assessment and the End-Semester Examination. In such case the course content shall be based on the syllabi of the course in force at the time of repeat of the course. However, at the time of repeating, if the same course is not being offered by the Department due to any reason, the student may choose any other course of similar nature and credits from the available courses on recommendation of the Mentor and approval of the concerned Head of Department.

14.10.3 If a student repeats a course, she/he has to submit a fee of Rs. 3000/- (may be revised time to time by the University) per course in addition to the prescribed semester fee of the semester in which she/he has been promoted/provisionally promoted, if applicable.

14.11 Promotion Rules:

14.11.1 A student shall be declared as **'Promoted'** to the next semester when s/he earns 'P' Grade or above in the last concluded semester examination, maintaining the spirit and pattern of semester system and covering the mandatory components, such as Continuous Internal Assessment and End-Semester Examinations in all the courses for which s/he was registered till date.

14.11.2 A student shall be **'Provisionally Promoted'** to the next semester if she/he secures less than 'P' grade in **maximum three courses** out of the total courses registered by her/him till date.

14.11.3 A student shall be deemed as **'Failed'** in a semester when she/he gets below 'P' Grade in **more than three courses** or does not appear in the End-Semester Examination of **more than three courses**, after fulfilling the attendance requirements as per this ordinance, out of the total courses registered by her/him till date. In such case(s), a student has to re-appear in the End-Semester Examination of the course(s) in subsequent odd/even semester(s) within the maximum permissible duration of the Programme on payment of Rs. 2000/- (may be revised time to time by the University) per course. Since, such student does not need to attend the classes of the course(s) again; the marks of Continuous Internal Assessment obtained by her/him in the course(s) earlier shall be carried forward to be added with the marks obtained by her/him in the latest End-Semester Examination of the respective course(s).

14.11.4 A student shall also be deemed as **'Failed'** in a semester when she/he failed to appear in the End-Semester Examinations of more than three courses due to the attendance criteria mentioned in 18.4 of this ordinance. Such student has to repeat the courses in the subsequent odd/even semester(s), whenever the courses are being offered, within the maximum permissible duration of the Programme, on payment of the prescribed fees as per the clause 14.10.3.

14.11.5 Under no circumstances, any student shall be permitted to register in a new course if she/he is having less than 'P' Grade in more than three courses.

14.11.6 A student shall be declared to have passed the Programme of study and award of the degree if she/he has secured the required credits with at least 'P' grade.

14.11.7 The re-examination of End-Semester Examination of the failed or provisionally promoted students shall be as per the clauses/sub-clauses under 14.8 above. However, only in a case where a student of final semester (within the minimum prescribed duration of the Programme) fails to appear or to achieve 'P' grade in maximum three courses including all backlogs after the result declaration of final semester, the Department may ask the concerned course Teacher(s) to conduct re-examination of End-Semester Examinations of such course(s) within a month from commencement of the next semester relaxing the condition of odd/even semester as given in 14.8.3 the student shall have to pay a fee of Rs. 2000/- per course.

14.11.8 If a candidate is repeating a course in an academic session, whatever may be the reason, it shall not be counted in the total number of seats and shall not affect the fresh intake of the M.Sc. (Mathematics) Programme in that academic session.

14.12 **Minimum Credit Requirements:**

For a two-year M.Sc. (Mathematics) Degree Programme, the credit requirements shall be 96 credits, including core and elective courses as prescribed in the detailed syllabus attached with this ordinance and regulations. A minimum of 8 credits and maximum of 16 credits shall be from elective courses offered by other Department(s).

15. Computation of SGPA and CGPA:

The University shall follow the following procedure to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

15.1. The SGPA is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student in a particular semester and sum of the number of credits of all the courses undergone by a student in that semester, i.e.,

SGPA (Si) = $\sum (Ci \times Gi)/\sum Ci$

Where, Ci is the number of credits of the i^{th} course and Gi is the grade point scored by the student in the i^{th} course.

15.2. The CGPA is also calculated in the same manner taking into account all the considerable courses as per the provision laid down in this ordinance out of the total courses undergone by a student over all the semesters of a Programme, i.e.,

$$CGPA = \sum (C_i \times G_i)/\sum C_i$$

Where, Ci is the number of credits of the i^{th} course (which is to be considered for the award of the PG Degree) and Gi is the grade point scored by the student in the i^{th} course.

15.3. The SGPA and CGPA shall be rounded off to 2 decimal points.

15.4 Since, the calculation of CGPA is not based on all the courses undergone by student, rather it is governed by other provisions laid down in this ordinance like, clause 7.2.3, 13.5 etc., the CGPA may differ from the corresponding calculations based on SGPA only.

16. Illustration of Computation of SGPA and CGPA:

16.1. Illustration for computing SGPA:

Course	Credit	Grade Letter	Grade Point	Credit Point
Course I	3	A	8	3 x 8 = 24
Course II	4	B+	7	4 x 7 = 28
Course III	3	B	6	3 x 6 = 18
Course IV	3	O	10	3 x 10 =30
	Total credits for the semester = 13			Total Credit points Earned = 100

Thus, SGPA = 100/13 = 7.69

16.2 Illustrations for computing CGPA:

Courses Considered for the Award of the Degree	Completed in the month (Year)	Credit	Grade Letter	Grade Point	Credit Point
Course I	Dec 2018	4	A	8	4 x 8 = 32
Course II	Dec 2018	4	B+	7	4 x 7 = 28

Course III	June 2019	4	B	6	4 x 6 = 24
Course IV	June 2020	4	O	10	4 x 10 = 40
		Total credits for the semester =16			Total Credit points earned= 124

Thus, CGPA= 124/16= 7.75

Note: Formula to calculate percentage from CGPA/SGPA= CGPA or SGPA x 10; and formula to calculate percentage to CGPA or SGPA = Percentage/10,

e.g., In case of example mentioned in Table 16.2, the percentage of CGPA = 7.75 x 10 = 77.50%

16.3. Transcript (Format): Based on the above, letter grades, grade points, and the SGPA, the Transcripts/Detail Grades Certificates (DGCs) shall be issued to the candidates for each semester and a consolidated transcript on completion of the Programme indicating the performance in all the courses considered for calculating the CGPA. Along with the CGPA, the percentage of marks obtained in the Programme shall be reflected in this consolidated transcript on the basis of the CGPA. However, this system may be changed by the University at any point of time without prior notice to the stakeholders as per the need.

17. Removal of Student Name from the Programme:

The name of a student falling under any one of the following categories shall automatically stand removed from the rolls of the University:

(a) A student who has failed to fulfill the minimum grade point requirements prescribed for the Programme during the maximum duration of the Programme.

(b) A student who has already exhausted the maximum duration allowed for completion of the Programme and has not fulfilled the requirements for the award of the degree.

(c) A student who is found to be involved in misconduct, forgery, indiscipline or any other objectionable conduct, upon recommendation of the Disciplinary Committee/ Proctorial Board or any other procedure deemed fit by the University.

(d) A student who has failed to attend the classes as stipulated under the clause of attendance requirements in this ordinance.

18. Attendance Rules:

18.1 A student is required to attend 100% of the classes held in a course in the specific semester in order to be eligible to appear in the End-semester examination of that particular course.

18.2 Waiving of attendance-deficit up to a maximum of 25% is permissible to accommodate following situations:

(a) Representing the University in any inter-collegiate, inter-University, local, national or international events; (b) Participating in an activity of the University with prior permission of the Competent Authority; (c) Participation in NCC/NSC/NSS Camps duly supported by certificate. (d) Participation in Educational Excursions, which form a part of teaching in any subject, conducted on working days duly certified by the concern Course Teacher/ Head of Department /Dean; and (e) to cover all unforeseen reasons like illness, hospitalization, personal engagements elsewhere or other personal reasons which compel a student to absent herself/himself from attending the classes.

18.3 Hence, it shall be mandatory/compulsory to every student to have attendance in 75% classes held in particular course. No waiver, for whatsoever reason, shall be given. Accordingly, no application requesting waiver below 75% attendance shall be entertained by the University. However, a further relaxation up to 10% or the days spent (whichever is lesser) on the basis of situations mentioned under a, b & c of Clause 18.2 above (not on the basis of d of Clause 18.2) may be considered by the Vice-Chancellor on the recommendation of the Head/In charge of the Department. In any other situation no appeal can be made for this purpose even to the Vice-Chancellor.

18.4 A student, however, shall not be allowed to appear in the End-Semester Examination of the courses which are not covered under above mentioned clauses 18.1, 18.2 and 18.3. Such a student shall be permitted to repeat the courses in the subsequent odd/even semester(s), whenever the courses are being offered, within the maximum permissible duration of the Programme, on payment of the prescribed fees as per the clause 14.10.3. However, in the first semester, for repeating the courses, it shall be mandatory for a student to have minimum 40% attendance in aggregate (taken together all the courses registered by her/him in the semester). If a student does not put in at least 40% of aggregate attendance in the first semester, she/he shall have to leave the Programme without claiming refund of any fees, and her/his admission shall be treated as cancelled.

18.5 The attendance of a newly admitted candidate shall be counted from the date of her/his admission/registration or date of beginning of classes, whichever is later. In the case of promoted candidates, attendance shall be counted from the date on which respective class begins. However, if a new student is admitted late after the commencement of the classes, s/he must get herself/himself registered in the desired courses following the due procedure within 5 working days after the admission failing which her/his attendance shall be counted after 5 working days from the date of admission.

18.6 In a case of changed registration as per the clause 13.3 of this ordinance the total classes held for calculating percentage of attendance in the newly registered course for a particular student shall be counted from the fresh registration in that particular course.

18.7 Monthly records of attendance of students in each of the courses taught by a teacher is to be prepared and submitted by the concerned teacher to the Office of the Head/In charge of the Department (HoD) and the Controller of Examinations' (CoE) office by the 10th day of the next month after displaying it to the students in the course and taking their signatures. The teacher will keep the original record of attendance with her/him and submit it finally to both the offices with her/his remarks regarding the eligibility of a student for appearing in the end semester examination within three working days after the last class or teaching day in the semester, whichever is later. Any failure in compliance in this matter must be informed by the concerned teacher to the Head of Department and the Controller of Examinations with justification.

18.8 There shall be an Attendance Monitoring Committee in the Department under the Chairmanship of the Head or her/his nominee for proper monitoring of attendance records and taking suitable action(s) as per the requirements.

19. Programme Structure:

The M.Sc. (Mathematics) Programme shall be of two year duration divided into four semesters. A student is required to earn at least 96 credits within the stipulated time as per the details given in **Annexure-1.**

20. Power to Relax and Amendments

20.1 All the above clauses are subject to the amendments, as and when required, as per the decisions pertaining to rules, regulations and norms of the University Statutory Bodies and other Regulatory Bodies etc. from time to time.

20.1.1 Notwithstanding what is contained in the foregoing clauses of this ordinance, the Academic Council may, in exceptional circumstances consider at its discretion and for reasons to be recorded, relax any of the provisions except those prescribing CGPA requirements.

20.2 Notwithstanding anything stated in this ordinance, for any unforeseen issues arising, and not covered by this ordinance, or in the event of differences of interpretation, the Vice-Chancellor may take a decision, after obtaining the opinion/advice, if required, of UATEC. The decision of the Vice-Chancellor shall be final.

Annexure – I

CENTRAL UNIVERSITY OF SOUTH BIHAR

Master of Science in Mathematics (M.Sc.) Programme Syllabus

(Effective from Academic Session 2018-2019)

Department of Mathematics

School of Mathematics, Statistics and Computer Science

Central University of South Bihar, Gaya
School of Mathematics, Statistics and Computer Science

DEPARTMENT OF MATHEMATICS

Two years M.Sc. (Mathematics) Programme
Under CBCS Scheme of UGC

COURSE STRUCTURE		
Sl. No.	**Course Division**	**Credits**
1.	Core courses (14) + Project	56+16=72
2.	Elective courses from the Department (2)	8
3.	Elective course out of Department (4)	16
	Total Credits	**96**

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)	
I	To provide students with a strong foundation in mathematical, scientific fundamentals so as to comprehend, analyse, design and create solutions for automation of real life processes.
II	To inculcate in students' professional and ethical attitude, effective communication skills, leadership, team work skills, multidisciplinary approach, and an ability to relate application based issues to broader social context.
III	To provide student with an academic environment with awareness of excellence, and the life-long learning needed for a successful professional career.

PROGRAM OUTCOMES (PEOs)	
1	An ability to apply knowledge of mathematics in different fields.
2	An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
3	An ability to function on multidisciplinary teams.
4	An ability to identify, formulate and solve real world problems.
5	An understanding of professional and ethical responsibility.
6	An ability to communicate effectively.
7	The broad education necessary to understand the impact of Mathematics solutions in a global and societal context.
8	Recognition of the need for, and an ability to engage in lifelong learning.
9	Knowledge of contemporary issues.
10	An ability to use the techniques, skills and modern Mathematical tools necessary for application based practices.
11	An ability to design and develop principles for solving complex problems of Mathematics.
12	An ability to plan, organize and use appropriate methods to carry on tasks within a given frame work.

COURSE STRUCTURE			
Sl. No.	**Course Code**	**Course Title**	**Credits**
Semester I			
1.	MSMTH1001C04	Real Analysis-I	4
2.	MSMTH1002C04	Linear Algebra	4
3.	MSMTH1003C04	Discrete Mathematics	4
4.	MSMTH1004C04	Ordinary Differential Equations and Laplace Transformation	4
5.	MSMTH1005C04	Operation Research	4
6.		Elective (Out of the Department of Mathematics)	4
Semester II			
7.	MSMTH2001C04	Complex Analysis	4
9.	MSMTH2002C04	Algebra-I	4
9.	MSMTH2003C04	Topology	4
10.	MSMTH2004C04	Measure and Integration	4
11.		Elective (Out of the Department of Mathematics)	4
12.		Elective (from the Department of Mathematics)	4
Semester III			
13.	MSMTH3001C04	Functional Analysis	4
14.	MSMTH3002C04	Algebra-II	4
15.	MSMTH3003C04	Partial Differential Equation and Fourier Analysis	4
16.	MSMTH3004C04	Numerical Analysis	4
17.	MSMTH3005C04	Project	6
		Project Seminar	2
Semester IV			
18.	MSMTH3005C04	Project continued	6
		Project Viva	2
19.	MSMTH4001C04	Probability and Statistics	4
20.		Elective (from the Department of Mathematics)	4
21.		Elective (from the Department of Mathematics)	4
22.		Swayam Course/Elective out of the school	4
		Total Credits	**96**

CORE COURSES				Page Number
Sl. No.	Course Code	Course Title	Credits	
Semester I				
1.	MSMTH1001C04	Real Analysis	4	9
2.	MSMTH1002C04	Linear Algebra	4	11
3.	MSMTH1003C04	Discrete Mathematics	4	13
4.	MSMTH1004C04	Ordinary Differential Equations and Laplace	4	16
5.	MSMTH1005C04	Operation Research	4	19
Semester II				
6.	MSMTH2001C04	Complex Analysis	4	21
7.	MSMTH2002C04	Algebra-I	4	24
8.	MSMTH2003C04	Topology	4	27
9.	MSMTH2004C04	Measure and Integration	4	29
Semester III				
10.	MSMTH3001C04	Functional Analysis	4	31
11.	MSMTH3002C04	Algebra-II	4	33
12.	MSMTH3003C04	Partial Differential Equation and Fourier Analysis	4	35
13.	MSMTH3004C04	Numerical Analysis	4	37
14.	MSMTH3005C04	Project	6	
		Project Seminar	2	
Semester IV				
15.	MSMTH3005C04	Project continued	6	
		Project Viva	2	
16.	MSMTH4001C04	Probability and Statistics	4	39
		Total Credits	72	

ELECTIVE BASKET				Page Number
S. No	Course Code	Course Name	Credits	
Semester II				
1.	MSMTH2001E04	Mechanics	4	43
2.	MSMTH2002E04	Calculus of Variations and Integral Equations	4	45
3.	MSMTH2003E04	Differential Geometry	4	47
4.	MSMTH2004E04	Graph Theory	4	49
5.	MSMTH2005E04	Number Theory	4	51
Semester IV				
6.	MSMTH4001E04	Fluid Mechanics	4	53
7.	MSMTH4002E04	Formal Languages and Automata Theory	4	55
8.	MSMTH4003E04	Numerical Solutions to PDE	4	57
9	MSMTH4004E04	Group Theory	4	59
10	MSMTH4005E04	Commutative Algebra	4	61
11	MSMTH4006E04	Algebraic Number Theory	4	63
12	MSMTH4007E04	Introduction to Finite Fields and Coding Theory	4	65
13	MSMTH4008E04	Lie Algebra	4	67
14	MSMTH4009E04	Operator Theory	4	69
15	MSMTH4010E04	Representation Theory Finite Groups	4	71
16	MSMTH4011E04	Algebraic Geometry	4	73
17	MSMTH4012E04	Spectral Graph Theory	4	75
18	MSMTH4013E04	Wavelet Analysis	4	77
19	MSMTH4014E04	Mathematical Cryptography	4	79

SWAYAM COURSES		
S. No.	Course Code	Course Name
1	MSMTH4007E04	Probability and Stochastic for Finance.
2	MSMTH4008E04	Partial Differential Equations for Engineers Solution by Spare.
3	MSMTH4009E04	Application of Molecular Geometry & Group Theory

SKILL BASED/SELF-STUDY COURSES (NON-CREDIT)		
S. No.	Course Code	Course Name
1	MSMTH40010E04	LATEX
2	MSMTH40011E04	MAT LAB

Syllabus
Core Courses

Course Details			
Course Title: Real Analysis-I			
Course Code	MSMTH1001C04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	I	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion, Presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives

- To understand the axiomatic foundation of the real number system, in particular the notion of completeness and some of its consequences.
- To understand the concepts of limits, limit points, sequence, continuity and Uniform continuity, in real line as well as in arbitrary Metric spaces.
- To understand the concepts of Homeomorphisms, Compactness, connectedness, and completeness in Metric spaces.

Learning Outcomes

Upon completion of this course, the student will be able to:

- Understand basic properties of R, such as its characterization as a complete and ordered field, Archimedean Property, density of Q and R\Q and unaccountability of each interval.

- Classify and explain open and closed sets, limit points, convergent and Cauchy convergent sequences, complete spaces, compactness, connectedness, and uniform continuity etc. in a metric space.

- Know how completeness, continuity and other notions are generalized from the real line to metric spaces.

Course Contents

UNIT I **(10% Weightage)**

Brief review of family of sets, indexing set, finite and infinite sets, countable and uncountable sets, Cantor's theorem, cardinal numbers, Schröder-Bernstein theorem, ordered fields, the field of real numbers, Archimedean property, density of rational numbers, the extended real number system.

UNIT II **(30% Weightage)**

Euclidean spaces, metric spaces, metric induced by norm, open ball, closed ball, open and closed sets, interior, exterior, closure, boundary points and their properties, Sequences in metric spaces, Complete Metric spaces, Completion of a metric space; relatively open sets in a subspace, Continuous function and Uniform continuity in Metric spaces.

UNIT III **(30% Weightage)**

Compact spaces; Heine-Borel theorem, finite intersection property, totally bounded set, Bolzano - Weierstrass theorem, sequentially compactness; Connected sets, connected subsets of real numbers, Intermediate value theorem, connected components, totally disconnected sets, , Cantor's Intersection Theorem.

UNIT IV **(30% Weightage)**

Riemann Integration and Riemann Stielzet Integration and its properties;
Pointwise and Uniform convergence of sequences of functions, Uniform convergence and continuity, uniform convergence and integration, uniform convergence and differentiation.

