ORDINANCES AND

OUTLINES OF TESTS, SYLLABI AND

COURSE OF READING FOR

M.Sc. (MATHEMATICS)

(2021-22)

COURSE CODE: MMTH

GENERAL SHIVDEV SINGH DIWAN GURBACHAN SINGH

KHALSA COLLEGE PATIALA

An Autonomous College
NAAC Accredited 'A' Grade
College with Potential for Excellence Status by UGC,
Star College Status-DBT
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APPROVED
Jasleen Kaur
Member Secretary
Academic Council

APPROVED
Principal
General Shivdev Singh Diwan Gurbachan Singh
Khalsa College Patiala

Preamble:

General Shivdev Singh Diwan Gurbachan Singh Khalsa College Patiala, accredited 'A' grade by NAAC (2015), recognized as "College with Potential for Excellence" status by UGC, New Delhi (2016) and an Autonomous College (2016), is a premier institute of higher education in the state of Punjab since 1960. Being concordant with the need to the creation of a self-sustaining, global knowledge society, the college has undertaken several measures initiated by UGC to bring equity, efficiency and excellence in the Higher Education System of the country.

The important measures taken to enhance academic standards and quality in higher education include innovation and improvements in curriculum, teaching-learning process, examination and evaluation system, besides governance and other matters.

The UGC has formulated various regulations and guidelines from time to time to improve the higher education system and maintain minimum standards and quality across the Higher Educational Institutions in India. The academic reforms recommended by the UGC in the recent past have led to overall improvement in the higher education system. However, due to lot of diversity in the system of higher education, there are multiple approaches followed by Higher Educational Institutions towards examination, evaluation and grading system. While the Higher Educational Institutions must have the flexibility and freedom in designing the examination and evaluation methods that best fits the curriculum, syllabi and teaching–learning methods, there is a need to devise a sensible system for awarding the grades based on the performance of students. Presently, the performance of the students is reported using the conventional system of marks secured in the examinations or grades or both. Then there is conversion from marks to letter grades as the letter grades are used widely across the Higher Educational Institutions in the country. This creates difficulty for the academia and the employers to understand and infer the performance of the students graduating from different universities and colleges based on grades.

The grading system is considered to be better than the conventional marks system and hence, it has been followed in the top institutions in India and abroad. So, it is desirable to introduce uniform grading system. This will facilitate student mobility across institutions within and across countries and will also enable potential employers to assess the performance of students. To bring in the desired uniformity in grading system and method for computing the cumulative grade point average (CGPA) based on the performance of students in the examinations, the UGC has formulated CBSS guidelines.

DEFINITIONS

a. Academic Year: Two consecutive (one odd + one even) semesters constitute one academic year.

b. Course: Usually referred to, as 'papers' is a component of a programme. All courses need not carry the same weight. The courses should define learning objectives and learning outcomes. A course may be designed to comprise lectures/tutorials/laboratory work/field work/outreach activities/ project work/vocational training/viva/seminars/term papers /assignments/ presentations/self study etc. or a combination of some of these.

c. 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.

d. Credit Point (CP): The numerical value obtained by multiplying the grade point (GP) by

the no. of credit(C) of the respective course i.e. CP= GP X C.

e. Credit(C): 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, i.e. a course with assigned L-T-P: 3-0-2 or 3-1-0 will be equivalent to 4 credits weight-age course.

f. 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 is expressed up to two decimal places.

g. Grade Point (GP): It is a numerical weight allotted to each letter grade on a 10 point scale.

h. 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.

i. Programme: An educational programme leading to award of a degree, diploma or certificate.

j. Semester Grade point Average (SGPA): It is a measure of performance of work done in a semester. It is ratio of total credit points (CPs) secured by a student in various courses registered in a semester and the total course credits taken during that semester. It shall be expressed upto two decimal places.

k. Semester: Each semester will 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.

l. Transcript or Grade Card (GC) 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, no. of credits, grades secured) along with SGPA of that semester and CGPA earned till date semester.

m.Semester Examinations: The comprehensive examinations conducted for summative evaluation of course. The duration of these examinations shall be 3 and 4 hours for theory and practical courses respectively; and the weight shall be as per the ordinance of relevant programme.

n. L-T-P: The prescribed hours/week during a semester for Lecture-Tutorial-Practical to a particular course, in accordance with curriculum prescriptions based on respective nature.

ORDINANCE FOR M.Sc. MATHEMATICS

Applicability of Ordinances for the time being in force.

Notwithstanding the integrated nature of a course spread over more than one academic year, the Ordinances in force at the time a student joins a course shall hold good only for the examination held during or at the end of the academic year. Nothing in these Ordinances shall be deemed to debar the College from amending the ordinances subsequently and the amended ordinances, if any, shall apply to all the students whether old or new.