Content Interaction Plan:

Lecture cum Discussion **(Each session of 1 Hour)**	**Unit/Topic/Sub-Topic**
1-2	Brief review of family of sets, indexing set, finite and infinite sets, Countable and uncountable sets.
3-4	Cantor's theorem, cardinal numbers.
5 -6	Schröder-Bernstein theorem, ordered fields, the field of real numbers, Archimedean property, density of rational numbers, the extended real number system.
7-9	Riemann integration
10-13	Riemann Steitelt integration and properties
14-15	Euclidean spaces, metric spaces, metric induced by norm.
16-19	Open ball, closed ball, open and closed sets, interior, exterior, closure, boundary points and their properties.
19-25	Sequences in metric spaces, relatively open sets in a subspace, Continuous function and Uniform continuity in Metric spaces.
26-29	Compact spaces; Heine-Borel theorem, finite intersection property, totally bounded set, Bolzano - Weierstrass theorem, sequentially compactness
30-35	Connected sets, connected subsets of real numbers, Intermediate value theorem, connected components, totally disconnected sets
35-40	Complete Metric spaces, Cantor's Intersection Theorem, Completion of a metric space.
41-45	Pointwise and Uniform convergence of sequences of functions, Uniform convergence and continuity, uniform convergence and integration, uniform convergence and differentiation.
15 Hours	*Tutorials*

Suggested Texts/References:

- R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd edition, John Wiley & Sons, Inc., New York, 2000.
- W. Rudin, Principles of Mathematical Analysis, 5th edition, McGraw Hill Kogakusha Ltd., 2004.
- N. L. Carother, Real Analysis, Cambridge University Press, 2000.
- T. Apostol, Mathematical Analysis, 5th edition, Addison-Wesley, Publishing Company, 2001.
- S. Kumaresan, Topology of Metric Spaces, 2nd edition, Narosa Book Distributors Pvt Ltd, 2011.

Course Details			
Course Title: Linear Algebra			
Course Code	MSMTH1002C04	Credits	4
L + T + P	3 + 1 + 0	Course Duration	One Semester
Semester	I	Contact Hours	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives

- To develop the understanding of concepts through examples, counter examples and problems.
- To orient the students with tools and techniques of Linear Algebra.
- To develop a skill to solve problems.

Learning Outcomes

After completion of the course the learners should be able to:

- solve system of linear equations
- check vector space and subspace.
- determine kernel and range space of a linear transformation.
- find the matrix of linear transformation.
- check whether given matrix or transformation is diagonal or not.
- determine Jordan Canonical form of a matrix.
- check bilinear form.
- determine the signature of real symmetric bilinear form.
- determine the orthogonal basis in an inner product space.
- find orthonormal matrix to diagonalize a Hermition matrix.

Course Contents

UNIT I: **(weightage 20%)**

System of linear equations, Basis and Dimension of a vector space, Sum and Direct sum of subspaces, Quotient spaces, Linear transformation, Null space, range space, Matrix representation of a linear transformation, Effect of change of basis on Matrix representation, rank and nullity of matrix, Fundamental theorem of homomorphism, Algebra of linear transformation, Hom(V,W) as a vector space, dual space, annihilator of a subset of a vector space

Unit II: **(weightage 25%)**

Invariant subspaces, Eigen values, Eigen vectors, Characteristic polynomials of a linear transformation, Diagonalization of a matrix with distinct Eigen values, Cayley Hamilton Theorem. Jordan Canonical forms.

Unit III **(weightage 25%)**

Bilinear forms on a vector space and examples, Matrix of a Bilinear from, Symmetric and Skew-symmetric bilinear forms, Definition of a Quadratic form, matrix of a quadratic form, Reduction to normal form, Orthogonal and congruent reduction., Sylvester's Law of Inertia. positive definiteness.

Unit IV **(weightage 30%)**

Inner product space: Definition and Examples, Norm of a Vector, orthogonally, Orthonormal set, Gram Schmidt orthogonalization, Orthogonal complement, adjoint of a linear transformation. Self-adjoint operator, Unitary operator, Orthogonal, Unitary, Hermitian, skew-Hermitian, symmetric and skew-symmetric matrices. Orthogonal reduction of symmetric matrices, Unitary reduction of Hermitian matrices. Polar and Singular value decomposition.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	Unit/Topic/Sub-Topic
1-2	System of linear equations
3-4	Basis and Dimension of a vector space, Sum and Direct sum of subspaces, Algebra of linear transformation,
5-6	Quotient spaces, Linear transformation,
7-8	Null space, range space, Matrix representation of a linear transformation,
9-10	Effect of change of basis on Matrix representation, rank and nullity of matrix, Fundamental theorem of homomorphism,
11-12	Hom(V,W) as a vector space, dual space, annihilator of a subset of a vector space
13-14	Invariant subspaces, Eigen values, Eigen vectors, Characteristic polynomials of a linear transformation,
15-16	Diagonalization of a matrix with distinct Eigen values,
17-18	Cayley Hamilton Theorem.
19-20	Jordan Canonical forms.
21-22	Bilinear forms on a vector space and examples, Matrix of a Bilinear from,
23-24	Symmetric and Skew-symmetric bilinear forms,
25-26	Definition of a Quadratic form, matrix of a quadratic form,
27-28	Reduction to normal form,
29-30	Orthogonal and congruent reduction., Sylvester's Law of Inertia.
31-32	positive definiteness.
33-34	Inner product space: Definition and Examples,
35-36	Norm of a Vector, orthogonally, Orthonormal set,
37-38	Gram Schmidt orthogonalization, Orthogonal complement
39-40	adjoint of a linear transformation. Self-adjoint operator,
41-42	Unitary operator, Orthogonal, Unitary, Hermitian, skew-Hermitian, symmetric and skew-symmetric matrices.
43-45	Orthogonal reduction of symmetric matrices, Unitary reduction of Hermitian matrices. Polar and Singular value decomposition and problems

- Texts/References

- K. Hoffman and R. A. Kunze, Linear Algebra, 3rd edition, Prentice Hall, 2002.
- S. Lang, Introduction to Linear Algebra, 3rd Edition, Addition-Wesley, 1999.
- M. Artin, Algebra, Prentice Hall of India, 1991.
- G. Strang, Linear Algebra and its Applications, Thomas Brooks/Cole. 2006.
- Promode Kumar Saikia, Linear Algebra, Pearson, Education. 2009.

Course Details			
Course Title: Discrete Mathematics			
Course Code	MSMTH1003C04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	I	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion, Self-study, Seminar, Presentations by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives

- Simplify and evaluate basic logic statements including compound statements, implications, inverse, converses, and contrapositives using truth tables and the properties of logic.
- Express a logic sentence in terms of predicates, quantifiers, and logical connectives.
- Apply the operations of sets and use Venn diagrams to solve applied problems; solve problems using the principle of Inclusion-Exclusion.
- Describe binary relations; determine if a binary relation is reflexive, symmetric, or transitive or is an equivalence relation; combine relations using set operations and composition.
- Use elementary number theory including the divisibility properties of numbers to determine prime numbers and composites, the greatest common divisor, and the least common multiple; perform modulo arithmetic and computer arithmetic.
- Solve counting problems by applying elementary counting techniques using the product and sum rules, permutations, combinations, the pigeon-hole principle, and the binomial expansion.
- Represent a graph using an adjacency matrix and graph theory to application problems such as computer networks.
- Determine if a graph has an Euler or a Hamilton path or circuit.

Learning Outcomes

After successful completion of this course, students should be able with:

- Constructing proofs.
- Elementary formal logic.
- Set algebra.
- Relations and functions.
- Combinatorial analysis.
- Recurrence relations.
- Graphs, digraphs, trees, Eulerian and Hamiltonian graphs.

Course Contents

UNIT I: Propositional Logic and Relations **(20 % Weightage)**

- Statements, Logical connectives, Truth tables, Equivalence, Inference and deduction, Predicates, Quantifiers.
- Relations and their compositions, Equivalence relations, Closures of relations, Transitive closure and the Warshall's algorithm, Partial ordering relation, Hasse diagram, Recursive functions.

UNIT II: Number Theory **(25 % Weightage)**

- Divisibility, The Division Algorithm, The greatest common divisors, The Euclidean algorithm, Linear Diophantine equations, Primes and their distribution, The fundamental theorem of arithmetic.
- Congruence, Chinese remainder theorem, Fermat Little theorem, Wilson theorem, Euler's Phi- function, Mobius function and Mobius inversion formula.
-

UNIT III: Combinatorics **(25 % Weightage)**

- The Pigeonhole Principle, Permutations and Combinations; Derangements, The Inclusion Exclusion Principle and Applications, Recurrence Relations and Generating functions, Catalan and Stirling numbers.
-

UNIT IV: Graph Theory **(30% Weightage)**

- Basic concepts of graphs, directed graphs and trees, Adjacency and incidence matrices, Spanning tree, Kruskal's and Prim's algorithms, Shortest Path, Dijkstra's algorithm, Planar Graphs, Graph Coloring, Eulerian and Hamiltonian graphs.
-

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-2	Relations and their compositions, Equivalence relations.
3-4	Closures of relations, Transitive closure and the Warshall's algorithm.
5	Partial ordering relation, Hasse diagram, Recursive functions.
6-7	Statements, Logical connectives, Truth tables, Equivalence.
8-10	Inference and deduction, Predicates, Quantifiers.
11-12	Divisibility, Division algorithm, Greatest common divisors, Euclidean algorithm.
13-14	Linear Diophantine equations, Primes and their distribution, Fundamental theorem of arithmetic.
15-17	Congruence, Chinese remainder theorem, Fermat Little theorem, Wilson theorem.
18-20	Euler's Phi- function, Mobius function and Mobius inversion formula.
21-23	Pigeonhole principle, Permutations, Combinations.
24-25	Derangements, Inclusion Exclusion principle and Applications.
26-29	Recurrence Relations and Generating functions.
30-31	Catalan and Stirling numbers.
32-33	Basic concepts of graphs, directed graphs and trees,
34	Adjacency and incidence matrices,

35-36	Spanning tree, Kruskal's and Prim's algorithms.
37	Shortest Path, Dijkstra's algorithm.
38-39	Planar Graphs.
40-41	Graph Coloring.
42-43	Eulerian graphs.
44-45	Hamiltonian graphs.

Suggested References:

- J. P. Trembley and R. P. Manohar, *Discrete Mathematical structures with Applications to Computer Science,* McGraw Hill.
- D. E. Burton, *Elementary Number Theory*, Tata McGraw-Hill.
- Richard A. Brualdi, *Introductory Combinatorics,* Pearson.
- N. Deo, *Graph Theory with Applications to Engineering and Computer Science,* Prentice Hall of India, 1980.
- R. P. Grimaldi, *Discrete and Combinatorial Mathematics,* Pearson Education, 1999.
- C.L. Liu, *Elements of Discrete Mathematics,* McGraw-Hill, 1977.
- I. Rosen, *Discrete Mathematics,* Tata McGraw Hill.

Course Details			
Course Title: Ordinary Differential Equations and Laplace Transformation			
Course Code	MSMTH1004C04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	I	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		
Prerequisite	• ODE course of undergraduate level		

Course Objectives

- To learn Picard's method of Successive Approximations
- To learn p- discriminants and c-discriminants, Singular solutions
- Learn to solve linear differential equations of higher-order
- Learn to solve differential equations with variable coefficients.
- Learn to use Laplace transform methods to solve differential equation

Learning Outcomes

After completion of the course the learners will be able to:

- Successive Approximations using successive approximation
- Find p- discriminants and c-discriminants
- Find singular solution
- Determine if a set of functions is linearly dependent or independent by definition and by using the Wronskian.
- Solve homogenous linear equations with constant coefficients.
- Solve application problems modeled by linear differential equations.
- Use power series methods to solve differential equations about ordinary points.
- Use the Method of Frobenius to solve differential equations about regular singular points.
- Find the Laplace transform of a function using the definition.
- Find the inverse Laplace function of a function. c. Use the Translation Theorems to find Laplace transforms.
- Find the Laplace transform of derivatives, integrals and periodic functions.
- Use the method of Laplace transforms to solve initial-value problems for linear differential equations with constant coefficients.

Course Contents

UNIT I: **(30% Weightage)**

Picard's method of Successive Approximations, Lipschitz' conditions, Existence and Uniqueness Theorems of Picard, p- discriminants and c-discriminants, Singular solutions, Existence and Uniqueness Theorems for systems of first order equations, Global Existence and uniqueness criteria, Equivalent first order systems for higher order equations, Criteria for convertibility of a system of equation into a higher order equation in one of the unknowns, General theory for linear systems, Wronskians and method of variation of parameters, Matrix methods for linear systems with constant coefficients.

UNIT II: **(30% Weightage)**

Power series method for general linear equations of higher order, Solutions near an ordinary point, Regular and Logarithmic solutions near a regular singular point, Legendre equation, Orthogonality relations for Legendre polynomials, Rodrigues' formula, Recurrence relations, Bessel's equation, Bessel functions of I and II kind, Recurrence relations, Zeros of Bessel functions, Orthogonality relations.

UNIT III: **(10% Weightage)**

Eigenvalue problems, self adjoint problems, Sturm-liouville problems, Eigenfunction and expansion formula.

UNIT IV: **(30%Weightage)**

Laplace transforms, Existence criteria, Properties, Transforms of standard functions, Transforms of derivatives and integrals, Derivatives and integrals of Transforms, Inverse Laplace transforms, Existence and uniqueness criteria, Exponential shifts, inverse of products of transforms, convolution theorem, Applications to Initial value problems.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	Unit/Topic/Sub-Topic
1	Picard's method of Successive Approximations, Lipschitz' conditions
2-3	Existence and Uniqueness Theorems of Picard, p- discriminants and c-discriminants, Singular solutions
4-5	Existence and Uniqueness Theorems for systems of first order equations
6-7	Global Existence and uniqueness criteria, Equivalent first order systems for higher order equations
8-9	Criteria for convertibility of a system of equation into a higher order equation in one of the unknowns
10-11	General theory for linear systems, Wronskians and method of variation of parameters
12-13	Matrix methods for linear systems with constant coefficients
14	Power series method for general linear equations of higher order
15-16	Solutions near an ordinary point
17-18	Regular and Logarithmic solutions near a regular singular point
19-20	Legendre equation, Orthogonality relations for Legendre polynomials
21-22	Orthogonality relations for Legendre polynomials, Rodrigues' formula, Recurrence relations
22-24	Bessel's equation, Bessel functions of I and II kind
25-26	Recurrence relations, Zeros of Bessel functions, Orthogonality relations.
27-30	Eigenvalue problems, Sturm-Liouville problems
31-32	Eigen function and expansion formula, self adjoint problems
33-34	Laplace transforms, Existence criteria, Properties,
37-39	Transforms of standard functions, Transforms of derivatives and integrals, Derivatives and integrals of Transforms
40-42	Inverse Laplace transforms, Existence and uniqueness criteria, Exponential shifts, inverse of products of transforms, convolution theorem
43-45	Applications to Initial value problems

Suggested References:

1. B. Rai, D.P. Choudhury and H.I. Freedman, *A Course in Ordinary Differential Equations*, Narosa Publishing House, New Delhi, 2002.
2. E. A. Coddington, *An Introduction to Ordinary Differential Equations*, Prentice Hall of India, New Delhi, 1968.
3. L. Elsgolts, *Differential Equations and Calculus of Variations*, Mir Publishers, 1970.
4. G. F. Simons, *Differential Equations*, Tata MacGraw Hill, New Delhi, 1972.

Course Details			
Course Title: Operations Research			
Course Code	MSMTH1005C04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	I	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		
Prerequisite	• Linear Algebra, Statistics, Matrix		

Course Objectives

- To acquaint the students with the principles and methods of Operations Research
- To orient the students with major link between mathematics and its applications.
- To develop a skill to formulate (if possible) problems.

Learning Outcomes

After completion of the course the learners should be able to:

- The basic results associated to different types of Topics and its applications.
- The student has knowledge of central concepts from Simplex Method, Duality, Transportation and Assignment problem, Game theory, Queuing and Non linear Analysis.
- Be able to produce examples illustrating the mathematical concepts presented in the course.
- Understand the statements and proofs of important theorems and be able to explain the key steps in proofs.

Course Contents

Unit I **(weightage 25%)**

Linear Programming: Convex sets, hyperplanes and half spaces, vertices of a convex set, polyhedron and polytopes, separating and supporting hyperplanes, basic definitions and theorems for a general linear programming problems using convex sets theory, A simple LPP model and its graphical solution, standard form of a general LPP, basic feasible solutions, Simplex method and algorithm, M Technique, Two-phase Technique, Duality.

Unit II **(weightage 25%)**

Mathematical formulation of transportation and assignment problems, balanced and unbalanced transportation problems, Initial basic feasible solutions of a T.P.using North-west corner rule, the Least Cost method and Vegel's approximation method (VAM), the optimum solution of a T.P. using u-v Method., Hungarian method for solving an assignment problem, Salesman routing problems, Problems of maximization.

Unit III **(weightage 25%)**

Game Theory: Basic concepts, pure and mixed strategies, Two Person Zero sum matrix game, saddle point and maximin minimax principle, reduction of size of pay off matrix by dominance rules, mixed strategies for games without saddle point, 2 x 2 games, 2 x n & n x 2 games, graphical method, subgames method, Matrix method for n x n games, ($n \geq 3$), solution of a game by linear programming method.

Unit IV **(weightage 25%)**

Non-Linear Programming: Kuhu-Tucker conditions, Quadratic programming and its solution by Wolfe's Method and Beale's Method, Poisson distributions, Kendall's Notation for representing Queueing Models, Single-Channel Queueing Theory, Single-channel Poisson Arrivals with Exponential Service Times, Infinite- Population (M/M/1) (FCFS/ ∞) and (M/M/1) (SIRO/ ∞).

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-6	Linear Programming: Convex sets, hyperplanes and half spaces, vertices of a convex set, polyhedron and polytopes, separating and supporting hyperplanes, basic definitions and theorems for a general linear programming problems using convex sets theory.
5-8	A simple LPP model and its graphical solution, standard form of a general LPP, basic feasible solutions,
9-11	Simplex method and algorithm, M Technique, Two-phase Technique, M Technique
12-13	Duality.
14-17	Mathematical formulation of transportation and assignment problems, balanced and unbalanced transportation problems, Initial basic feasible solutions of a T.P.using North-west corner rule, the Least Cost method and Vegel's approximation method (VAM), the optimum solution of a T.P. using u-v Method.
18-20	Hungarian method for solving an assignment problem, Salesman routing problems, Problems of maximization.
21-24	Game Theory: Basic concepts, pure and mixed strategies, Two Person Żero sum matrix game, saddle point and maximin minimax principle, reduction of size of pay off matrix by dominance rules,
25-30	Mixed strategies for games without saddle point, 2 x 2 games, 2 x n & n x 2 games, graphical method, subgames method, Matrix method for n x n games, ($n \geq 3$), solution of a game by linear programming
31-36	Non-Linear Programming: Kuhu-Tucker conditions,
37-40	Quadratic programming and its solution by Wolfe's Method and Beale's Method,
41-42	Poisson distributions, Kendall's Notation for representing Queueing Models, Single-Channel Queueing Theory, Single-channel Poisson
43-45	Arrivals with Exponential Service Times, Infinite- Population (M/M/1) (FCFS/ ∞) and (M/M/1) (SIRO/ ∞).
15	Tutorial

Texts/ References

- Robert J. Vanderbei, Linear Programming Foundations and extensions, 3rd Edition, Springer.
- 2008.
- H. A. Taha, Operations Research An Introduction, 7th Edition, Pearson Education.
- P. K. Gupta & D. S. Hira, Operations Research, S. Chand and Co., New Delhi.
- V. K. Kapoor and S. Kapoor, Operation Research, Sultan Chand and Sons, New Delhi.
- Kanti Swarup , P. K. Gupta, Man Moha, Operation research, Sultan Chand & Sons (New Delhi)

Course Details			
Course Title: Complex Analysis			
Course Code	MSMTH2001C04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	II	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		
Prerequisite	• Real Analysis course of undergraduate level		

Course Objectives

- learning the concepts of analyticity, Cauchy-Riemann relation, harmonic functions and the concepts and types of singularities.
- evaluation of a complex integral using parameterization, fundamental theorem of calculus, Cauchy's integral theorem and Cauchy's integral formula;
- learning of power series to find the Taylor series and Laurent series of a function
- compute the residue of a function and use the residue theory to evaluate a contour integral or an integral over the real line;
- learning of conformal mapping with applications
- study of Meromorphic function and its applications
- study of analytic continuation and its applications

Learning Outcomes

After completion of the course the learners will be able to:

- justify the need for a Complex Number System and explain how is related to other existing number systems
- define a function of complex variable and carry out basic mathematical operations with complex numbers.
- know the condition(s) for a complex variable function to be analytic and/or harmonic. .
- define singularities of a function, know the different types of singularities, and be able to determine the points of singularities of a function.
- evaluate the complex integrals.
- find the Taylor's and Laurent's series of the functions.
- evaluate contour integrals or an integral over the real line using residue theory.
- know linear and bilinear transformations and their mappings.
- know about Meromorphic functions and its applications.
- know about analytic continuations and its applications.

Course Contents

UNIT I: **(10% Weightage)**
Review of functions of several variables, Limits and Differentiability of function of several variables, partial derivatives and directional derivatives.

UNIT II: **(30% Weightage)**
Differentiable functions, Analytic and Harmonic Functions, The Cauchy-Riemann Equations. Complex Integrals, Contours and Contours Integrals, The fundamental theorem of Integration, Cauchy's Integral Theorem, Independence of path, Cauchy's integral formula. Morera's theorem, Liouville's theorem, Fundamental theorem of algebra.

UNIT III: **(30 % Weightage)**
Infinite series, sequence and series of functions, Power series, Power series expansion of an analytic functions, The zeroes of an analytic function, Taylor's and Laurent series, Singularities, Maximum Modulus Principle. Cauchy's residues Theorem, evaluation of contour integral and integral over the real line using residue theorem.

UNIT IV: **(30%Weightage)**
Meromorphic function, Argument Principle, Rouche's Theorem, Hurwitz's theorem, Critical Points, Winding Numbers, Analytic continuation, Conformal mappings and Mobius Transformation.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1	Brief introduction, Course outline, Introduction to complex number system
2, 3-4	Introducing Complex Variables, Operations with Complex numbers, Conjugate and Absolute values of complex numbers, Graphical Representation of Complex numbers, Polar form of complex numbers, De Moivres' theorem
5-8	More on Complex number: Definitions of some basic concepts, Limits and continuity of functions of complex variables, Differentiability and continuity, Derivation of Cauchy-Riemann equations, Analytic and Harmonic functions
9-8	Introduction to the line integration, simply and multiply connected domains, Introduction to the contour integration,
10-12	Cauchy's Integral Theorem (with proof) and its deduction for multiply connected domain, Independence of path
13-14	Cauchy's integral formula and its derivative form
15-18	The fundamental theorem of Integration, Morera's theorem (with proof) Liouville's theorem (with proof)
19-20	Infinite series, sequence and series of functions
21-22	Power series, Convergence of power series
23-26	Taylor's and Laurent series, The zeroes of an analytic function Singularities
27-28	Maximum Modulus Principle. Cauchy's residues Theorem (with proof)
29-32	Evaluation of contour integral and integral over the real line using residue theorem.
33-34	Meromorphic function, Argument Principle, Critical Points, Winding Numbers
35-36	Rouche's Theorem (with proof), Hurwitz's theorem (with proof)
37-38	Introductory idea of holomorphic function and homotopic functions
39-40	Open mapping and Inverse Function Theorems with their proofs

41-45	Conformal mappings and Mobius Transformations

Suggested References:

- Spiegel, M.R. (1988). Schaum's Outline of Theory and Problems of Complex Variable. Mcgraw-Hill Book Company, Singapore.
- Stroud, K.A. (1996). Further Engineering Mathematics. 3rd Edition. The Bath Press, London, Great Britain.
- Lang, S. (1976). Complex Analysis, Addison Wesley Publishing Company, Ontario, Canada.
- Priestley, H.A. (1990). Introduction to Complex Analysis. Oxford University Press, Oxford, U.K.
- J. B. Conway (1973), Functions of Complex variable, Narosa publication.
- 5. R. V. Churchill (2009), J.W. Brown, Complex Variables and Applications, McGraw-Hill International

Course Details			
Course Title: Algebra I			
Course Code	MSMTH2002C04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	II	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		
Prerequisite	• Basic knowledge of Groups and Ring		

Course Objectives

- To develop the understanding of concepts through examples, counter examples and problems.
- To orient the students with tools and techniques of Algebra.
- To develop a skill to solve problems.

Learning Outcomes

After completion of the course the learners should be able to:

- check subgroup, normal subgroup, subring, ideal.
- determine kernel and range space of a group homomorphism.
- understand Symmetric group, Dihedral group.
- solve problems related to Sylow groups.
- understand difference among ID,PID,UFD and ED.
- check the irreducibility of polynomials.

Course Contents

UNIT I: **(weightage 25%)**

A brief review of groups, their elementary properties and examples, subgroups, cyclic groups. homomorphism of groups and Lagrange's theorem; permutation groups, permutations as products of cycles, even and odd permutations, normal subgroups, quotient groups. isomorphism theorems, correspondence theorem, conjugacy classes in S n and A_n , simplicity of A_n.

Unit II **(weightage 25%)**

Normal and subnormal series, composition series, Jordan-Holder theorem, solvable groups, Group action; Cayley's theorem, group of symmetries, dihedral groups and their elementary properties; orbit decomposition; counting formula; class equation, consequences for p-groups; Sylow's theorems (proofs using group actions). Applications of Sylow's theorems, direct product; structure theorem for finite abelian groups; invariants of a finite abelian group (Statements only)

Unit III **(weightage 25%)**

Basic properties and examples of ring, domain, division ring and field; direct products of rings, characteristic of a domain, field of fractions of an integral domain, ring homomorphisms, ideals, factor rings prime and maximal ideals, principal ideal domain.

Unit IV **(weightage 25%)**

A Euclidean domain, unique factorization domain; brief review of polynomial rings over a field, reducible and irreducible polynomials, Gauss' theorem for reducibility of f(x) ∈ Z[x], Eisenstein's criterion for irreducibility of f(x) ∈ Z[x] over Q, roots of polynomials.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	Unit/Topic/Sub-Topic
1-2	A brief review of groups, their elementary properties and examples,
3-4	subgroups, cyclic groups,
5-6	homomorphism of groups and Lagrange's theorem;
7-8	permutation groups,
9-10	permutations as products of cycles, even and odd permutations,
11-12	normal subgroups, quotient groups,
13-14	isomorphism theorems, correspondence theorem,
15-16	conjugacy classes in S n and A_n , simplicity of A_n
17-18	Cayley Hamilton Theorem.
19-20	Normal and subnormal series, composition series,
21-22	Jordan-Holder theorem, solvable groups,
23-24	Group action; Cayley's theorem, group of symmetries, dihedral groups and their elementary
25-26	properties; orbit decomposition; counting formula; class equation, consequences for p-groups;
27-28	Sylow's theorems (proofs using group actions). Applications of Sylow's theorems,
29-30	direct product; structure theorem for finite abelian groups; invariants of a finite abelian group (Statements only)
31-32	Basic properties and examples of ring, domain, division ring and field;
33-34	direct products of rings, characteristic of a domain, field of fractions of an integral domain,
35-36	ring homomorphisms, ideals, factor rings prime and maximal ideals,
37-38	principal ideal domain, A Euclidean domain,
39-40	unique factorization domain;
41-42	brief review of polynomial rings over a field, reducible and irreducible polynomials,
43-45	Gauss' theorem for reducibility of f(x) ∈ Z[x], Eisenstein's criterion for irreducibility of f(x) ∈ Z[x] over Q, roots of polynomials and problems.

Texts/ References

- N. Jacobson, Basic Algebra I, 3rd edition, Hindustan Publishing corporation, New Delhi, 2002.
- I. N. Herstein, Topics in Algebra, 4th edition, Wiley Eastern Limited, New Delhi, 2003.
- J. B. Fraleigh, A First Course in Abstract Algebra, 4th edition, Narosa Publishing House, New Delhi, 2002.
- D. S. Dummit and R.M. Foote, Abstract Algebra, John Wiley & Sons, 2003.
- M. Artin, Algebra, Prentice Hall of India, 1994.
- P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, Basic Abstract Algebra, 3rd edition.
- Cambridge University Press, 2000.
- 7. Joseph A Gallian, Contemporary Abstract Algebra, Narosa Publishing House PVT. L.T.D.

Course Details			
Course Title: Topology			
Course Code	MSMTH2003C04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	II	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion, Presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives

- To teach the fundamentals of point set topology
- Constitute an awareness of need for the topology in Mathematics.

Learning Outcomes

Upon completion of this course, the student will be able to:

1. Understand to construct topological spaces from metric spaces and using general properties of neighbourhoods, open sets, close sets, basis and sub-basis.
2. Apply the properties of open sets, close sets, interior points, accumulation points and derived sets in deriving the proofs of various theorems.
3. Understand the concepts of countable spaces and separable spaces.
4. Understand the concepts and properties of the compact and connected topological spaces.

Course Contents

UNIT I **(25% Weightage)**

Definition and examples of topological spaces (including metric spaces), Open and closed sets, Subspaces and relative topology, Closure and interior, Accumulation points and derived sets, Dense sets, Neighbourhoods, Boundary, Bases and sub-bases, Alternative methods of defining a topology in terms of the Kuratowski closure operator and neighbourhood systems.

UNIT II **(25 % Weightage)**

Filter and Ultra filter, Continuous functions and homeomorphism, Quotient topology, First and second countability and separabilty, Lindelöf spaces, Separation axioms T_0, T_1, T_2, T_3, $T_{3½}$, and T_4 and their characterizations, Uryschn's lemma, Tietze's extension theorem.

UNIT III **(25 % Weightage)**

Compactness, Compactness and the finite intersection property, Local compactness, One-point compactification, Connected spaces, Connectedness of the real line, Components, Locally connected spaces, Path connectedness

UNIT IV **(25% Weightage)**

Product topology in terms of the standard sub-base and its characterizations, Product topology and separation axioms, connectedness, countability properties and compactness, Tychonoff's theorem.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-4	Definition and examples of topological spaces (including metric spaces). Open and closed sets.
5-7	Subspaces and relative topology, Closure and interior, Accumulation points and derived sets,
8-11	Dense sets, Neighbourhoods, Boundary, Bases and sub-bases, Alternative methods of defining a topology in terms of the Kuratowski closure operator and neighbourhood systems
12-15	Filter and Ultra filter
16-19	Continuous functions and homeomorphism, Quotient topology, First and second countability and separabilty.
20-23	Lindelöf spaces, Separation axioms T_0, T_1, T_2, T_3, $T_{3\frac{1}{2}}$, and T_4 and their characterizations, Urysohn's lemma, Tietze's extension theorem.
24-26	Compactness, Compactness and the finite intersection property.
27-30	Local compactness, One-point compactification, Connected spaces,
31-34	Connectedness of the real line, Components, Locally connected spaces, Path connectedness.
35-37	Product topology in terms of the standard sub-base and its characterizations.
38-41	Product topology and separation axioms, connectedness.
42-45	Countability properties and compactness, Tychonoff's theorem.
15 Hours	*Tutorials*

Suggested Texts/References:

- J. L. Kelley, General Topology, Van Nostrand, 1995.
- K. D. Joshi, Introduction to General Topology, Wiley Eastern, 1983.
- James R. Munkres, Topology, 2nd Edition, Pearson International, 2000.
- J. Dugundji, Topology, Prentice-Hall of India, 1966.
- George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 1963.
- S. Willard, General Topology, Addison-Wesley, 1970.

Course Details			
Course Title: Measures and Integration			
Course Code	MSMTH2004C04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	II	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion, Self-study, Seminar, Presentations by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives

- To give a very streamlined development of a course in Lebesgue integration.
- To introduce the concept of Lebesgue measure.
- To develop the theory of Lebesgue integration which gives stronger and better results as compared to the theory of Riemann integration?
- To study the measurable sets and Lebesgue measurable functions.
- To provide a basis for further studies in Analysis, Probability, and Dynamical Systems.

Learning Outcomes

After successful completion of this course, students should be able to:

- Describe the basic properties of Lebesgue measure and measurable functions.
- Construct the Lebesgue integral, elucidate its basic properties.
- Appreciate the existence of other useful integration theories besides Riemann's.
- Understand the basic features of Lp-spaces.
- Use the ideas of this course in unseen situation.

Course Contents

UNIT I: **(20% Weightage)**

- Review of Riemann Integral, Its drawbacks and Lebesgue's recipe to extend it. Extension of length function.
- Semi-algebra and algebra of sets, Lebesgue outer measure, Measurable sets, Measure space, complete measure space.

UNIT II: **(25 % Weightage)**

- The Lebesgue measure on **R**, Properties of Lebesgue measure, Uniqueness of Lebesgue Measure, Construction of non-measurable subsets of **R.**

UNIT III: **(30 % Weightage)**

- Lebesgue integration: The integration of non-negative functions, Measurable functions, Fatou's Lemma.
- Integrable functions and their properties, Lebesgue's dominated convergence theorem.

UNIT IV: **(25% Weightage)**

- Absolutely continuous function, Lebesgue-Young theorem (without proof). Fundamental theorem of Integral calculus and its applications. Product of two measure spaces, Fubini's theorem.
- Lp-spaces, Holder's inequality, Minkowski's inequality, Completion of Lp-spaces.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-2	Review of Riemann Integral, Its drawbacks and Lebesgue's recipe to extend it.
3-4	Extension of length function.
5-6	Semi-algebra and algebra of sets.
7-8	Lebesgue outer measure.
9-10	Measurable sets.
11-12	Measure space, complete measure space.
13-15	The Lebesgue measure on **R**, Properties of Lebesgue measure.
16-17	Uniqueness of Lebesgue Measure.
18-19	Construction of non-measurable subsets of **R**.
20-24	Integration of non-negative functions.
25-27	Measurable functions.
28-29	Fatou's Lemma.
30-31	Integrable functions and their properties.
32	Lebesgue's dominated convergence theorem.
33-34	Absolutely continuous function, Lebesgue-Young theorem (without proof).
35-36	Fundamental theorem of Integral calculus and its applications.
37-39	Product of two measure spaces, Fubini's theorem.
40-43	Lp-spaces, Holder's inequality, Minkowski's inequality.
44-45	Completion of Lp-spaces.
15 Hours	*Tutorials*

Suggested References:

- Inder K. Rana, An introduction to Measure and Integration, Narosa, 1997.
- G. De Barra, Measure Theory and Integration, John Wiley and Sons, 1981.
- J. L. Kelly, T. P. Srinivasan, Measure and Integration, Springer, 1988.

Course Details			
Course Title: Functional Analysis			
Course Code	MSMTH3001C04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	III	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		
Prerequisite	• Linear Algebra, Real Analysis I, Metric Space		

Course Objectives

- To acquaint the students with the principles and methods of functional analysis.
- To orient the students with major link between mathematics and its applications.
- To develop a skill to formulate (if possible) problems.

Learning Outcomes

After completion of the course the learners should be able to:

- The basic results associated to different types of convergences in normed spaces and its applications.
- The student has knowledge of central concepts from functional analysis, including the Hahn-Banach theorem, the open mapping and closed graph theorems, the Banach-Steinhaus theorem, dual spaces, weak convergence, the Banach-Alaoglu theorem, and bounded self-adjoint operators.
- Be able to produce examples and counterexamples illustrating the mathematical concepts presented in the course.
- Understand the statements and proofs of important theorems and be able to explain the key steps in proofs.

Course Contents

Unit I **(weightage 25%)**

Normed linear spaces, Quotient norm, Banach spaces and examples, l^p spaces as Banach spaces, Bounded linear transformations on normed linear spaces, B(X,Y) as a normed linear spaces, Open mapping and closed graph theorems, Uniform boundedness principle,

Unit II **(weightage 25%)**

Hahn-Banach theorem and its applications, Dual space, Separability, Reflexivity, Finite dimensional norm linear space, Reisz lemma, Weak and weak* convergence of operators,

Unit III **(weightage 25%)**

Inner product spaces, Hilbert spaces, Orthogonal sets, Bessel's inequality, Complete orthonormal sets and Parseval's identity, Structure of Hilbert spaces, Projection theorem, Riesz representation theorem, Riesz-Fischer theorem,

Unit IV **(weightage 25%)**

Adjoint of an operator on a Hilbert space, Reflexivity of Hilbert spaces, Self-adjoint operators, Positive, projection, normal and unitary operators and their basic properties.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	Unit/Topic/Sub-Topic
1-2	Normed linear spaces, Quotient norm
3-4	Banach spaces and examples
5-6	l^p spaces as Banach spaces
6-9	Bounded linear transformations on normed linear spaces, B(X,Y) as a normed linear spaces,
10-11	Open mapping
12-13	closed graph theorems
14-15	Uniform boundedness principle
16-17	Hahn-Banach theorem and its applications
18-20	Dual space, Separability, Reflexivity
21-23	Finite dimensional norm linear space, Reisz lemma,
24-26	Weak and weak* convergence of operators,
27-29	Inner product spaces
30-32	, Hilbert spaces
33-35	Orthogonal sets, Bessel's inequality, Complete orthonormal sets and Parseval's identity, Structure of Hilbert spaces
36-37	Projection theorem, Riesz representation theorem, Riesz-Fischer theorem
38-39	Adjoint of an operator on a Hilbert space, Reflexivity of Hilbert spaces,
40-41	Self-adjoint operators, Positive, projection
42-45	normal and unitary operators and their basic properties.

Texts/ References

- G. Bachman and L. Narici, Functional Analysis, Academic Press, 1966.
- J. B. Conway, A First Course in Functional Analysis, Springer, 2000.
- R. E. Edwards, Functional Analysis, Holt Rinehart and Winston, 1965.
- C. Goffman and G. Pedrick, First Course in Functional Analysis, Prentice-Hall of India, 1987.
- B. V. Limaye, Functional Analysis, New Age International, 1996.
- G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 1963.
  W. Rudin, Principles of Mathematical Analysis, 5th edition, McGraw Hill Kogakusha Ltd., 2004.

Course Details			
Course Title: Algebra-II			
Course Code	MSMTH3002C04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	III	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion, Presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives

This course focuses on theory of fields and Galois Theory. The main objective of the course is to study Galois correspondence and its applications to solvability of polynomial equations and classical problems of ruler-compass constructions. The course also aims to give the introduction to Finite fields.

Learning Outcomes

Upon completion of this course, the student will be able to:

- Prove that a given field extension is a Galois extension.
- Identify the Galois Group of a given Galois extension and describe the action of this on the set of roots.
- Apply the Galois Correspondence to analyze specific examples of finite field extensions
- Prove that quantic is not solvable by radicals
- Prove that squaring the circle and doubling the cube is not possible by ruler and compass.
- Prove the fundamental theorem of algebra using Galois Theory.

Course Contents

UNIT I **(25% Weightage)**

Field Extensions, finite extensions, algebraic and transcendental elements, adjunction of algebraic elements, Kronecker theorem, algebraic extensions, splitting fields.

UNIT II **(25 % Weightage)**

Simple and multiple roots of polynomials, criterion for simple roots, separable and inseparable polynomials, perfect fields, separable and inseparable extensions, Structure of finite fields, Irreducible polynomials over finite fields, roots of unity and cyclotomic polynomials

UNIT III **(25 % Weightage)**

Algebraically closed fields and algebraic closures, primitive element theorem, Normal extensions, Automorphism groups and fixed fields, Galois pairing, determination of Galois groups, Fundamental theorem of Galois Theory, Norms and Traces.

UNIT IV **(25% Weightage)**

Solvability by radicals, solvability of algebraic equations, symmetric functions, ruler and compass constructions, Fundamental theorem of algebra, Abelian and Cyclic extensions, Infinite algebraic extensions.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	Unit/Topic/Sub-Topic
1-3	Field Extensions, finite extensions.
4-7	Algebraic and transcendental elements, adjunction of algebraic elements, Kronecker theorem.
8 -11	Algebraic extensions, splitting fields.
12-15	Simple and multiple roots of polynomials, criterion for simple roots.
16-19	Separable and inseparable polynomials, perfect fields, separable and inseparable extensions,
20-23	Structure of finite fields, Irreducible polynomials over finite fields, roots of unity and cyclotomic polynomials.
24-27	Algebraically closed fields and algebraic closures.
28-31	Primitive element theorem, Normal extensions, Automorphism groups and fixed fields.
32-34	Galois pairing, determination of Galois groups, Fundamental theorem of Galois Theory, Norms and Traces.
35-37	Solvability by radicals, solvability of algebraic equations, symmetric functions.
38-40	Ruler and compass constructions, Fundamental theorem of algebra.
41-45	Abelian and Cyclic extensions. Infinite algebraic extensions.
15 Hours	*Tutorials*

Suggested Texts/References:

- Patrick Morandi, Fields and Galois Theory, Springer (GTM), 2010.
- Steven Roman, Field Theory, Springer (GTM).
- S. Lang, Algebra, Springer.
- D. S. Dummit and R. M. Foote, Abstract Algebra, 2nd Ed., John Wiley, 2002.
- Emil Artin, Galois Theory, Dover Publication, INC.