1. The examination for the degree of Master of Mathematics shall be held in two parts to be called M.Sc. (Mathematics) Part-I and M.Sc. (Mathematics) Part-II. Each part shall consist of two semesters, viz. Semester 1st and 2nd in Part –I and semester 3rd and 4th in Part-II. The examination shall be held in the months of November/December for 1st and 3rd semester and April /May for 2nd and 4th semester or on such other dates as may be fixed by the Institute.
2. The examination in M.Sc (Mathematics) Part-I shall be open to a student who produces the following certificates to the Principal of the college.

   a
   (i) (a) B.A./ B.Sc. /B.Sc. (Honours) with Mathematics from any recognized university with at Least 50% marks for general candidates.
   (b) Mathematics as an additional subject during three year graduation course from any recognized university with at least 50% marks.
   (ii) 5% Relaxation in marks for SC/ST/ Physical Challenged Student.

   Note: Candidate placed under reappear in one or more subjects in B.A./B.Sc. or any other examination, recognized as equivalent thereto shall not be eligible for admission to M.Sc. (Mathematics) Part-I Course.

   (iii) of having good character.
3. M.Sc. (Mathematics) Part- II shall be open to any person who has passed M.Sc. (Mathematics) Part- I examination or has cleared at least 50% of total papers prescribed for first and second semesters of M.Sc. (Mathematics) courses. In case, the result of 2nd semester is not declared at the time of admission to 3rd semester, the student may be admitted provisionally and will be allowed to take the examination of 3rd semester if he/she has passed 50% of the total papers of first year (i.e. 1st and 2nd semester).
4. A candidate must complete and pass the whole course of two years within a maximum of four years from the date of admission in M.Sc. (Mathematics) First semester. If the candidate does not clear the lower examination within stipulated period the higher result of the candidate will stand automatically cancelled.
5. Semester examinations will be open to regular candidates who have been on the rolls of the college and meet the attendance and other requirements as prescribed in the ordinances of the course.
6. **Examination Rules**

6.1 Paper Setting/Evaluation will be done by an External Examiner or as decided by the Examination Cell.

6.2 The supplementary examination will be held along with the routine End Semester Tests. The supplementary paper would be from the syllabi prescribed for that session in which the candidate is appearing. The student can appear in the theory/practical paper on the payment of the required fee.

The candidate will have consecutive two attempts to clear the Supplementary Examination, marks of practical and internal assessment will be carried forward as original.

6.3 Re-evaluation of answer sheet in two subjects is allowed after paying the requisite fee. The application for Re-evaluation should be submitted within 15 days of the declaration of the results. In case there is a difference of more than 10 % between the marking of the First evaluator and the Second evaluator, then the paper would be sent to a Third Evaluator. The mean of the marks of the Second and Third evaluators is then considered as the final marks. The re-evaluated marks will be considered final irrespective of the increase or decrease in marks.

6.4 The students who have reappear in the IIIrd semester only in Two Year Degree Course at the Postgraduate Level will be allowed to appear in their Reappear examination along with the Final Semester Examinations of their respective courses.

6.5 A Candidate placed under reappear in any paper, will be allowed two chances to clear the reappear, which should be availed within consecutive two year/chances i.e. to pass in a paper the candidate will have a total of three chances, one as regular student and two as reappear candidate.

6.6 The examination of reappear papers of odd semester will be held with regular examination of the odd semester and reappear examination in even semester with the even semester. But if a candidate is placed under reappear in the last semester of the course, he/she will be provided chance to pass the reappear with the examination of the next semester, provided his/her reappear of lower semester does not go beyond next semester.

6.7 The Principal can provide Golden Chance (with special chance fee) to students who have been unable to clear their exams even after two attempts.

6.8 Viva- voce/Practical examination shall be conducted by a committee consisting of the following:-

1. One external experts
2. One Internal examiner (to be nominated by the Principal of the College/Head of the Department or his/her nominee)

The quorum of Committee meeting would comprise one external and one internal examiner.

7. **IMPROVEMENT EXAMINATIONS:**

I. A student who has been declared 'pass' in the Postgraduate course he/she was admitted to, may apply for improvement examination within a year from the declaration of the result of the final semester and he/she can take maximum of 50% of the total papers for that course for improvement.

II. A student shall have to appear in End semester examination of the paper chosen for improvement along with the regular students. No special exam shall be held for him/her.

III. If a student fails to improve upon the original marks obtained in the paper chosen for improvement, his/her original marks shall be retained and he/she shall not get a second chance for improvement.