Course Details			
Course Title: Partial Differential Equation and Fourier Analysis			
Course Code	MSMTH3003C04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	III	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		
Prerequisite	• Differential and Integral calculus		

Course Objectives

- To acquaint the students with application of Fourier analysis and its application in solving PDE
- To orient the students with tools and techniques of solving PDE
- To develop skills to apply PDE in engineering problems
- To enable students understanding of geometrical interpretation of PDE

Learning Outcomes

After completion of the course the learners will be able to:

- To solve linear and non linear PDE
- To apply Fourier series in solving PDE
- Solve Heat and wave equations
- Formulate mechanical problems in PDE
-

Course Contents

UNIT I: **(30% Weightage)**

Formation of P.D.E's, P.D.E's of first order, Classification of equations and integrals, Complete, general, singular and special integrals, Lagrange's or Quasi- linear equations, Integral surfaces through a given curve, Surfaces orthogonal to a given system of surfaces, Pfaffian differential equations, Cauchy's Method of Characteristics, Compatible systems, Charpit's method and Jacobi's method.

UNIT II: **(30% Weightage)**

Classification of second order P.D.E.'s, Reduction to canonical forms, Linear equations with constant coefficients, Separation of variables, The method of Integral Transform, Laplace, Diffusion and wave equation in various coordinate systems.

UNIT III: **(20 % Weightage)**

Fourier analysis: Periodic functions, trigonometric series, Fourier series, Euler formulas, Functions having arbitrary periods, Even and odd functions, Half range expansions, Approximation by Trigonometric Polynomials, Fourier Integral.

UNIT IV: **(20%Weightage)**

Fourier Transform (including cosine and sine transforms), Solution of PDE using Fourier transforms, Boundary value problems on transverse vibrations of strings and heat diffusion in rods.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	Unit/Topic/Sub-Topic
1-2	Formation of P.D.E's, P.D.E's of first order,
3-4	Classification of equations and integrals, Complete, general, singular and special integrals,
5-6	Lagrange's or Quasi- linear equations,
7-8	Integral surfaces through a given curve, Surfaces orthogonal to a given system of surfaces,
9-10	Pfaffian differential equations, and some exercise
11-12	Cauchy's Method of Characteristics, Compatible systems
13-14	Charpit's method and Jacobi's method.
15-17	Classification of second order P.D.E.'s, Reduction to canonical forms, and some examples
18-20	Linear equations with constant coefficients, Separation of variables.
21-22	The method of Integral Transform,
23-24	Nonlinear Equation of the second order (Monge's Method),
25-27	Laplace, Diffusion and wave equation in various coordinate systems.
28-30	Fourier analysis: Periodic functions, trigonometric series, Fourier series, Euler formulas
31-33	Functions having arbitrary periods, Even and odd functions, Half range expansions,
34-35	Approximation by Trigonometric Polynomials,
36	Fourier Integral.
37-39	Fourier Transform (including cosine and sine transforms),
40-42	Solution of PDE using Fourier transforms,
43-45	Boundary value problems on transverse vibrations of strings and heat diffusion in rods.
15 Hours	*Tutorials*

- Suggested References:
- N. Sneddon, *Elements of Partial Differential Equations*, McGraw Hill Publications.
- T. Amaranath, *Partial Differential Equations*, Narosa Publ.
- P. Prasad and R. Ravindran, *Partial Differential Equations*, Wiley Eastern Ltd, New Delhi, 1991.
- C. R. Chester, *Techniques in Partial Differential Equations*, McGraw-Hill, New York, 1971.
- L. C. Evans, *Partial Differential Equations*, Graduate Studies in Mathematics, Vol 19, American Mathematical Society, 1999.

Course Details			
Course Title: Numerical Analysis			
Course Code	MSMTH3004C04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	IV	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		
Prerequisite	• Matrix Algebra , System of linear equations, sequence of real numbers		

Course Objectives

- To acquaint the students with application of Numerical analysis and its application engineering and applied sciences
- To orient the students with tools and techniques of solving algebraic and transcendental equations
- To understand interpolation theory to estimate missing data by using interpolation
- To learn numerical methods to solve differential equations
- To understand the error analysis and convergence of numerical scemes

Learning Outcomes

After completion of the course the learners will be able to:

- To solve algebraic and transcendental equations approximately
- Interpolate missing value of a statistical data
- To find numerical solution of Boundary value problems
-

Course Contents

UNIT I: **(25% Weightage)**

General Theory of Approximations and Errors, Scientific notation for representing decimal numbers, Floating point arithmetic, Valid significant digits, Absolute and Relative errors and error bounds, Errors of sum, difference, product, quotient, power and root, General formula for Errors. Solutions of arbitrary equations, Methods of Bisection, Fixed point iteration, Regula-falsi,and Newton-Raphson together with their convergence and error bounds.

UNIT II: **(25% Weightage)**

Interpolation, Lagrangian and Divided difference interpolation formulas along with error estimates, Calculus of operators Δ,δ,μ,E,D etc. Gregory-Newton forward and backward interpolation formulas with error estimates, Central difference interpolation formulas of Gauss (forward and backward), Stirling, Bessel and Everett Inverse interpolation, Spline interpolation, Numerical Differentiation.

UNIT III: **(25 % Weightage)**

Numerical Integration,Newton-Cotes Formulas,Trapezoidal, Simpson's 1/3 and 3/8- rules along with error estimates, Euler-Maclaurin formula. Numerical techniques for solution of Ordinary differential equations, Incremental methods, Euler's and Improved Euler's methods, Fourth order, Runge-Kutta method along with error bounds, Predictor-Corrector methods of Adams-Bashforth-Moulton and Milne's types with error estimates.

UNIT IV: **(25%Weightage)**

Numerical Linear Algebra, Gaussian elimination and Gauss-Jordan methods for solving systems of linear equations, LU and Cholesky decomposition and solutions of linear systems and matrix inversion using these decompositions, Gauss-Jacobi and Gauss-Seidel Iterative methods and their convergence, Estimation of eigenvalues and eigenvectors, Gerschgorin's circles, Power method for the first and second dominant eigenvalues along with convergence criteria.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1	General Theory of Approximations and Errors,
2-3	Scientific notation for representing decimal numbers, Floating point arithmetic, Valid significant digits,
4-7	Absolute and Relative errors and error bounds, Errors of sum, difference, product, quotient, power and root, General formula for Errors,
8	Solutions of arbitrary equations, Methods of Bisection,
9-11	Fixed point iteration, Regula- falsi,and Newton-Raphson together with their convergence and error bounds.
12-14	Interpolation, Lagrangian and Divided difference interpolation formulas along with error estimates,
14	Calculus of operators Δ,δ,μ,E,D etc.
15-16	Gregory-Newton forward and backward interpolation formulas with error estimates,
17-18	Central difference interpolation formulas of Gauss (forward and backward)
19-20	Stirling, Bessel and Everett Inverse interpolation, Spline interpolation,
21-22	Numerical Differentiation
23	Numerical Integration,Newton-Cotes Formulas,
24-26	Simpson's 1/3 and 3/8- rules along with error estimates, Euler-Maclaurin formula
27-29	Numerical techniques for solution of Ordinary differential equations, Incremental methods, Euler's and Improved Euler's methods,
30-31	Fourth order Runge-Kutta method along with error bounds,
32-33	Predictor-Corrector methods of Adams-Bashforth-Moulton and Milne's types with error estimates.
34-36	Numerical Linear Algebra, Gaussian elimination and Gauss-Jordan methods for solving systems of linear equations,
37-38	LU and Cholesky decomposition and solutions of linear systems and matrix inversion using these decompositions,
39-40	Gauss-Jacobi and Gauss-Seidel Iterative methods and their convergence.
41-42	Estimation of eigenvalues and eigenvectors
43-45	Gerschgorin's circles, Power method for the first and second dominant eigenvalues along with convergence criteria.
15 Hours	*Tutorials*

- Suggested References:
- D. Prasad, *Introduction to Numerical Analysis*. Narosa Publishing House.
- M. K. Jain, S. R. K. Iyengar& R. K. Jain, *Numerical Methods for Scientific and Engineering Computation*, New Age.
- K. Sankar Rao, *Numerical Methods for Scientists and Engineers*, Prentice Hall of India.
- S. D. Conte & C.de Boor, *Elementary Numerical Analysis*, an Algorithmic Approach. Tata McGraw-Hill.
- F. B. Hildebrandt, *Introduction to Numerical Analysis*, Dover.
- H. M. Antia, *Numerical Methods for Scientists and Engineers*, Hindustan Book Agency

Course Details			
Course Title: Probability and Statistics			
Course Code	MSMTH4001C04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	IV	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		
Prerequisite	• Sets, functions and basics of probability		

Course Objectives

- Explain simple unconditional probabilities and conditional probabilities, Bayes' theorem
- Define the probability mass function of a discrete random variable and the binomial distribution
- Define the probability density function of a continuous random variable
- Define the expectation of a function of a random variable and properties in one dimension and two dimensions.
- Define binomial Poisson and Normal distributions
- Define correlation and simple linear regression
- Methods of Finding Estimators
- Explain approximating probabilities using the Central Limit Theorem
- Define confidence intervals for population parameters
- Define hypothesis tests for large and small samples
- Define the Chi - Square Test and goodness of fit
- Define Concepts of Hypothesis Testing: Neyman-Pearson lemma, Likelihood Ratio Test

Learning Outcomes

After completion of the course the learners will be able to:

- calculate a simple unconditional probability and conditional probability, Application of Bayes' theorem
- calculate a probability from a probability mass function of a discrete random variable and a binomial distribution, Poisson distribution
- calculate a probability from a probability density function of a continuous random variable and a and normal distribution
- calculate correlation and a linear regression for a given data set
- calculate an expectation of a random variable for a given distribution
- calculate estimations using method of Maximum Likelihood and method of Moments
- calculate a probability using the Central Limit Theorem
- Hypothesis testing for single and two large samples
- Hypothesis testing through t and F distribution
- perform a Chi - Square Test of Independence for a contingency table
- find best test using Neyman-Pearson lemma,
- apply Likelihood Ratio Test

Course Contents

UNIT I: **(30% Weightage)**

Sample Space, Axioms of Probability, Conditional Probability, Independence, Bayes Theorem, Random Variables: Discrete and Continuous random variables, Probability Distribution Functions, Probability mass function, Probability density function, Expectation (operations on one dimension and two dimensions): Moments, Independent Random Variables, Marginal, Joint and Conditional distributions, Conditional Expectation, Covariance, Moment generating functions.

UNIT II: **(20% Weightage)**

Some standard probability distributions and their properties: Bernoulli, Binomial, Poisson, Normal, Correlation and Simple linear regression.

UNIT III: **(15 % Weightage)**

Introduction to the sampling distribution, bounds on probability Weak and Strong law of large numbers. , Central Limit theorem, Methods of Finding Estimators: Point Estimation (Method of Maximum Likelihood, Method of Moments); Interval Estimation (Estimation of mean, standard error of estimate);.

UNIT IV: **(35%Weightage)**

Hypothesis testing: Confidence interval, Level of Significance Type I and Type II errors; single large sample test, Two large sample test; t-test (paired and unpaired), F-test, Chi-Square test and goodness of fit; Concepts of Hypothesis Testing: Neyman-Pearson lemma, Likelihood Ratio Test.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-4	Sample Space, Axioms of Probability, Conditional Probability, Independence, Bayes Theorem
5-6	Random Variables: Discrete and Continuous random variables, Probability Distribution Functions
7-8	Probability mass function, Probability density function
9-11	Expectation (operations on one dimension)
11-14	Expectation (operations on two dimensions)
15-16	Bernoulli, Binomial probability distributions
17-18	Normal probability distribution
19-22	Correlation and Simple linear regression
23-24	Introduction to the sampling distribution, Central Limit theorem, bounds on probability Weak and Strong law of large numbers
25-26	Methods of Finding Estimators: Point Estimation (Method of Maximum Likelihood, Method of Moments);
27-29	Interval Estimation (Estimation of mean, maximum error of estimate); Confidence interval, Type I and Type II errors
30-32	Hypothesis testing: single large sample test
32-35	Two large sample test
36-39	t-test (paired and unpaired), F-test
40-41	Chi-Square test and goodness of fit
42-45	Concepts of Hypothesis Testing: Neyman-Pearson lemma, Likelihood Ratio Test.

Suggested References:

- V. Rohatgi, A. Saleh, Introduction to Probability Theory and Statistics, Second Edition, Wiley-Interscience, 2000.
- W. Feller, Introduction to Probability Theory and Its Applications, Vol.1, Third Edition, Wiley, 1968.
- G. Casella, R. L. Berger, Statistical Inference, Second Edition, Duxbury Press, 2001.
- J. S. Rosenthal, A Fist look at Rigorous Probability Theory, Second Edition, World Scientific, 2006.
- Robert V. Hogg, Joseph W. McKean and T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.

Syllabus Elective Courses

Course Details			
Course Title: Mechanics			
Course Code	MSMTH1003E04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	I	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	□ 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) □ 70% - End Term External Examination (University Examination)		
Prerequisite	□ Calculus, vector Calculus		

Course Objectives

- To acquaint the students with the principles of Mechanics
- To orient the students with major link between mechanics theory and its applications.
- To develop a skill to formulate (if possible) problems and its solution

Learning Outcomes

After completion of the course the learners should be able to:

- The basic results associated to different types partial differential equations.
- The student has knowledge of central concepts from parabolic, elliptic and Hyperbolic Partial differential equations.
- Be able to produce examples illustrating the mathematical concepts presented in the course.
- Understand the statements and proofs of important method and be able to explain the key steps.

Course Contents

Unit I **(weightage 25%)**

D' Alembert's Principle, System of Particles -Energy and Momentum methods, Use of Centroid. Motion of a Rigid Body - Euler's Theorem, Angular momentum and kinetic energy.

Unit II **(weightage 25%)**

Euler's equation of motion of rigid body with one point fixed, Eulerian angles, motion of a symmetrical top, Generalized coordinates, Velocities and momenta, Holonomic and non-holonomic systems,.

Unit III **(weightage 25%)**

Lagrange's equations of motion, Conservative forces, Lagrange's equations for impulsive forces, Theory of small Oscillations of conservative holonomic dynamical system, Hamilton's equations of motion.

Unit IV **(weightage 25%)**

Finite Variational Principle and Principle of Least Action, Contact transformations, Generating functions, Poisson's Brackets, Hamilton Jacobi equation.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-6	System of Particles -Energy and Momentum methods. Use of Centroid. Motion of a Rigid Body - Euler's Theorem
7-10	Angular momentum and kinetic energy.
11-15	Euler's equation of motion of rigid body with one point fixed Eulerian angles, motion of a symmetrical top
16-18	Generalized coordinates, Velocities and momenta,
19-21	Solutions of Dirichlet, Neuman and mixed type problems.
22-25	Holonomic and non-holonomic systems, D' Alembert's Principle.
26-28	Lagrange's equations of motion, Conservative forces,
29-31	Lagrange's equations for impulsive forces,
32-35	Theory of small Oscillations of conservative holonomic dynamical system
36-38	Hamilton's equations of motion
39-41	Finite Variational Principle and Principle of Least Action
42-45	Contact transformations, Generating functions Poisson's Brackets Hamilton Jacobi equation

Texts/ References

- H. Goldstein, Classical Mechanics, Narosa Publishing House, 1980.
- F. Charlton, Text book of Dynamics, 2nd edition, CBS Publishers, 1985.
- R.G. Takwale& P.S. Puranik, Introduction to Classical Mechanics, Tata McGraw Hill Publishing Co., New Delhi.
- E.T. Whittaker, A Treatise on Analytical Dynamics of Particles and Rigid Bodies, Cambridge University Press, 1993.

Course Details			
Course Title: Calculus of variation and Integral Equation			
Course Code	MSMTH2002E04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	II	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	· 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) · 70% - End Term External Examination (University Examination)		
Prerequisite	· Integral calculus, Differentiation		

Course Objectives

- To make familiar students with integral equations
- To make familiar Variational problems
- To orient the students with tools and techniques of solving Integral equations
- To develop skills to apply Integral equations in engineering problems

Learning Outcomes

After completion of the course the learners will be able to:

- To solve various types of Integral equations
- To convert BVP into Integral equations
- apply Integral equations in engineering problems

Course Contents

UNIT I: **(20% Weightage)**

Euler's equations, Functional dependence on higher-order derivatives, Functional dependence on functions of several dependent variables, Isoperimetric problems.

UNIT II: **(30% Weightage)**

Variational problems with moving boundaries, One sided variations, Extermals with Corners, Variational problems with subsidiary conditions, Direct method: Rayleigh-Ritz method, Galerkin's method..

UNIT III: **(30 % Weightage)**

Classification of Integral equations, Integral Equation with separable kernels, Iterative method for Fredholm's equation of second kind, Volterra type integral equation, Integral equations of first kind, Convolution type Integral Equations.

UNIT IV: **(20%Weightage)**

Symmetric Kernels, Singular Integral Equation, Non-linear Volterra equations, Hilbert Schmidt theory, Application to mixed boundary value problems..

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-2	Euler's equations
3-5	Functional dependence on higher-order derivatives
6-9	Functional dependence on functions of several dependent variables.
10-12	Variational problems with moving boundaries
12-14	One sided variations, Extermals with Corners.
14-15	Variational problems with subsidiary conditions
15-16	Isoperimetric problems
17-20	Rayleigh-Ritz method
21-22	Galerkin's method.
23-24	Classification of Integral equations
25-26	Integral Equation with separable kernels,
27-29	Iterative method for Fredholm's equation of second kind,
30-32	volterra type integral equation, Integral equations of first kind,
33-35	Convolution type Integral Equations
36-38	Symmetric Kernels
38-39	Singular Integral Equation,
40-41	Non-linear Volterra equations
42-43	Hilbert Schmidt theory,
44-45	Application to mixed boundary value problems.
15 Hours	*Tutorials*

- Suggested References:

- S. Gupta, *Calculus of Variations*, Prentice Hall of India Pvt. Ltd., 2003.
- I. M. Gelfand and S. V. Francis, *Calculus of Variations*, Prentice Hall, New Jersey, 2000.
- L. G. Chambers, *Integral Equations*, International Text Book Company Ltd., London, 1976.
- F. G. Tricomi, *Integral Equations*, Interscience, New York, 1957.
- R. P. Kanwal, *Linear Integral Equation: Theory and Technique*, Birkhauser, 1997

Course Details			
Course Title: Differential Geometry			
Course Code	MSMTH2001E04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	II	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	· 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) · 70% - End Term External Examination (University Examination)		
Prerequisite	Prerequisites: Linear Algebra (MTH 502) and Algebra (MTH 553)		

Course Objectives

- To develop the understanding of concepts through examples, counter examples and problems.
- To orient the students with tools and techniques of differential geometry.
- To develop a skill to solve problems.

Learning Outcomes

After completion of the course the learners should be able to:

Course Contents

Unit I **(weightage 25%)**
Graph and level sets, vector fields, the tangent space, surfaces, orientation, the Gauss map, geodesics, parallel transport, the Weingarten map.

Unit II **(weightage 25%)**
Curvature of plane curves, arc length and line integrals, curvature of surfaces, parametrized surfaces, surface area and volume, surfaces with boundary, the Gauss-Bonnet Theorem.

Unit III **(weightage 25%)**
Riemannian geometry of surfaces, Parallel translation and connections, structural equations and curvature, interpretation of curvature.

Unit IV **(weightage 25%)**
Geodesic Coordinate systems, isometries and spaces of constant curvature.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-2	Graph and level sets
3-4	vector fields
5-6	the tangent space
7-8	Surfaces
9-10	Orientation
11-12	the Gauss map,
13-14	Geodesics
15-16	parallel transport
17-18	the Weingarten map
19-20	Curvature of plane curves
21-22	arc length and line integrals, curvature.
23-24	curvature of surfaces
25-26	parametrized surfaces
27-28	surface area and volume
29-30	surface area and volume
31-32	surfaces with boundary
33-34	the Gauss-Bonnet Theorem.
35-36	Riemannian geometry of surfaces,
37-38	Parallel translation and connections
39-40	structural equations and curvature,
41-42	interpretation of curvature.
43-45	Geodesic Coordinate systems isometries and spaces of constant

Texts/References

1. W. Kuhnel, Differential Geometry-curves-surfaces-Manifolds, AMS 2006.
2. A. Mishchenko and A. Formentko, A course of Differential Geometry and Topology, Mir Publishers Moscow, 1988.
3. A. Pressley, Elementary Differential Geometry, SUMS, Springer, 2004.
4. I. A. Thorpe, Elementary Topics in Differential Geometry. Springer, 2004

Course Details			
Course Title: Graph Theory			
Course Code	MSMTH3002E04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	III	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion, Self-study, Seminar, Presentations by students.		
Assessment and Evaluation	· 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) · 70% - End Term External Examination (University Examination)		

Course Objectives

The learning objectives of this course are to:

- Introduce students to the mathematical foundations of theory of graphs.
- Understand and apply the fundamental concepts in graph theory.
- To apply graph theory based tools in solving practical problems.
- To improve the proof writing.

Learning Outcomes

After successful completion of this course, students will be able to:

- Understand basic concepts of graphs and its associated matrices.
- Apply principles and concepts of graph theory in practical situations.
- Demonstrate their understanding of key notions, such as Matchings, Colorings, and Planar graphs.
- Prove the basic results of graphs.

Course Contents

UNIT I: **(25 % Weightage)**

Basic notions of Graph theory, Eulerian graph, Bipartite graph, Adjacency and Incidence matrices, Graph isomorphism, Bipartite graph and matrices, Diameter and eigenvalues.

UNIT II: **(25 % Weightage)**

Trees, Leaves, Forests, Counting labelled trees, Spanning subgraphs, Minimum spanning trees and Kruskal's Algorithm, Colouring of Graphs, Colouring Trees and Cycles, Polya Theory.

UNIT III: **(25 % Weightage)**

The Marriage theorem, Doubly Stochastic matrices, Weighted Bipartite matching, Matching in general graph, Connectivity, Planer graphs, Euler's formula, The five colour theorem.

UNIT IV: **(25 % Weightage)**

Edges and cycles, Edge colouring, Hamiltonian cycles, Regular graphs, Eigen values of regular graphs, Diameter of regular graphs, Ramanujan graphs.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	Unit/Topic/Sub-Topic
1-6	Basic notions of Graph theory, Eulerian graph, Bipartite graph, Adjacency and Incidence matrices.
7-10	Graph isomorphism, Bipartite graph and matrices, Diameter and eigenvalues.
11-13	Trees, Leaves, Forests, Counting labelled trees.
14-16	Spanning subgraphs, Minimum spanning trees and Kruskal's Algorithm.
17-22	Colouring of Graphs, Colouring Trees and Cycles, Polya Theory.
23-27	The Marriage theorem, Doubly Stochastic matrices, Weighted Bipartite matching, Matching in general graph.
28-35	Connectivity, Planer graphs, Euler's formula, The five colour theorem.
36-39	Edges and cycles, Edge colouring.
40-42	Hamiltonian cycles, Regular graphs, Eigen values of regular graphs.
43-45	Diameter of regular graphs, Ramanujan graphs.

Suggested References:

- S. M. Cioaba, M. Ram Murty, *A first Course in Graph Theory and Combinatorics*, TRIM, Hindustan Book Agency, 2009.
- Reinhard Diestel, *Graph Theory*, Graduate Texts in Mathematics, Springer, 1997.
- B. Bollobas, *Graph theory an Introductory Course*, GTM 63, Springer-Verlag, New york, 1979.
- J. H. Van Lint and R.M. Wilson, *A Course in Combinatorics*, Cambridge University press, 1992.
- F. Harary, *Graph Theory*, Narosa Publishing House.

Course Title: Number Theory			
Course Code	MSMTH1004E04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	I	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion, Presentation.		
Assessment and Evaluation	☐ 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) ☐ 70% - End Term External Examination (University Examination)		

Course Objectives

- To study the basics of Number Theory
- To give the introduction to elliptic curve cryptography
- To give the introduction to combinatorial and additive number theory

Learning Outcomes

Upon completion of this course, the student will be able to understand basics of several branches of Number Theory like Algebraic, combinatorial, Analytic and elliptic curves.

Prerequisite: Nil

Course Contents

UNIT I **(25% Weightage)**

Multiplicative functions, Functions τ, σ, and μ and their multiplicativity, Mobius inversion formula and its converse, Group structure under convolution product and relations between various standard functions, primitive roots, Quadratic Residues, Legendre symbols, Gauss' lemma, Quadratic Reciprocity Law and applications, Jacobi symbol.

UNIT II **(25 % Weightage)**

Diophantine equations: $ax + by = c$, $x^2 + y^2 = z^2$, $x^4 + y^4 = z^2$, Sums of squares, Waring's problem, Binary quadratic forms over integers. Farey sequences, Rational approximations, Hurwitz'Theorem.

UNIT III **(25 % Weightage)**

Simple continued fractions, Infinite continued fractions and irrational numbers, Periodicity, Pell's equation. Distribution of primes, Function $\pi(x)$, Tschebyschef 's theorem, Bertrand's postulate. Partition function, Ferrer's Graph, Formal power series, Euler's identity, Euler's formula for $\varphi(n)$, Jacobi's formula.

UNIT IV **(25% Weightage)**

The congruent number problem, Elliptic curves, The addition law on a elliptic curves, the group of rational points, the group of points modulo p, integer points on elliptic curve. Algebraic numbers and algebraic integers, The fundamental theorem of arithmetic in k(1), k(i), Quadratic fields.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-2	Multiplicative functions, Functions τ, σ, and μ and their multiplicativity,
3-4	Mobius inversion formula and its converse
5 -6	Group structure under convolution product and relations between various standard functions,
7-9	Primitive roots
10-13	Quadratic Residues, Legendre symbols, Gauss' lemma, Quadratic Reciprocity Law and applications, Jacobi symbol.
14-15	Diophantine equations: $ax + by = c$, $x^2 + y^2 = z^2$, $x^4 + y^4 = z^2$
16-19	Sums of squares, Waring's problem
19-25	Binary quadratic forms over integers. Farey sequences,
26-29	Rational approximations, Hurwitz' Theorem.
30-33	Simple continued fractions, Infinite continued fractions and irrational numbers, Periodicity, Pell's equation.
34-39	Distribution of primes, Function $\pi(x)$, Tschebyschef 's theorem, Bertrand's postulate. Partition function, Ferrer's Graph, Formal power series, Euler's identity, Euler's formula for $\varphi(n)$, Jacobi's formula.
40-45	The congruent number problem, Elliptic curves, The addition law on a elliptic curves, the group of rational points, the group of points modulo p, integer points on elliptic curve. Algebraic numbers and algebraic integers, The fundamental theorem of arithmetic in k(1), k(i), Quadratic fields.
15 Hours	*Tutorials*

Suggested Texts/References

1. I. Niven and T. Zuckermann, *An Introduction to the Theory of Numbers*, Wiley Eastern.
2. G. H. Hardy and E.M. Wright, *Theory of Numbers*, Oxford University Press & E.L.B.S.
3. D. E. Burton, *Elementary Number Theory*, Tata McGraw-Hill.
5. T. M. Apostal, *Analytic Number Theory*.

•

Course Details			
Course Title: Fluid Mechanics			
Course Code	MSMTH1001E04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	I	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	☐ 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) ☐ 70% - End Term External Examination (University Examination)		
Prerequisite	☐ Vector calculus, Differential equation		

Course Objectives

- To acquaint the students with concepts of fluid motion and its governing equations
- To enable students in understating of kinematics of fluid
- To develop students understanding of fluid flow under various physical configurations and boundary conditions.

Learning Outcomes

After completion of the course the learners will be able to:

- To understand Lagrangian and Eulerian description of fluid motion
- To understand modeling of fluid flow
- To solve flow equations in some special cases

Course Contents

UNIT I: **(30% Weightage)**

Lagrangian and Eulerian description of fluid motion, Motion of a continuum, Velocity and Acceleration, Stream lines, Path lines, Steady motion, Kinematics of vorticity and circulation. Equation of continuity (Cartesian, general vector form, cylindrical and spherical coordinates), Euler's equation of motion, Bernoulli's equation Motion in two dimensions-Stream function, Irrotational motion, Velocity and Complex potentials, Cauchy-Riemann's equations, Sources and Sinks.

UNIT II: **(30% Weightage)**

Kinematics of Deformation; Rate of strain tensor, Body and Surface forces, Stress Principle of Cauchy; Newtonian fluids, Constitutive equations for Newtonian fluids; Navier- Stokes equations in Vector and general Tensor forms, Navier-Stokes equations in orthogonal coordinate systems (particularly in Cartesian, cylindrical and spherical coordinate systems).

UNIT III: **(20 % Weightage)**

Dynamical Similarity, Role of Reynolds number in Fluid dynamics; Some Exact solutions– Steady flow between parallel plates, Couette flow between coaxial rotating cylinders, Steady flow between pipes of uniform cross-section, Small Reynolds number flow, Stokes equations, steady flow past a sphere

UNIT IV: **(20%Weightage)**

Boundary layer concept, 2-dimensional boundary layer equations, separation phenomena; boundary layer on a semi-infinite plane, Blasius solution; boundary layer thickness, Karman's Integral method.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-2	Lagrangian and Eulerian description of fluid motion,
3-4	Motion of a continuum, Velocity and Acceleration, Stream lines, Path lines
5-6	Steady motion, Kinematics of vorticity and circulation.
7-8	Equation of continuity (Cartesian, general vector form, cylindrical and spherical coordinates),
9-10	Euler's equation of motion, Bernoulli's equation Motion in two dimensions-Stream function
11-12	Irrotational motion, Velocity and Complex potentials,
13-14	Cauchy-Riemann's equations, Sources and Sinks.
15-17	Kinematics of Deformation; Rate of strain tensor, Body and Surface forces,
18-20	Stress Principle of Cauchy; Newtonian fluids, Constitutive equations for Newtonian fluids,
21-22	Navier- Stokes equations in Vector and general Tensor forms,
23-27	Navier-Stokes equations in orthogonal coordinate systems (particularly in Cartesian, cylindrical and spherical coordinate systems).
28-30	Dynamical Similarity, Role of Reynolds number in Fluid dynamics. Some Exact solutions–Steady flow between parallel plates.
31-33	Couette flow between coaxial rotating cylinders, Steady flow between pipes of uniform cross-section,
34-35	Small Reynolds number flow, Stokes equations,
36	Steady flow, past a sphere.
37-39	Boundary layer concept, 2-dimensional boundary layer equations
40-42	separation phenomena; boundary layer on a semi-infinite plane, Blasius solution;
43-45	boundary layer thickness, Karman's Integral method.
15 Hours	*Tutorials*

- Suggested References:

- ☐ Bachelor G. K., *An introduction to fluid dynamics*, Cambridge University Press.
- ☐ F. Chorlton, *Text book of Fluid Dynamics*, CBS Publishers
- ☐ W. H. Besant and A. S. Ramsey, *A Treatise on Hydrodynamics*, CBS Publishers
- ☐ Z. U. A. Warsi, *Fluid Dynamics*, CRC Press, 1999
- ☐ Yuan S. W. *Foundation of fluid Mechanics*.

Course Title: Formal Languages and Automata Theory			
Course Code	MSMTH1002E04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	I	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion, Self-study, Seminar, Presentations by students.		
Assessment and Evaluation	☐ 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) ☐ 70% - End Term External Examination (University Examination)		

Course Objectives

The learning objectives of this course are to:

- Introduce students to the mathematical foundations of computations including automata theory; the theory of formal languages and grammars; the notions of complexity and computability.
- Enhance/develop students' ability to understand and conduct mathematical proofs for computations.

Learning Outcomes

After successful completion of this course, students will be able to:

- Analyse and design finite automata, pushdown automata, Turing machines, formal languages, regular languages, and context free grammars.
- Demonstrate their understanding of key notions, such as computability, decidability, and complexity through problem solving.
- Prove the basic results of the theory of computation.
- State and explain the relevance of the Church-Turing thesis.

Course Contents

UNIT I: Finite Automata and Regular Expressions **(25 % Weightage)**

Finite Automata, Deterministic and Nondeterministic versions including possibilities of λ-transitions, Minimization of finite automata, Regular Expressions and their calculus, Regular languages, Closure properties of the class of regular languages, Pumping Lemma for regular languages and its applications.

UNIT II: Context-free Grammars and Pushdown Automata **(25 % Weightage)**

Context-free Grammars, Derivation Trees, Leftmost derivation, Ambiguity, Simplification of context-free grammars, Removal of useless variables and productions, λ-productions and unit rules, Chomsky and Greibach Normal Forms, Pumping Lemma for context-free languages, Pushdown Automata, Deterministic PDA's, Equivalence of PDA's and CFG's as devices for generating languages.

UNIT III: Turing Machines **(25 % Weightage)**

Turing Machines, Instantaneous Description, Language acceptance, String manipulation, Computation of values of Number theoretic functions, Turing Computability, Primitive Recursion, μ-recursion, Equivalence of Turing computability and Partial recuresiveness.

UNIT IV: Undecidability **(25 % Weightage)**

Undecidability, Recursive and recursively enumerable languages, Equivalence of recursive enumerability and Turing acceptability with general type 0 grammars, Undecidability of membership problem for type 0 languages, Undecidability of the Halting Problem for Turing machines.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	Unit/Topic/Sub-Topic
1-6	Finite Automata, Deterministic and Nondeterministic versions including possibilities of λ-transitions, Minimization of finite automata.
7-9	Regular Expressions and their calculus, Regular languages, Closure properties of the class of regular languages,
10-11	Pumping Lemma for regular languages and its applications.
12-16	Context-free Grammars (CFG), Derivation Trees, Leftmost derivation. Ambiguity, Simplification of context-free grammars, Removal of useless variables and productions, λ-productions and unit rules, Chomsky and Greibach Normal Forms.
17-20	Pushdown Automata (PDA), Deterministic PDA's, Equivalence of PDA's and CFG's as devices for generating languages.
21-22	Pumping Lemma for context-free languages.
23-25	Turing Machines, Instantaneous Description, Language acceptance. String manipulation.
26-29	Computation of values of Number theoretic functions, Turing Computability.
30-33	Primitive Recursion, μ-recursion, Equivalence of Turing computability and Partial recuresiveness.
34-39	Undecidability, Recursive and recursively enumerable languages, Equivalence of recursive enumerability and Turing acceptability with general type 0 grammars.
40-42	Undecidability of membership problem for type 0 languages.
43-45	Undecidability of the Halting Problem for Turing machines.

Suggested References:

- Peter Linz, *An Introduction to Formal Languages and Automata*, Narosa Publishing House, New Delhi, 2002.
- John Martin, *Introduction to Languages and the Theory of Computation*, Tata McGraw-Hill, New Delhi, 2002.
- K. L. P. Mishra and N. Chandrasekaran, *Theory of Computer Science*, Prentice-Hall of India, 2001.
- J. E. Hopcroft and J. D. Ullman, *Introduction to Automata Theory, Languages and Computation,* Narosa Publishing House, 2002.
- G. E. Revesz, *Introduction to Formal Languages*, McGraw-Hill, New York, 1985.
- F. Hennie, *Introduction to Computability*, Addison-Wesley, 1977.

Course Title: Numerical Solutions of Partial differential Equations			
Course Code	MSMTH2004E04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	II	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	☐ 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) ☐ 70% - End Term External Examination (University Examination)		
Prerequisite	☐ Linear Algebra, Statistics, Matrix		

Course Objectives

- To acquaint the students with the principles and methods of Numerical Analysis
- To orient the students with major link between mathematics theory and its applications.
- To develop a skill to formulate (if possible) problems and solution by numerical method.

Learning Outcomes

After completion of the course the learners should be able to:

- The basic results associated to different types partial differential equations.
- The student has knowledge of central concepts from parabolic, elliptic and Hyperbolic Partial differential equations.
- Be able to produce examples illustrating the mathematical concepts presented in the course.
- Understand the statements and proofs of important method and be able to explain the key steps.

Course Contents

Unit I **(weightage 25%)**

Numerical solutions of parabolic PDE in one space: two and three levels explicit and implicit difference schemes, Convergence and stability analysis.

Numerical solution of parabolic PDE of second order in two space dimension: implicit methods, alternating direction implicit (ADI) methods, Nonlinear initial BVP.

Unit II **(weightage 25%)**

Difference schemes for parabolic PDE in spherical and cylindrical coordinate systems in one dimension, Numerical solution of hyperbolic PDE in one and two space dimension: explicit and implicit schemes, ADI methods, Difference schemes for first order equations.

Unit III **(weightage 25%)**

Numerical solutions of elliptic equations, approximations of Laplace and biharmonic operators Solutions of Dirichlet, Neuman and mixed type problems.

Unit IV **(weightage 25%)**

Finite element method: Linear, triangular elements and rectangular elements.

<u>Content Interaction Plan:</u>

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-4	Numerical solutions of parabolic PDE in one space: two and three levels explicit and implicit difference schemes, Convergence and stability analysis.
5-10	Numerical solution of parabolic PDE of second order in two space dimension: implicit methods, alternating direction implicit (ADI) methods, Nonlinear initial BVP.
10-18	Tutorial
19-25	Difference schemes for parabolic PDE in spherical and cylindrical coordinate systems in one dimension,
26-35	Numerical solution of hyperbolic PDE in one and two space dimension: explicit and implicit schemes, ADI methods, Difference schemes for first order equations.
36-44	Tutorial
45-50	Numerical solutions of elliptic equations, approximations of Laplace and biharmonic operators
50-52	Solutions of Dirichlet, Neuman and mixed type problems.
53-55	Tutorial
56-59	Finite element method: Linear, triangular elements and rectangular elements.
60	Tutorial

Texts/ References

- M. K. Jain, S. R. K. Iyenger and R. K. Jain, Computational Methods for Partial Differential Equations, Wiley Eastern, 1994.
- M. K. Jain, Numerical Solution of Differential Equations, 2nd edition, Wiley Eastern.
- D. V. Griffiths and I. M. Smith, Numerical Methods of Engineers, Oxford University
- Press, 1993.
- C. F. General and P. O. Wheatley Applied Numerical Analysis, Addison- Wesley, 1998.

Course Details			
Course Title: Group Theory			
Course Code	MSMTH3001E04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	III	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		
Prerequisite	Linear Algebra and Algebra 1		

Course Objectives

- To develop the understanding of concepts through examples, counter examples and problems.
- To orient the students with tools and techniques of Group Theory.
- To develop a skill to solve problems.

Learning Outcomes

After completion of the course the learners should be able to:

- understand classical groups, free groups solvable and nilpotent groups.
- find orders, centers in classical groups.
- understand central product.
- Simplicity of Projective special linear group.

Course Contents

UNIT I: **(weightage 25%)**

Unit I Basic structure of General Linear Group, Special linear group and Projective special linear group, Simplicity of Projective special linear group, Bruhat decomposition in general linear group.

Unit II **(weightage 25%)**

Free groups, Generators and relations, Todd Coxeter Algorithm, Semidirect product, Free product of groups, Generalized free products, Presentation of group, Finitely presented group, Central product.

Unit III **(weightage 30%)**

Lower and Upper central series, Nilpotent group, p-group, Commutator calculus, Characterizations of finite nilpotent group, Fitting theorem, Fitting subgroup, P-Hall criteria for nilpotency, Frattini subgroup, Quaternion group, The Burnside basis theorem, Dedekind groups, Extra special p-groups.

Unit IV **(weightage 20%)**

Groups of order p^m, p^mq, p^2q^2 or pqr are solvable.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-2	Basic structure of General Linear Group,
3-4	Special linear group and
5-6	Projective special linear group
7-8	Simplicity of Projective special linear group,
9-10	Bruhat decomposition in general linear group
11-12	Bruhat decomposition in general linear group
13-14	Free groups
15-16	Generators and relations
17-18	Todd Coxeter Algorithm
19-20	Semidirect product, Free product of groups
21-22	Generalized free products, Presentation of group
23-24	Finitely presented group, Central product.
25-26	Lower and Upper central series, Nilpotent group, p-group,
27-28	Commutator calculus, Characterizations of finite nilpotent group
29-30	Fitting theorem, Fitting subgroup,
31-32	P-Hall criteria for nilpotency, Frattini subgroup
33-34	Quaternion group,
35-36	The Burnside basis theorem Dedekind groups
37-38	Extra special p-groups.
39-40	Groups of order p^m are solvable
41-42	Groups of order p^mq are solvable
43-45	Groups of order p^2q^2 are solvable. Groups of order pqr are solvable.