IV. Improvement examination in practical/MST paper shall not be allowed.

V. A student taking improvement examination shall have to pay a fee decided by the college.

8 **Grading System:**

The grades and their description, along with equivalent numerical grade points are listed in the Grading Assignment Table as follows:

Grade Assignment Table

Range of Marks	Description	Grade	Grade Point
91-100	Outstanding	O	10
81-90	Excellent	A+	9
71-80	Very Good	A	8
61-70	Good	B+	7
51-60	Above Average	B	6
41-50	Average	C	5
35-40	Pass/Fair	P	4
0-34	Fail	F	0
Otherwise	Absent/Detained	Ab/D	0

a. A student obtaining Grade F shall be considered failed and will be required to reappear in the examination.

b. For non credit courses **'Satisfactory' or 'Unsatisfactory'** shall be indicated instead of the letter grade and this will not be counted for the computation of SGPA/CGPA.

9. **Computation of SGPA and CGPA**

The UGC recommends the following procedure to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

a. 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 and the sum of the number of credits of all the courses undergone by a student, i.e.

SGPA (Si) = ∑(Earned Credits Ci x Grade Point Gi)/∑Earned Credits Ci;

Where Ci is the number of credits of the ith course and Gi is the Grade Point Scored by the student in the ith course.

b. The CGPA is also calculated in the same manner taking into account all the courses undergone by a student over all the semesters of a programme, i.e.

CGPA (Ci) = ∑(Earned Credits Ci x SGPA Si)/∑Ci);

Where Si is the SGPA of the ith semesters and Ci is the total number of credits in that semester.

c. The SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.

Illustration of the computation of SGPA and CGPA and Format for Transcripts

i. **Computation of SGPA and CGPA**

Illustration for SGPA

Course	Credits	Grade	Grade Point	Credit Point (Credit x Grade)
Course 1	3	A	8	3 X 8 = 24
Course 2	4	B	7	4 X 7 = 28
Course 3	3	B	6	3 X 6 = 18
Course 4	3	O	1	3 X 10 = 30
Course 5	3	C	5	3 X 5 = 15
Course 6	4	B	6	4 X 6 = 24
	2			139

Thus, **SGPA = 139/20 = 6.95**

Illustration for CGPA

Semester 1	**Semester 2**	**Semester 3**	**Semester 4**
Credit : 20 SGPA : 6.9	Credit : 22 SGPA : 7.8	Credit : 25 SGPA : 5.6	Credit : 26 SGPA : 6.0
Semester 5	**Semester 6**		
Credit : 26 SGPA : 6.3	Credit : 25 SGPA : 8.0		

Thus, **CGPA** = $\frac{20 \times 6.9 + 22 \times 7.8 + 25 \times 5.6 + 26 \times 6.0 + 26 \times 6.3 + 25 \times 8.0}{144} = 6.73$

ii. **Transcripts (Format):**

Based on the above recommendations on Letter grades, grade points, SGPA and CGPA, the College may issue the transcript for each semester and a consolidated transcript indicating the performance in all semesters.

10. **Division and Position:**

Division shall be awarded in the following manner, to the candidates on the basis of their respective CGPA:

CGPA 7.5 or more	1st Division with Distinction
CGPA 6.0 or more but less than 7.5	1st Division
CGPA 5.0 or more but less than 6.0	2nd Division
CGPA 3.5 or more but less than 5.0	3rd Division
Otherwise	Fail

However, First, Second or Third position shall be awarded to the candidates, provided they meet the following conditions:

a) Rank shall be solely decided on the final CGPA, on completion of degree credit requirement.

b) The candidate has completed all the prescribed requirements, in the prescribed programme duration.

c) The candidate has passed / secured valid grades in all the prescribed courses, in the first attempt.

d) No disciplinary action is pending or has ever been lodged against him/her.

e) In case of an exceptional tie, both candidates shall be awarded the same rank.

11. **Grade Card:**

At the end of each semester, a student will be given a 'Grade Card' which will contain Course Code, Title, Credits, Grades Awarded, Earned Credits and Earned Point secured by him/her in each course, together with his/her SGPA in that semester. On the completion of the programme, a Final Grade Card will be issued to the student, giving full semester-wise details about the absolute marks and grades obtained by him/her in each course together with his/her SGPA and also the CGPA and Division awarded to him/her.