- Texts/References

- Michael Artin, Algebra, Prentice- Hall of India, 1991.
- J. J. Rotman, Theory of Groups: An Introduction, Allyn and Bacon, 1973.
- D. J. S. Robinson, A course in theory of groups, Springer, 1996.
- M. Suzuki, Group Theory-I, Springer, 1986.
- J. L. Alperin, R.B. Bell, Groups and Representations, Springer, 1995.

Course Details			
Course Title: Commutative Algebra			
Course Code	MSMTH3003E04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	III	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	□ 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) □ 70% - End Term External Examination (University Examination)		
Prerequisite	Prerequisites: Linear Algebra (MTH 502) and Algebra (MTH 553)		

Course Objectives

- To develop the understanding of concepts through examples, counter examples and problems.
- To orient the students with tools and techniques of Commutative Algebra.
- To develop a skill to solve problems.

Learning Outcomes

After completion of the course the learners should be able to:

- understand ideal, rings and module over ring.
- understand tensor product of modules
- calculate exact sequences.
- understand localization of rings

Course Contents

UNIT I: **(weightage 25%)**

Preliminaries on rings and ideals, local and semilocal rings, nilradical and Jacobson radical, operations on ideals, extension and contraction ideals, modules and module homomorphisms, submodules and quotient modules, operations on submodules; annihilator of a module, generators for a module, finitely generated modules, Nakayama's lemma,

Unit II: **(weightage 25%)**

Exact sequences. Existence and uniqueness of tensor product of two modules, tensor product of n modules, restriction and extension of scalars exactness properties of tensor products flat modules,

Unit III **(weightage 25%)**

Multiplicatively closed subsets, saturated subsets; ring of fractions of a ring, localization of a ring, module of fractions and its properties, extended and contracted ideals in a ring of fractions, total ring of fractions of a ring.

Unit IV **(weightage 25%)**

Primary ideals, p-primary ideals, Primary decomposition, Minimal primary decomposition, uniqueness theorems, Primary submodules of a module.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-2	Preliminaries on rings and ideals, local and semilocal rings,
3-4	nilradical and Jacobson radical,
5-6	operations on ideals, extension and contraction ideals,
7-8	modules and module homomorphisms,
9-10	submodules and quotient modules, operations on submodules;
11-12	annihilator of a module, generators for a module, finitely generated modules, Nakayama's lemma,
13-14	exact sequences.
15-16	Existence and uniqueness of tensor product of two modules,
17-18	tensor product of n modules, restriction and extension of scalars exactness
19-20	properties of tensor products flat modules,
21-22	Multiplicatively closed subsets, saturated subsets
23-24	ring of fractions of a ring, localization of a ring,
25-26	module of fractions and its properties,
27-28	extended and contracted ideals in a ring of fractions,
29-30	total ring of fractions of a ring.
31-32	Primary ideals
33-34	p-primary ideals
35-36	Primary decomposition,
37-38	Minimal primary decomposition,
39-40	Minimal primary decomposition,
41-42	uniqueness theorems,
43-45	Primary submodules of a module. Primary submodules of a module.

Texts/References

1. M. F. Atiyah and I. G. Macdonald, Introduction to Commutative Algebra, Addison Wesley, 2000.
2. M. Reid, Undergraduate Commutative Algebra, London Math. Soc. Student Texts, No. 29, 1995.
3. I. S. Luther and I. B. S. Passi, Algebra (Volume 2: Rings), Narosa Publishing House, New Delhi,1999.
4. I. S. Luther and I. B. S. Passi , Algebra (Volume 3: Modules), Narosa Publishing House, New Delhi, 1999.
5. S. Lang, Algebra, Addison-Wesley Publishing Company, London, 2000.
6. D. Eisenbud, Commutative Algebra.

Course Details			
Course Title: Algebraic Number Theory			
Course Code	MSMTH3004E04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	III	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion, Presentation.		
Assessment and Evaluation	□ 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) □ 70% - End Term External Examination (University Examination)		

Course Objectives

- To show how tools from algebra can be used to solve problems in number theory.
- To study Dedekind domains, Norm and Classes of ideals
- To study Class Field theory, Hilbert and Takagi's theory

Learning Outcomes

Upon completion of this course, the student will be able to:

- be able to compute norms and discriminants and to use them to determine the integer rings in algabraic number fields;
- be able to factorize ideals into prime ideals in algebraic number fields in straightforward examples;
- understand the proof of Minkowski's Theorem on lattices, and be able to apply it, for example, to prove that all positive integers are the sum of four squares.

Prerequisites: Algebra-I (MTH553), Algebra-II (MTH 602)

Course Contents

UNIT I **(15% Weightage)**

Rudiments of Field extensions, Trace and Norm, Discriminant and Resultant of Polynomials, Steinitz' Theorem, Transcendence Bases,

UNIT II **(15 % Weightage)**

Algebraic Integers, Integral elements, Integrally closed Domains, Rings of Algebraic integers, Arithmetic in **Z**[i], Integers of Quadratic number fields, Integers of Cyclotomic fields, Integral basis, Discriminant of quadratic and cyclotomic fields.

UNIT III **(35 % Weightage)**

Decomposition of Ideals, Dedekind domains, Norm and Classes of ideals. Units of quadratic and cyclotomic fields, Dirichlet's Theorem on Group of units of algebraic integers of **Q**(ζ) with ζ a primitive p^{th} root of unity.

UNIT IV **(35% Weightage)**

Extension of Ideals, Decomposition of prime numbers in quadratic and cyclotomic fields, Decomposition of Prime ideals in Galois extensions, Ramificaions, Theory of Kronecker and Weber on Abelian extensions, Class Field theory, Hilbert and Takagi's theory

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-4	Rudiments of Field extensions, Trace and Norm
5-8	Discriminant and Resultant of Polynomials. Steinitz' Theorem. Transcendence Bases
9 -12	Algebraic Integers, Integral elements, Integrally closed Domains, Rings of Algebraic integers
13-16	Arithmetic in **Z**[i], Integers of Quadratic number fields. Integers of Cyclotomic fields
17-20	Integral basis, Discriminant of quadratic and cyclotomic fields.
21-24	Decomposition of Ideals, Dedekind domains.
25-28	Norm and Classes of ideals. Units of quadratic and cyclotomic fields.
29-32	Dirichlet's Theorem on Group of units of algebraic integers of $\mathbf{Q}(\zeta)$ with ζ a primitive p^{th} root of unity.
33-36	Extension of Ideals, Decomposition of prime numbers in quadratic and cyclotomic fields.
37-40	Decomposition of Prime ideals in Galois extensions, Ramificaions.
41-45	Theory of Kronecker and Weber on Abelian extensions. Class Field theory. Hilbert and Takagi's theory
15 Hours	*Tutorials*

Suggested Texts/References:

Texts/References

1. P. Ribenboim, *Classical Theory of Algebraic Numbers*, Springer Universitext.

2. N. Borevich and I. Shafarevich, *Number Theory*, Academic Press.

3. S. Lang, *Algebraic Number Theory*, Springer-Verlag, New York, 1994.

4. M. Rosen and K. Ireland, *A Classical Introduction to Number Theory*, Graduate Texts in Mathematics. Springer, 1982.

Course Title: Introduction to Finite Fields and Coding theory			
Course Code	MSMTH3005E04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	III	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion, Presentation.		
Assessment and Evaluation	☐ 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) ☐ 70% - End Term External Examination (University Examination)		

Course Objectives

- To give the introduction to finite fields
- To study results related to polynomials over finite fields
- To give the introduction to coding theory and applications of finite fields to coding theory
-

Learning Outcomes

Upon completion of this course, the student will be able to understand basic structure of finite fields, polynomials and irreducible polynomials over finite fields and different types of codes; Hamming codes, cyclic codes and BCH codes etc.

Prerequisite (Algebra-I).

Course Contents

UNIT I **(25% Weightage)**

Characterization of finite fields, Roots of Irreducible Polynomials, Trace, Norms, and Bases, Roots of Unity and Cyclotomic polynomials, Representation of elements of finite fields, Order of polynomials and primitive polynomials.

UNIT II **(25 % Weightage)**

Irreducible polynomials, Construction of irreducible polynomials, Linearized polynomials, Binomials and trinomials Factorization of polynomials over small finite fields, factorization of polynomials over large finite fields, Calculation of roots of polynomials.

UNIT III **(25 % Weightage)**

The coding problem, Linear codes, generator and parity check matrices, dual codes, weights and distances, new codes from old codes, Permutation equivalent codes.

UNIT IV **(25% Weightage)**

Hamming codes, basic theory of cyclic codes, idempotent and multipliers, zeros of a cyclic codes, minimum distance of cyclic codes, BCH Codes.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-2	Characterization of finite fields
3-4	Roots of Irreducible Polynomials
5 -8	Trace, Norms, and Bases, Roots of Unity and Cyclotomic polynomials
9-11	Representation of elements of finite fields, Order of polynomials and primitive polynomials.
12-16	Irreducible polynomials, Construction of irreducible polynomials, Linearized polynomials, Binomials and trinomials
17-22	Factorization of polynomials over small finite fields, factorization of polynomials over large finite fields, Calculation of roots of polynomials.
23-26	The coding problem, Linear codes.
27-30	Generator and parity check matrices, dual codes, weights and distances.
31-33	New codes from old codes, Permutation equivalent codes.
34-35	Hamming codes, basic theory of cyclic codes
35-40	Idempotent and multipliers, zeros of a cyclic codes, minimum distance of cyclic codes
15 Hours	*Tutorials*

Suggested Texts/References:

1. Rudolf Lidl and Harald Niederreiter, Finite Fields and their Applications, *Cambridge University Press, 1994.*
2. S. Ling and C. Xing: *Coding Theory - A First Course, Cambridge University Press, 2004.*
3. E. R. Berlekamp: *Algebraic Coding Theory, Aegean Park Press, 1984.*
4. S. Roman, Fields and Galois Theory, *Springer GTM.*

Course Details			
Course Title: Lie Algebra			
Course Code	MSMTH4001E04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	IV	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	☐ 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) ☐ 70% - End Term External Examination (University Examination)		
Prerequisite	Prerequisite: Linear Algebra (MTH 502)		

Course Objectives

- To develop the understanding of concepts through examples, counter examples and problems.
- To orient the students with tools and techniques of Commutative Algebra.
- To develop a skill to solve problems.

Learning Outcomes

After completion of the course the learners should be able to:

- ☐ understand ideal, rings and module over ring.
- ☐ understand tensor product of modules
- ☐ calculate exact sequences.
- ☐ understand localization of rings

Course Contents

Unit I

Definition and examples of Lie Algebra, examples of classical Lie Algebras, derivation of Lie Algebras, abelian Lie Algebra, Lie subalgebras, ideals and homomorphisms, normalizers and centralizers of a Lie subalgebras, representation of Lie algebras (definition and some examples), automorphisms of a Lie algebra, solvable algebra, solvable radical, nilpotent algebra, Engel's Theorem.

Unit II

Semi-simple Lie algebra, Lie's Theorem, Jordan-Chevalley decomposition (existence and uniqueness) Cartan's trace criterion for solvability, Killing form and criterion for semi-simplicity, Simple ideals, inner derivations, abstract Jordan-Chevalley decomposition, definition and examples of Lie algebra modules, Schur's Lemma, Casimir elements of representation, Weyl's Theorem preservation of Jordan decomposition.

Unit III

Representation of sl(2,C), weights, highest weight, maximal vectors, classification of irreducible modules, toral and maximal toral subalgebra, root space decomposition and properties of roots.

Unit IV

Abstract root system (definition, examples and basic properties), Weyl group, root strings bases and their existence, Weyl chambers, classification of rank 2 root systems.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	Unit/Topic/Sub-Topic
1-2	Definition and examples of Lie Algebra, examples of classical Lie Algebras,
3-4	derivation of Lie Algebras,
5-6	Lie subalgebras, ideals and homomorphisms,
7-8	normalizers and centralizers of a Lie subalgebras,
9-10	representation of Lie algebras (definition and some examples),
11-12	automorphisms of a Lie algebra, solvable algebra, solvable radical,
13-14	nilpotent algebra, Engel's Theorem.
15-16	Semi-simple Lie algebra, Lie's Theorem,
17-18	Jordan-Chevalley decomposition (existence and uniqueness)
19-20	Cartan's trace criterion for solvability,
21-22	Killing form and criterion for semi-simplicity,
23-24	Simple ideals, inner derivations, abstract Jordan-Chevalley decomposition.
25-26	definition and examples of Lie algebra modules,
27-28	Schur's Lemma, Casimir elements of representation
29-30	Weyl's Theorem preservation of Jordan decomposition.
31-32	Representation of sl(2,C), weights, highest weight,
33-34	maximal vectors, classification of irreducible modules,
35-36	toral and maximal toral subalgebra, root space decomposition and properties of roots.
37-38	Abstract root system (definition, examples and basic properties),
39-40	Weyl group,
41-42	root strings bases and their existence,
43-45	Weyl chambers, classification of rank 2 root systems.

Texts/References

1. J. E. Humphreys, Lie algebra and Representation Theory, Graduate Text in Mathematics 9, Springer, New York 1978.
2. K. Erdmann and M.J. Wildon Introduction to Lie Algebras, Springer Undergraduate series, Springer-Verlag, London 2006.
3. N. Jacobson, Lie algebras, Dover, New York, 1962.

13-14

Course Title: Operator Theory			
Course Code	MSMTH4002E04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	IV	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	☐ 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) ☐ 70% - End Term External Examination (University Examination)		
Prerequisite	☐ Complex Analysis, Functional Analysis and Measure and integration.		

Course Objectives

- To acquaint the students with the operator theory
- To orient the students with major link between opertor theory and its applications.

Learning Outcomes

After completion of the course the learners should be able to:

- The basic results associated to bounded linear opertor.
- The student has knowledge of central concepts from different theorems.
- Be able to produce examples illustrating the mathematical concepts presented in the course.
- Understand the statements and proofs of important theorem and be able to explain the key steps.

Course Contents

Unit I **(weightage 25%)**

Linear operators in normed linear spaces: Definition and examples, Linear operators on finite dimensional linear spaces and bounded linear operators on normed linear spaces, Spectrum and resolvent sets of bounded linear operator, compact operator and its properties.

Unit II **(weightage 25%)**

Spectral properties of operators on finite dimensional spaces and the spectral theory of operators on Banach spaces including the use of complex analysis in the theory.

Unit III **(weightage 25%)**

Banach algebras: Definition and examples, Commutative Banach algebra and C*-algebra.

Unit IV **(weightage 25%)**

General theory of Banach algebras including Gelfand-Naimark theorem for commutative C*-algebras. Spectral theory of bounded linear operator.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	Unit/Topic/Sub-Topic
1-4	Linear operators in normed linear spaces: Definition and examples, Linear operators on finite dimensional linear spaces,
5-7	Bounded linear operators on normed linear spaces
8-10	Spectrum and resolvent sets of bounded linear operator.
11-15	Spectral properties of operators on finite dimensional spaces
16-20	The spectral theory of operators on Banach spaces
21-23	Its use in complex analysis in the theory.
24-28	Banach algebras: Definition and examples
28-33	Commutative Banach algebra
34-40	C*-algebra
41-43	General theory of Banach algebras
44-45	Gelfand-Naimark theorem for commutative C*-algebras

Texts/ References

- C. D. Aliprintis, An invitation to Operator Theory, American Mathematical Society, 2008.
- G. Bachman and L. Narici, Functional Analysis, Academic Press,1966.
- J. B. Conway, A First Course in Functional Analysis, Springer- Verlag, 2000.
- N. Dunford and J.T. Schwartz, Linear Operators, Part-I,Interscience, 1958.
- E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley and sons, 1978.
- G. F. Simmons, Introduction to Topology and Modern Analysis,McGrawh-Hill, 1963.

V. S. Sunder, Functional Analysis, Hindustan Publishing House, 2001.

Course Title: Representation theory of finite groups			
Course Code	MSMTH4003E04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	IV	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	☐ 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) ☐ 70% - End Term External Examination (University Examination)		
Prerequisite	Linear Algebra (MTH 502) and Algebra 1 (MTH 553)		

Course Objectives

- To develop the understanding of concepts through examples, counter examples and problems.
- To orient the students with tools and techniques of Representation Theory.
- To develop a skill to solve problems.

Learning Outcomes

After completion of the course the learners should be able to:

- understand module, irreducible and reducible module.
- understand character map.
- understand representation of small order groups.
- understand induced representation.

Course Contents

UNIT I: **(weightage 25%)**

Irreducible and completely reducible modules, Schur's Lemma, Jacobson density Theorem, Wedderburn Structure theorem for semisimple modules and rings, group algebra, Maschke's Theorem.

Unit II **(weightage 25%)**

Representations, Subrepresentations, Characters, Orthogonality relations, Decomposition of regular representation, Number of irreducible representations, canonical decomposition and explicit decompositions, Subgroups, Product groups, Abelian groups.

Unit III

Example including cyclic groups, dihedral groups, quaternion group of order 8, symmetric and alternating groups on 3 and 4 symbols. Representations of direct product of two groups, Integrality properties of characters, Burnside's p^aq^b theorem.

Unit IV

Induced representations, The character of induced representation, Frobenius Reciprocity Theorem, Mackey's irreducibility criterion, Examples of induced representations, Statement of Brauer and Artin's Theorems.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-2	Irreducible and completely reducible modules,
3-4	Schur's Lemma
5-6	Jacobson density Theorem,
7-8	Wedderburn Structure theorem for semisimple modules and rings,
9-10	group algebra,
11-12	Maschke's Theorem.
13-14	Representations, Subrepresentations, Characters,
15-16	Orthogonality relations
17-18	Decomposition of regular representation
19-20	Number of irreducible representations
21-22	canonical decomposition and explicit decompositions,
23-24	Subgroups, Product groups, Abelian groups.
25-26	Example including cyclic groups
27-28	dihedral groups, quaternion group of order 8
29-30	symmetric and alternating groups on 3 and 4 symbols.
31-32	Representations of direct product of two groups,
33-34	Integrality properties of characters,
35-36	Burnside's p^aq^b theorem.
37-38	Induced representations
39-40	The character of induced representation
41-42	Frobenius Reciprocity Theorem
43-45	Mackey's irreducibility criterion, Examples of induced representations, Statement of Brauer and Artin's Theorems

Texts/References

1. M. Burrow, Representation Theory of Finite Groups, Academic Press, 1965.
2. L. Dornhoff, Group Representation Theory-I, Marcel Dekker, New York, 1971.
3. N. Jacobson, Basic Algebra II, Hindustan Publishing Corprpation, 1983.
4. S. Lang, Algebra, 3rd Ed. Springer, 2004.
5. J. P. Serre, Linear Representation of Groups, Springer-Verlag, 1977.

Course Details

Course Title: Algebraic Geometry			
Course Code	MSMTH4004E04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	IV	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	- 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) - 70% - End Term External Examination (University Examination)		
Prerequisite			

Course Objectives

- To develop the understanding of concepts through examples, counter examples and problems.
- To orient the students with tools and techniques of Algebraic Topology
- To develop a skill to solve problems.

Learning Outcomes

After completion of the course the learners should be able to:

- understand zariski topology.
- understand affine varieties
- understanding of plane curves

Course Contents

UNIT I **(weightage 25%)**

Affine algebraic sets, Zariski topology, algebraic set and ideal correspondence, Hilbert's nullstellensatz, affine varieties.

UNIT II **(weightage 25%)**

Polynomial maps, the coordinate ring functor, rational maps and birational equivalence, dimension and product of affine varieties.

UNIT III **(weightage 25%)**

Projective algebraic sets and projective varieties, projective closures, rational functions and morphisms, Segre embedding and Veronese embedding. Tangent spaces, smooth and singular points, algebraic characterizations of the blowing-up a point on a variety.
dimension of a variety,

UNIT IV **(weightage 25%)**

Plane curves, rational curves, multiple points, intersection numbers, Bezout's theorem, Max Noether's fundamental theorem.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	Unit/Topic/Sub-Topic
1-2	Affine algebraic sets , Zariski topology,
3-4	algebraic set and ideal correspondence
5-6	Hilbert's nullstellensatz
7-8	affine varieties
9-10	Polynomial maps,
11-12	the coordinate ring functor
13-14	rational maps and birational equivalence
15-16	dimension and product of affine varieties
17-18	Projective algebraic sets and projective varieties,
19-20	projective closures,
21-22	rational functions and morphisms,
23-24	Segre embedding and Veronese embedding.
25-26	Tangent spaces
27-28	smooth and singular points
29-30	algebraic characterizations of the blowing-up a point on a variety.
31-32	dimension of a variety,
33-34	Plane curves
35-36	rational curves
37-38	multiple points,
39-40	intersection numbers,
41-42	Bezout's theorem
43-45	Max Noether's fundamental theorem.

Books Recommended:

1. C. Musli, Algebraic Geometry for Beginners, TRIM-20, Hindustan Book Agency, 2001.
2. W. Fulton, Algebraic Curves, An Introduction to Algebraic Geometry, W.A. Benjamin, 1969.
3. K. Hulek, Elementary Algebraic Geometry , SML, vol 20, American Mathematical Society, 2003.
4. M. Ried, Undergraduate Algebraic Geometry, LMS Student texts 12, Crambridge University Press, 1988.

Course Title: Spectral Graph Theory			
Course Code	MSMTH4005E04	Credits	4
L + T + P	3 + 1 + 0	Course Duration	One Semester
Semester	IV	Contact Hours	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion, Self-study, Seminar, Presentations by students.		
Assessment and Evaluation	☐ 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) ☐ 70% - End Term External Examination (University Examination)		

Course Objectives

The learning objectives of this course are to:

- Introduce students to the mathematical foundations of spectral graph theory.
- Understand and apply the fundamental concepts in graph theory.
- To apply matrix theory based tools in solving practical problems.
- View the adjacency (or related) matrix of a graph with a linear algebra lens.
- Identify connections between spectral properties of such a matrix and structural properties of the graph such as connectivity, bipartiteness, and cut.

Learning Outcomes

After successful completion of this course, students will be able to:

- Understand concepts and compute spectra of graphs.
- Use spectra of graphs to deduce other graph properties.
- Use spectral method to analyse real-world graphs.
- Read research papers and present results in the class.
- Apply principles and concepts of spectra of graphs in practical situations.

Course Contents

UNIT I: **(25 % Weightage)**

- A brief review of matrices and graphs, Adjacency matrix, The spectrum of a graph, Integral graphs, Isomorphic graphs, Cospectral graphs, The spectrum of various graphs, Operations on graphs and the resulting spectra, Graph characterization using spectra.

UNIT II: **(25 % Weightage)**

- Symmetric matrices, positive semidefinite matrices, Spectral gap, Spectral radius, The Perron-Frobenius theorem, Interlacing, Equitable partitions, Strongly regular graphs and its eigenvalues.

UNIT III: **(25 % Weightage)**

- Laplacian matrix, The Laplacian spectrum, Laplacian integral graphs, The Laplacian spectrum of various graphs, Graph operations and the resulting Laplacian spectra, Matrix-Tree theorem, Largest Laplacian eigenvalue, Algebraic connectivity, Laplacian eigenvalues and graph structure.

UNIT IV: **(25 % Weightage)**

- Graph partitioning, Graph expansion, Sparsest cut, Cheeger constant, Cheeger inequality, Normalized Laplacian matrix, Signless Laplacian matrix, Distance matrix, The spectrum of Cayley graphs.

<u>**Content Interaction Plan:**</u>

Lecture cum Discussion (Each session of 1 Hour)	Unit/Topic/Sub-Topic
1-4	A brief review of matrices and graphs.
5-8	Adjacency matrix, The spectrum of a graph, Integral graphs, Isomorphic graphs, Cospectral graphs, The spectrum of various graphs.
9-11	Operations on graphs and the resulting spectra, Graph characterization using spectra.
12-18	Symmetric matrices, positive semidefinite matrices, Spectral gap, Spectral radius, The Perron-Frobenius theorem, Interlacing.
19-22	Equitable partitions, Strongly regular graphs and its eigenvalues.
23-28	Laplacian matrix, The Laplacian spectrum, Laplacian integral graphs, The Laplacian spectrum of various graphs, Graph operations and the resulting Laplacian spectra.
29-33	Matrix-Tree theorem, Largest Laplacian eigenvalue, Algebraic connectivity, Laplacian eigenvalues and graph structure.
34-40	Graph partitioning, Graph expansion, Sparsest cut, Cheeger constant, Cheeger inequality.
41-45	Normalized Laplacian matrix, Signless Laplacian matrix, Distance matrix, The spectrum of Cayley graphs.

Suggested References:

- Fan R. K. Chung, Spectral graph theory, American Mathematical Society, Volume 92, 1997.
- D. M. Cvetkovic, M. Doob, and H. Sachs, Spectra of graphs, Theory and Applications.
- A. E. Brouwer and W. H. Haemers, Spectra of graphs, Electrical Book.
- C. Godsil and G. Royle, Algebraic graph theory, Springer, 2009.
- N. Biggs, Algebraic graph theory, Cambridge Mathematical Library, 2nd edition.
- Dan Spielman, Lecture notes of spectral graph theory in http://cs-www.cs.yale.edu/homes/spielman/.

Course Title: Wavelet Analysis			
Course Code	MSMTH4006E04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	IV	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students		
Assessment and Evaluation	☐ 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) ☐ 70% - End Term External Examination (University Examination)		
Prerequisite	☐ Basic knowledge of integral transforms		

Course Objectives

- Learning of Discrete time and continuous Fourier series and Fourier transform
- Learning of Haar basis Wavelet system
- Learning of multiresolution analysis
- Learning of construction of orthogonal wavelet bases
- Learning of scaling function from scaling sequences
- Learning of smooth compactly supported wavelets
- Learning of debauchees' wavelets
- Learning of image analysis with smooth wavelets

Learning Outcomes

After completion of the course the learners will be able to:

- understand Discrete time and continuous Fourier series and Fourier transform
- Haar basis Wavelet system
- multiresolution analysis
- construction of orthogonal wavelet bases
- scaling function from scaling sequences
- smooth compactly supported wavelets
- debauchees' wavelets
- image analysis with smooth wavelets

Course Contents

UNIT I: **(20% Weightage)**

Discrete time Fourier series, discrete time Fourier transforms, Continuous time Fourier series and Continuous time Fourier transform.

UNIT II: **(15% Weightage)**

Introduction to Wavelets, The Haar basis wavelet system

UNIT III: **(30 % Weightage)**

Orthogonal wavelet bases: Orthogonal systems and translates, multiresolution analysis, Examples of multiresolution analysis, construction of orthogonal wavelet bases and examples, General spline wavelets.

UNIT IV: **(35%Weightage)**

Discrete wavelet transforms: scaling function from scaling sequences, smooth compactly supported wavelets, Debauchies wavelets, image analysis with smooth wavelets.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	Unit/Topic/Sub-Topic
1-2	Discrete time Fourier series
3-4	Discrete time Fourier transforms
5-6	Continuous time Fourier series
7-9	Continuous time Fourier transform
10-11	Introduction to Wavelets
12-16	Haar basis wavelet system
17-19	Orthogonal systems and translates
20-22	multiresolution analysis
23-24	Examples of multiresolution analysis
25-27	construction of orthogonal wavelet bases and examples
28-30	General spline wavelets
31-34	Discrete wavelet transforms: scaling function from scaling sequences
35-38	smooth compactly supported wavelets
39-42	debauchees' wavelets
43-45	image analysis with smooth wavelets

Suggested References:

- David Walnut , An introduction to wavelet analysis.
- Stephan Mallat, A wavelet tour of signal processing, Academic press, 1998.
- R.S. Pathak, The wavelet Transforms, 2009.

Course Details			
Course Title: Mathematical Cryptography			
Course Code	MSMTH1005E04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	I	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion, Presentation.		
Assessment and Evaluation	☐ 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) ☐ 70% - End Term External Examination (University Examination)		

Course Objectives

- To understand basics of number theory
- To study computational aspects of Number Theory
- To study Cryptographic applications of Number Theory.
-

Learning Outcomes

At the end of the course, the student will be able:

- to understand some computational application of number theory
- to understand algorithm for primality testing and integer factorization
- to understand public key cryptography and elliptic curves

Prerequisite: Nil

Course Contents

UNIT I **(25% Weightage)**

Primitive Roots, Quadratic reciprocity, Arithmetic functions. Asymptotaic notations Machine models and complexity theory, computing with large integers, basic integer arithmetic, computing in Zn, faster integer arithmetic.

UNIT II **(25 % Weightage)**

Primality Testing and factorization algorithms, Pseudo-primes, Fermat's pseudo-primes, Pollard's rho method for factorization, Continued fractions

UNIT III **(25 % Weightage)**

Public Key Cryptography, Diffie-Hellmann key exchange, RSA crypto-system, Discrete logarithm-based crypto-systems, Signature Schemes and Hash functions, Digital signature standard, RSA Signature schemes, Knapsack problem.

UNIT IV **(25% Weightage)**

Elliptic curves - basic facts, Elliptic curves over R, C, Q, finite fields, Group Law, Elliptic curve cryptosystems, Primality testing and factorizations.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-2	Brief review divisibility and congruence
3-4	Brief review Fermat's little theorem, Wilson theorem and applications
5 -8	Number Theoretic functions, Mobious inversion formula, Greatest Integer Function, Eulers Phi function and its properties
9 -11	Primitive roots, primitive roots for primes, Composite numbers having primitive roots
12-14	Eulers criterion for quadratic congruence, Legendre symbol, Quadratic reciprocity
15-19	Asymptotaic notations Machine models and complexity theory, computing with large integers, basic integer arithmetic, computing in Zn, faster integer arithmetic.
20- 29	Primality Testing and factorization algorithms, Pseudo-primes, Fermat's pseudo-primes, Pollard's rho method for factorization, Continued fractions
30-34	Public Key Cryptography, Diffie-Hellmann key exchange, RSA crypto-system, Discrete logarithm-based crypto-systems,
35-38	Signature Schemes and Hash functions, Digital signature standard, RSA Signature schemes, Knapsack problem.
39-45	Elliptic curves - basic facts, Elliptic curves over R, C, Q, finite fields, Group Law, Elliptic curve cryptosystems, Primality testing and factorizations.
15 Hours	*Tutorials*

Suggested Texts/ References

1. N. Koblitz, *A Course in Number Theory and Cryptography*, Springer 2006.
2. Victor Shoup, *A Computational Introduction to Number Theory and Algebra*, Cambridge University Press, 2008.
3. D. M. Bressoud: *Factorization and Primality Testing*, Springer-Verlag, New York, 1989.
4. I. Niven, H.S. Zuckerman, H.L. Montgomery, *An Introduction to theory of Numbers*, Wiley, 2006.
4. Jonathan Katz, Yehuda Lindell, *Introduction to Modern Cryptography*, Chapman & Hall/CRC Press 2007.
5. Jill Pipher, Jeffrey Hoffstein, Joseph H. Silverman, An Introduction to Mathematical Cryptography, Springer, 2008
6. Douglas R. Stinson, *Cryptography: Theory & Practice*, Second Edition, CRC Press, 2002.

Matlab

UNIT I

Starting MATLAB, MATLAB Windows, Working in the command window, Arithmetic operations with scalars, Order of Precedence , Using MATLAB as a Calculator, Display formats , Elementary math built-in functions , Defining scalar variables, The Assignment Operator , Rules About Variable Names , Predefined Variables and Keywords.

UNIT II

Creating a one-dimensional array, Creating a two dimensional array, The zeros, ones and, eye Commands , Variables in Matlab, The transpose operator, Array addressing, Vector, Matrix, Using a colon : In addressing arrays , Adding elements to existing variables , Deleting elements, Built-in functions for handling arrays, Strings and strings as variables.

UNIT III

Mathematical Operations with Arrays: Addition and subtraction, Array multiplication, Array division , Element-by-element operations , Using arrays in MATLAB Built-in-math functions , Built-in-functions for analyzing arrays , Examples of MATLAB applications.

UNIT IV

Using Script Files and Managing Data: The MATLAB workspace and the workspace window, Input to a script file , Output Commands , The disp Command ,The fprintf Command, The save and load Commands, The save Command , The load Command , Importing and Exporting data , Commands for Importing and Exporting Data.

Reference:

1. Amos Gilat, MATLAB_ An Introduction with Applications-Wiley (2010) .
2. Steven Chapra, Applied Numerical Methods with MATLAB for Engineers and Scientists-McGraw-Hill Higher Education (2006).

Course Details			
Course Title: LATEX			
Course Code:****		**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Odd/Even	**Contact Hours**	45 (L) + 15 (P) Hours
Methods of Content Interaction	Lecture, Tutorials, self-study, Lab Assignments		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives

To enable students understand

- Basics of document preparation using latex.
- To know how to do text formatting in a latex document.
- To insert mathematical symbols and equations in a document
- To insert figures, graphs, charts, images, tables in a document

Learning outcomes

After completing the course the students

- Will be able to understand fundamentals of latex and beamer and commonly required packages.
- Will be able prepare variety document like report, papers, thesis, and so on
- Will be able to prepare professional presentation with variety of themes using beamer.

LATEX

Unit - 1 **(15% Weightage)**

Installation of the software LaTeX, Understanding Latex compilation. Latex features. general syntax of a document in latex, latex editors.

Unit - 2 **(30% Weightage)**

Formatting the text, defining color for text, fonts, sections and paragraphs, inserting mathematical symbols, writing equations, creating Matrices and Array, Tables in Latex, inserting images, animation and videos , creating lists, common latex packages.

Unit - 3 **(25% Weightage)**

Latex Page Layout, Sections and subsections, Equation references, References and citation in latex, bibliography database

Unit - 4 **(30% Weightage)**

Writing Resume, question paper, articles/research papers, thesis report, creating presentation using beamer.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-2	Installation of the software LaTeX
3-3	Understanding Latex compilation.
4-4	Latex features
5-6	General syntax of a document in latex
7-10	Latex editors
10-12	Formatting the text, defining color for text, fonts
12-13	Sections and paragraphs
14-15	Inserting mathematical symbols
16-18	Writing equations.
19-20	Creating Matrices and Array
20-22	Tables in Latex
23-25	Inserting images, animation and videos,

26-26	Creating lists
27-27	Common latex packages.
28-28	Latex Page Layout
29-29	Sections and subsections,
30-31	Equation references, References and citation in latex
32-32	Bibliography database
33-33	Writing Resume, question paper,
34-35	Articles/research papers
36-38	Thesis report
39-45	Creating presentation using beamer
15 Hours	Lab Work

Text Book:

1. LaTeX Beginner's Guide, Stefan Kottwitz, ISBN 13-9781847199867, Packt Publishing Limited.
2. Latex: A Document Preparation System, 2/E, Lamport, Pearson Education India, ISBN 8177584146, 9788177584141

Reference Books:

1. More Math Into LaTeX, George Grätzer, Springer, 15-Feb-2016, ISBN 9783319237961.
2. Guide to LaTeX, Tools and Techniques for Computer Typesetting, Helmut Kopka, Patrick W. Daly, Pearson Education, 2003, ISBN 0321617746, 9780321617743
3. https://www.latex-project.org/
4. https://ctan.org/

Annexure I

Course Structure and Syllabus for the Courses of Mathematics in B.Sc. – B.Ed. dual degree programme

Semester I

Introductory Mathematics (4 credits) (3 theory+1 tutorial)

Unit I Sets, relation, Functions, domain, codomain and range of a function, graph of functions, injection, surjection and bijection, composition of functions, Countability, The algebraic and order properties of R, suprema and infima, the completeness property of R, the Archimedean property, density of rational numbers in R, characterization of intervals, Cantor intersection theorem for nested intervals, Cardinal arithmetic, Schroeder-Bernstein Theorem, Equivalence relation, Zorn's lemma, Axiom of choice.

Unit II Divisibility, The Division Algorithm, The greatest common divisors, The Euclidean algorithm, Linear Diophantine equations, Primes and their distribution, The fundamental theorem of arithmetic, Congruence, The Chinese remainder theorem, Fermat Little theorem, Wilson theorem, Euler's Phi- function, Number theoretic functions.

Unit III Line and plane, Shortest distance, Equation of sphere, Tangent plane, Intersection of two spheres, Radical plane Coaxial spheres, Conjugate systems, Equation of cone, Intersection of Cone with plane and a line, Cone and Cylinder, Enveloping and right circular cylinders, Equations of central conicoids, Plane of contact and polar plane, Enveloping cone and enveloping cylinder, Conjugate diameters and diameters planes, Equations of paraboloids and its simple properties.

Texts/References

1. K. K. Jha, *Advanced Set Theory, Axiomatic Set Theory and Boolean Algebra*, Navbharat Publishing House, Patna.
2. R. G. Bartle and D. R. Sherbert, *Introduction to Real Analysis* (3rd Edition), John Wiley and Sons (Asia) Pte. Ltd., Sigapore, 2002.
3. John M. Howie, Real Analysis, SUMS, 2001.
4. S. C. Malik, *Principles of Real Analysis*, Revised Edition, New Age International, New Delhi, 2000.
5. David M. Burton, *Elementary Number Theory*, McGraw - Hill Higher Education, 2007.
6. R. J. T. Bell, Elementary Treatise on Co-ordinate Geometry of Three Dimensions, Machmillan India Ltd., 1994.

7. P. K. Jain and Khalil Ahmad, Analytical Geometry of Three Dimensions, New Age, International (P) Ltd., New Delhi, 1991.

Semester II

Analysis I (4 credits) (3 theory+1 tutorial)

Unit I: Sequences, limit of a sequence, convergent sequences, limit theorems, monotone sequences, monotone convergence theorem, subsequences, convergence and divergence criteria, existence of monotonic subsequences, Bolzano-Weierstrass theorem for sequences, Cauchy sequence, Cauchy's convergence criterion, limit superior and limit inferior of a sequence.

Unit II Definition of infinite series, sequence of partial sums, convergence of infinite series, Cauchy criterion, absolute and conditional convergence, convergence via boundedness of sequence of partial sums, tests of convergence: comparison test, limit comparison test, ratio test, Cauchy's nth root test (proof based on limit superior), integral test (without proof), alternating series, Leibniz test, Limits of functions of a real variable, Continuity of functions, Basic properties of continuous functions.

Unit III Differentiability, Successive differentiation, Leibnitz theorem, Asymtotes, curvature, envelope, concavity and convexity, Tracing of curves in Cartesian and polar coordinates, Caratheodory theorem, chain rule, derivative of inverse functions, intermediate value property for derivatives (Darboux'stheorem), Rolle's theorem, Mean value theorem, Cauchy's mean value theorem, Power series, radius of convergence, Taylor series, Maclaurin series, L'Hˆopital's Rule.

Texts/References

1. R. G. Bartle and D. R. Sherbert, *Introduction to Real Analysis* (3rd Edition), John Wiley and Sons (Asia) Pte. Ltd., Sigapore, 2002.
2. K. A. Ross, *Elementary Analysis: The Theory of Calculus*, Undergraduate Text in Mathematics, Springer (SIE), Indian reprint, 2004.
3. Sudhir R. Ghorpade, Balmohan V. Limaye, *A Course in Calculas and Real Analysis*, Springer (UTM), New York, 2006.
4. John M. Howie, *Real Analysis*, SUMS, 2001.
5. Franf Morgan, *Real Analysis*, AMS, Indian Edition, 2010.
6. Tom M. Apostel. Mathematical Analysis, Narosa Publications, NewDelhi, 2002.
7. Walter Rudin, *Principles of Mathematical Analysis*, McGraw-Hill International Editions, 1976.
8. S.C.Malik, Principles of Real Analysis, Revised Edition, New Age International, New Delhi, 2000.
9. M. J. Strauss, G. L. Bradley and K. J. Smith, *Calculus* (3rd Edition), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.

10. H. Anton, I. Bivens and S. Davis, *Calculas* (7th Edition), John Wiley and Sons (Asia) Pvt. Ltd, Singapore, 2002, dersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.

Semester III

Linear Algebra (4 credits) (3 theory+1 tutorial)

Unit I Algebra of matrices, Systems of linear equations, Equivalent systems, Elementary row operations, The elimination methods, Augmented matrix, Echelon form, Reduced Echelon form, LU decomposition, Solutions to linear systems, Homogeneous systems of linear equations, Elementary Matrices, Inverse of a matrix, Determinants, Properties of Determinant, Cramer's Rule.

Unit II Vector Spaces and examples, Subspace, Special example of Rn and its coordinates, Sum and intersection of subspaces, Solution space of linear equations, Linear independence of vectors, Basis and Dimension, Coordinates with respect to different basis. Linear Transformation between two vector spaces, representing Linear Transformation by a Matrix, Rank-Nullity Theorem, Linear Operators and square Matrices, Base change and similarity of matrices.

Unit III Eigen value and Eigen vector, Characteristic polynomials, Diagonalisation and Triangulation of matrices, Cayley Hamilton theorem, Minimal Polynomial of a matrix, Inner Product Spaces, Cauchy- Schwartz Inequality, Orthogonal basis, Grahm-Schmidt orthonormalization.

Texts/References

1. K. Hoffman and R. A. Kunze, *Linear Algebra*, 3rd edition, Prentice Hall, 2002.
2. S. Lang, *Introduction to Linear Algebra*, 3nd Edition, Addition-Wesley, 1999.
3. Sheldon Axler, Linear Algebra Done right, Springer UTM, 1997.
4. David Poole, Linear Algebra: A Modern Introduction, Thomson Brooks/cole, 2006.
5. G. Strang, *Linear Algebra and its Applications*, Thomas Brooks/Cole, 2006.
6. Paul R. Halmos, *Linear Algebra Problem Book*, Dolciani Mathematical Expositions, The Mathematical Association of America.
7. Promode Kumar Saikia, *Linear Algebra*, Pearson Education, 2009.

Semester IV

Analysis II (4 credits) (3 theory+1 tutorial)

Unit I Integration and its application to length, area, volume and surface area of revolution, centroids and quadrature rules, Riemann Integral, Integrability of continuous and monotonic functions, Fundamental theorems of integral calculus, Mean Value theorems of integral calculus

Unit II: Introduction to function of several variables, neighbourhood of a point in R^2, Limit of function of several variables, continuity of function of several variables, partial derivatives, Gradient, Directional derivatives, Tangent planes and normal lines, Jacobian, Differentiability of function of two variables, Extreme values of functions of several variables, Necessary and Sufficient conditions for extreme values.

Unit III: Multiple integrals, Existence and Properties of integrals, iterated integrals, change of variables, Parametric equations, Cylindrical, Spherical and polar coordinates, Divergence, Curl, Laplacian in Cartesian, cylindrical and spherical coordinates, Vector Fields, line integrals, The Fundamental Theorem for line integrals, Green's theorem, Parametric surfaces and their areas, surface integrals, volume integrals, Green, Stoke's and Gauss's divergence theorem.

Texts/References

1. J. Stewart, *Calculus with Early Transcendental Functions*, Cengage Learning.
2. M. J. Strauss, G. L. Bradley and K. J. Smith, *Calculus* (3rd Edition), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
3. T.M. Apostol, *Mathematical Analysis*, 5th edition, Addison-Wesley; Publishing Company, 2001.
4. T. M. Apostol, *Calculus-II*, 2nd edition, John Wiley & Sons, 2003.
5. W. Rudin, *Principles of Mathematical Analysis*, 5th edition, McGraw Hill Kogakusha Ltd., 2004.
6. R. G. Bartle, *The elements of Real Analysis*, 2nd edition, John Wiley & Sons, Inc., New York, 1976.
7. Sudhir R. Ghorpade, Balmohan V. Limaye, *A Course in Multivariable Calculus and Analysis*, Springer International Edition, 2010.

12-07-2018

8. Sean Dineen, *Multivariate Calculus and Geometry*, SUMS, 2001.

9. H. M. Schey, Div grad curl and all that, W. W. Noorton and Company, New York, London.

Semester V

Algebra I (3 credits) (2 theory+1 tutorial)

Unit I Symmetry of square, Dihedral groups, Matrix Groups, definition and examples of groups including permutation groups and Quaternion groups (illustration through matrices), elementary properties of groups, subgroups and example of subgroups, centralizer, center of a group, cyclic group, classification of subgroups of cyclic groups, Cycle notation for permutation, properties of permutations, even and odd permutation, a check-digit scheme based on the dihedral group D5, Product of two subgroups, definition and properties of cosets, Lagrange's theorem and its consequences including Fermat's Little theorem, an application of cosets to permutation groups, the rotation group of a cube and a soccer ball.

Unit II External direct product of groups, normal subgroup, factor groups, homomorphism, isomorphism, automorphisms of group, Caley's theorem, Cauchy's theorem for finite abelian groups, conjugacy, actions, orbits, stabilizers, counting orbits, Finite rotation groups, The Euclidean Groups.

Texts/References

1. J. A. Gallian, *Contemporary Abstract Algebra*, 7th Edition, Cengage Learning, 2010.
2. M. A. Armstrong, *Groups and Symmetry*, Springer.
3. M. Artin, Algebra, Prentice Hall of India, 1994.
4. D.S. Dummit and R.M. Foote, *Abstract Algebra*, John Wiley & Sons, 2003.
5. I. N. Herstein, *Topics in Algebra*, 4th Edition, Wiley Eastern Limited, New Delhi, 2003.

Ordinary Differential Equations (3 credits) (2 theory+1 tutorial)

Unit I Order and degree of ODE, Solution of first order ODE, first-order differential equations of higher degree, solvable for p, solvable for y, solvable for x, Clairaut's form, application of first-order differential equations, Higher order Differential equation, homogeneous and non-homogeneous equation, Reduction of order, solution of Linear equation with constant coefficients, method of undetermined coefficients, wronskian, method of variation of parameters.

Unit II Power series solutions of linear Differential equations about ordinary point and singular point, the method of Frobenius, Bessel's equation, Legendre's equation, properties of Bessel's and Legendre's functions, Laplace transforms and its applications to ODE.

Texts/References

1. Earl A. Coddington, *An Introduction to Ordinary Differential Equations*, New Delhi PHI 2010.

2. S. L. Ross, *Differential Equations*, 3rd Edn., Wiley India, 1984.
3. George F. Simmons, *Differential Equations with Applications and Historical Notes*, TMH.
4. A H Siddiqi, P Manchanda, *A first course in Differential Equations with Application*, Macmillan publishers, 2009.
5. M. D. Rai Singhania, Advanced Differential Equation, S. Chand 2009.

Semester VI

Analysis III (3 credits) (2 theory+1 tutorial)

Unit I: Improper integrals and their convergence, Comparison test, Abel's and Dirichlet's test, Integral as a function of a parameter and its applications, Beta and Gamma functions and their relations.

Series of functions, Weierstrass M-test, Weierstrass approximation theorem (statement only), Pointwise and uniform convergence of sequence of functions, uniform convergence and continuity, uniform convergence and differentiation, Uniform convergence and integration.

Unit II: Definition and examples of metric spaces, isolated points, accumulation and boundary points, limit points, closure and interior, open and closed sets, Cantor's intersection theorem, open and closed balls, convergence, Cauchy sequence and boundedness, Continuity and uniform continuity, completeness, contraction mapping theorem.

Texts/References

1. R. G. Bartle and D. R. Sherbert, *Introduction to Real Analysis* (3rd Edition), John Wiley and Sons (Asia) Pvt. Ltd., Sigapore, 2002.
2. Tom M. Apostel, *Mathematical Analysis*, Narosa Publications, NewDelhi, 2002.
3. Walter Rudin, *Principles of Mathematical Analysis*, McGraw-Hill International Editions, 1976.
4. S. C. Malik, Savita Arora, *Principles of Real Analysis*, Revised Edition, New Age International, New Delhi, 2000.
5. S. Kumarsan, *Topology of Metric Spaces* 2nd Edition, Narosa Publications, NewDelhi,

Partial Differential Equation and Complex Analysis (3 credits) (2 theory +1 tutorial)

Unit I Basic concepts and definition of Partial differential equation, Classification of partial differential equation, solution of first order partial differential equation, solution of linear partial differential equation with constant coefficient, higher order linear and non linear equation of variable coefficients, Monge's method for a special class of Non-Linear Equations (Quasilinear Equation) of the second order.

Unit II Complex Numbers, Stereographic Projection, Elementary Functions, Limits, Continuity of complex functions, Differentiable functions, Analytic and Harmonic Functions, The Cauchy-Riemann Equations, Complex line Integration, Cauchy;s theorem using Green's Theorem, Cauchy's Integral formula.

Texts/References

1. T. Amaranath, *An elementary course in partial differential equation*, Narosa publication 2009.

12-07-2018

2. I. N. Sneddon, *Elements of Partial Differential Equations*, McGraw Hill Publications.
3. Theodore W. Gamelin, Complex Analysis, *Springer, UTM, 2001.*
4. John H. Mathews, Russel W. Howel, Complex Analysis for Mathematics and Engineering, *Jones and Bartlett Publishers.*
5. Titu Andreescu and Dorin Andrica, *Complex Numbers from A to .....Z*, Birkhauser, 2006.

Semester VII

Algebra II (3 credits) (2 theory+1 tutorial)

Unit I Definition and examples of rings, properties of rings, subrings, integral domains, fields, characteristic of rings, ideals, ideal generated by subsets in a commutative ring with unity, factor rings, prime ideals, maximal ideals, homomorphisms and isomorphisms of rings, Polynomial rings over commutative rings, Division algorithm and its consequences, factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion, unique factorization in Z[X].

Unit II Fundamental theorem of Algebra (statement only), roots and their multiplicity, Relationship between roots and the coefficients, Fundamental theorem of symmetric polynomial (without proof), Evaluation of symmetric functions of roots, rational roots of polynomials with integral coefficients, Descartes rule of sign, Strum's theorem (statement only). Field extensions, Kronecker's theorem, construction of finite fields.

Texts/References

1. J. A. Gallian, *Contemporary Abstract Algebra*, 7^{th} Edition, Cengage Learning, 2010.
2. D.S. Dummit and R.M. Foote, *Abstract Algebra*, John Wiley & Sons, 2003.
3. M. Artin, *Algebra*, Prentice Hall of India, 1994.
4. I. N. Herstein, *Topics in Algebra*, 4th Edition, Wiley Eastern Limited, New Delhi, 2003.
5. Mapa, S. K., *Higher Algebra*, (Asoke Prakashan, Calcutta, 2006)

Numerical Methods (3 credits) (2 theory+1 tutorial)

Unit I Errors, Convergence, Bisection Method, Regula-Falsi Method, Fixed point iteration method, Matrix Computation, factorial, Newton's method, Secant method, finite difference operator, forward differences, backward difference and central difference, Lagrange and newton interpolation, Numerical differentiation, Integration, trapezoidal rule, Simpson's rule.

Unit II Solution of first order ODE, Euler's method, Runge Kutta (explicit), some implicit methods,

Inversion of matrix. Solution of system of linear equations, Gauss elimination, Gauss Siedal method, Matrix inversion, Matrix Triangularisation method.

Texts/References

1. M. K. Jain, S. R. K. Iyengar and R.K. Jain, *Numerical methods for Scientific and Engineering Computation*, New age International Publisher, India, 2007.
2. Brian W. Kernighan, Dennis M. Ritchie, *The C Programming Language*, 2nd Edition, Prentice Hall, PTR.
3. E. Balagurusawy, *Programming in ANSI C*, the Mc Graw-Hill companies 2009.
4. D. Prasad, *An Introduction to Numerical Analysis*, 3rd Edition Narosa Publishing house 2011.
5. S. Balachandra Rao, H.R. Anuradha, *Differential Equation with Application and Programs*, Hyderabad University press 1996.
6. S. S. Sastry, *Introduction to Numerical Analysis*, Prentice Hall.

12.07.2018

Semester VIII

Probability and Statistics (3 credits) (2 theory+1 tutorial)

Unit I Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moments generating function, characteristic function, discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential.

Unit II Joint probability density functions, marginal and conditional distributions, Joint cumulative distribution function and its properties, expectation of functions of two random variables, conditional expectations, independent random variables, bivariate normal distribution, joint moment generating function, correlation, regression, Central limit theorem, Chebyshev's inequality.

Texts/References

1. Robert V. Hogg, Joseph W. McKean and T. Craig, *Introduction to Mathematical Statistics*, Pearson Education, Asia, 2007.
2. Irwin Miller and Marylees Miller, *John E. Freud's Mathematical Statistics with Applications*, Pearson Education, Asia, 2006.
3. Sheldon Ross, Introduction to Probability Models, Academic Press, Indian Reprint, 2007.
4. Alexander McFarlane Mood, Franklin A. Graybill, *Introduction to the Theory of Statistics*, TMH.

Elective (3 credits) (2 theory+1 tutorial)

List of Electives

1. Linear Programing
2. Discrete mathematics
3. Graph Theory
4. Number Theory
5. Statics and Dynamics
6. Hydrodynamics

Number Theory (3 credits) (2 theory+ 1 tutorial)

Unit I Review of multiplicative functions, τ, σ, and μ and Mobius inversion formula; primitive roots, Quadratic Residues, Legendre symbols, Gauss' lemma, Quadratic Reciprocity Law and applications. Diophantine equations: $x^2 + y^2 = z^2$, $x^4 + y^4 = z^2$, Sums of squares, Waring's problem.

Unit II Binary quadratic forms over integers, Farey sequences, Rational approximations, Hurwitz'Theorem, Simple continued fractions, Infinite continued fractions and irrational numbers, Periodicity, Pell's equation. Distribution of primes, Function $\pi(x)$, Tschebyschef's theorem, Bertrand's postulate.

Texts/References

1. I. Niven and T. Zuckermann, *An Introduction to the Theory of Numbers*, Wiley Eastern.

2. G. H. Hardy and E.M. Wright, *Theory of Numbers*, Oxford University Press & E.L.B.S.

3. D. E. Burton, *Elementary Number Theory*, Tata McGraw-Hill.

5. T. M. Apostal, *Analytic Number Theory.*

Linear programming (3 credits) (2 theory+ 1tutorial)

Unit I: Operations Research (OR) and its Scope, Modeling in OR, Scientific Method in Operations Research, Linear Programming: Definition, Convex sets, mathematical formulation, standard form, Solution space, solution – feasible, basic feasible, optimal, infeasible, multiple, redundancy, degeneracy, Solution of LP Problems - Graphical Method.

Unit- II: Fundamental theorem of linear programming, Simplex method,Artificial variables, Big-M method, Two phase method. Duality in LP, Dual Simplex Method, Transportation Problem, Basic feasible solution using different methods (North-West corner, Least Cost, Vogel's Approximation Method), Optimality Methods, Unbalanced transportation problem, Degeneracy in transportation problems. Assignment Problem, Hungarian Method for Assignment Problem.

Texts/References

1. *J. K. Sharma, Operations Research – Theory and Application, Macmillian Pub.*
2. *J. K. Sharma, Operations Research – Problems and Solutions, Macmillian Pub.*
3. *G. Hadly, Linear Programming, Narosa Publishing House*
4. *A. H. Taha, Operations Research – An Introduction. Prentice Hall*
5. *Hillier and Lieberman, Introduction to Operations Research, McGraw Hill.*
6. *Kanti Swaroop, Gupta P.K. and Manmohan, Operation Research, Sultan Chand & Sons.*

Hydrodynamics (3 credit) (2 theory + 1 tutorial)

Unit I Basic Properties of fluid, Viscosity, Viscous and in viscid fluid, Newtonian and non – Newtonian fluid. Stress and Strain in a fluid, Laminar and turbulent flows, Stream line, path lines, vortex lines, Steady, Unsteady, rotational and irrotational flows.

Unit II Motion of fluid particle, Lagrangian and Eulerian methods for describing motion of fluid, Equation of continuity in Cartesian and polar co-ordinate system, Euler equation of motion, Bernaulli theorem, D' Alembert Paradox, One dimensional and two dimensional flows, stream function, velocity and complex potential, Navier Stokes equation in Cartesian coordinate for Incompressible fluid, Laminar flow of viscous Incompressible fluid, plane couette flow and plane poiseuille flow.

Texts/References

1. S. W. Yuan, *Foundations of Fluid Dynamics*, Prentice-Hall of India 1988.
2. F. Charlton, *A text book of Fluid Dynamics*, CBC, 1985
3. M. D Raisinghania, *Fluid Dynamics*, S. Chand, 2003.

Discrete Mathematics (3 credits) (2 theory+ 1 tutorial)

UNIT I: Sets & Relations: Power sets, Operations on Power sets, De-Morgan's laws, Cartesian products, Inverse relation, Pictorial representation of relations, Operations on relations, Matrices of relations, Types of relations and their closures, Equivalence relations and partitions, Congruence relation of Integers, Partial ordering relations, Hasse diagram, Logic: Propositions, Logical connectives, Truth Tables, Tautology and contradiction, Logical equivalence, Valid Arguments, Rule of Inference, Methods of proofs, Predicates and Quantifiers; Universal and Existential quantifications.

UNIT II: Combinatorics & Recurrence Relations: Permutation, Combination, Principle of Inclusion and Exclusion, Pigeonhole Principle, Recurrence Relations, Generating Functions. Graph Theory: Graphs, Degree of a vertex, Hand-Shaking Lemma, Types of graphs, Matrix representation of graphs, Walk, Trail, Paths and cycles, Connected graphs, Eulerian graphs, Hamiltonian graphs, Trees, Minimum Spanning Trees, Kruskal's Algorithm, Planar Graphs, Graph Colouring.

Texts/References

1. C.L. Liu, Elements of discrete mathematics, McGraw-Hill.
2. J.T. Tremblay and R.P. Manohar, Discrete mathematical structures with applications to computer science, McGraw-Hill.
3. B. Kolman, R. C. Busby, S. Ross, Discrete mathematical structures, Prentice Hall of India.
4. Kenneth H. Rosen, Discrete Mathematics and its Applications, McGraw-Hill.
5. Edward R. Scheinerman, Mathematics--A Discrete Introduction, Cengage Learning.

Statics and Dynamics (3 credits) (2 theory +1 tutorial)

Unit-I Velocity and acceleration components in Cartesian, polar and intrinsic systems, Velocity and acceleration along radial and transverse direction and along tangential and normal direction, Simple harmonic motion; Motion in resisting medium, Constrained motion (circular and cycloidal only), Linear momentum, Angular momentum, Conservation of angular momentum.

Unit-II Motion on smooth and rough plane curves, Central orbits and Kepler's law, Rocket motion, Work, Potential energy of a gravitational field; Analytic condition of equilibrium for coplanar forces; Equation of the resultant force, Virtual work, Common catenary, Stable and unstable equilibrium.

Texts/References

1. R.S. Verma - A Text Book on Statics, Pothishala Pvt. Ltd., Allahabad.
2. J.L. Synge & B.A. Griffith - Principles of Mechanics, Tata McGraw-Hill, 1959.
3. S.L. Loney - An Elementary Treatise on the Dynamics of a Particle and of Rigid Bodies, Kalyani Publishers, New Delhi.

GRAPH THEORY (3 credits) (2 theory +1 tutorial)

UNIT I: Graphs, Degree sequences, Subgraphs, Types of graphs, Types of subgraphs, Petersen graph, Independent sets and Coverings, Operations on graphs, Matrix representation of graphs, Isomorphism of graphs, Walks, Trails, Paths, Connected graphs, Components, Cut vertices, Cut edges, Eularian graphs, Hamiltonian graphs, Trees and Forests, Spanning trees, Rooted and Binary trees.

UNIT II: Weighted graphs, Minimum spanning trees, Kruskal's algorithms, Prim's algorithm, Travelling Salesman's problem, Shortest paths, Dijkstra's algorithm, Matchings, Hall's theorem, Planar Graphs and Duality, Euler's formula, Kuratowski's theorem, Vertex coloring, Edge coloring, Coloring of Planar graphs, Digraphs, Networks, Flows and Cuts..

Texts/References

1. John Clark and Derek A. Holton, A first look at Graph Theory, Allied Publishers Ltd., New Delhi, 1995.
2. Robin J.Wilson, Introduction to Graph Theory, Longman Group Ltd.
3. Douglas B. West, Introduction to Graph Theory, 2^{nd} Edition.
4. V. K. Balakrishnan, Graph Theory, Schaum's Outline Series, McGraw-Hill.
5. J.A.Bondy and U.S.R. Murthy, Graph Theory with Applications, Macmillon, London.

12.07.2010