12 **Equivalence:**

Percentage (P) equivalent to CGPA earned by a candidate may be calculated using the following formula:

P= CGPA X 10

13**. MALPRACTICES/UNFAIR MEANS**

13.1 The following shall be deemed to be unfair means:

I. Leaving the Examination Hall without submitting the answer book to the invigilator or taking away, tearing off or otherwise disposing off the same or any part thereof.
II. Using abusive language in the examination hall or writing the same in the answer sheet.
III. Making an appeal to the evaluator through answer sheet.
IV. Possession by examinee or having access to books, notes, papers, mobile or any other electronic material which can prove to be helpful in the exam.
V. Any action on the part of candidate at an examination trying to get undue advantage in the performance at examinations or trying to help another, or derive the same.
VI. Impersonating for a candidate in the examination.
VII. Intimidating, threatening, manhandling, using violence, show of force in any form against any invigilator or any person on duty, creating disturbance to the smooth conduct of the examination.
VIII. Any other action which the Controller Examination / Chief Controller deem fit to be a case of UMC.

13.2 In case the student is found to have used any of the above Unfair means:

I. His/her answer book shall be seized and He/She will be given a new answer sheet.
II. Invigilator shall submit a detailed report along with the answer book of the student and the related material, if any, to the Centre Superintendent who will subsequently hand it over to Controller Examination.
III. Written statement to this effect shall be obtained from the student by the Centre Superintendent. In case the student refuses to do the same, the fact of refusal must be recorded.
IV. The student reported to have used unfair means shall be allowed to appear in the subsequent papers. However, no marks would be awarded for the paper in which unfair means were used.
V. The Principal shall refer the cases of malpractices in Mid Semester tests, House Tests and End Semester Examinations, to an Unfair Means Committee, constituted by him/her for the purpose. Such committee shall follow the approved scales of punishment. The Principal shall

take necessary action, against the erring students based on the recommendations of the committee.

13.3 The involvement of the Staff, who are in charge of conducting examinations, evaluating examination papers and preparing/keeping records of documents relating to the examinations if involved in such acts (inclusive of providing incorrect or misleading information) that infringe upon the course of natural justice to one and all concerned at the examination shall be viewed seriously and recommended for award of appropriate punishment after enquiry.

14. Attendance Regulations & Condonation:

14.1 A student shall be eligible to appear for end semester examinations, if he/she acquires . a minimum of 75% of attendance in each subject.

14.2 Request to the Principal for Condonation of shortage of attendance after the recommendation of the HOD will be forwarded to Lecture Shortage Condonation Committee. The committee can finally condone the shortage in aggregate up to 15% on medical grounds in each semester.

14.3 Any student representing the Institute/ University/ State/ Nation in any Academic/ Sports/ Cultural/Extra Co curricular/ NSS/NCC or any other event shall be considered on duty. His/ Her shortage of lectures shall be condoned, provided that the student is permitted in writing by the Principal/HOD concerned and a certificate to this effect signed by the competent authority where the student attended the event is taken.

14.4 A Student will not be promoted to the next semester unless he/she satisfies the attendance requirement of the present semester as applicable.

14.5 Students whose shortage of attendance is not condoned in any semester are not eligible to take their end semester examination of that particular semester and their registration for examination shall stand cancelled and no fee shall be refunded.

15. Late college students: A candidate, who has completed the prescribed course of instructions for a semester but has not appeared in the examination or having appeared, has failed in the examination, may appear as a late college student within the prescribed period.

16. Applications for admission to the examination shall be made on the prescribed form attested by the competent authority as per the college rules.

17. Amount of examination fee to be paid by a candidate for each semester shall be as fixed by the College from time to time.

18. The last date by which examination forms and fees must reach the College office shall be as follows.

Semester	Without late fee	With Late fee of Rs. 800/-	With Late fee of Rs.1200/-	With Late fee of Rs. 5000/-	With Late fee of Rs. 10000/-
Nov./Dec. (Odd)	Sept. 30	Oct.15	Oct. 21	Oct. 31	Nov. 10*
April/May(Even)	Feb. 28	March 15	March 21	March 31	April 15*

***Note: No Examination Form will be accepted after the prescribed date.**

19. College medal will be awarded to a candidate who secures first position in the College on the basis of the marks of all the four semesters taken together. The general rules and conditions of the College/University for the Award of medal/prizes etc. will be applicable in the award of College medal to the topper of this examination.
20. The syllabus for the session shall be such as prescribed by the institute from time to time.
21. The medium of instruction and examination shall be English.
22. **Assessment:**

22.1 M.Sc. (Mathematics) course is Credit Based Semester System (CBSS) as described in the Introduction.

22.2 The assessment in all semesters of M.Sc. (Mathematics) Part- I & II will be 30% internal and 70% external for each paper. The result for the internal examinations shall be conveyed to the students/Examination Branch by the Head of the Department as per approved schedule.

22.3 There shall be Two Mid Semester tests in each Semester.

22.4 Internal Assessment of 30% will be based on Continuous Comprehensive Assessment (CCA) pattern and the breakup of 30% will be as under:

(i)	Average of Two mid Semester Tests	:	40%
(ii)	Assignment/Seminar/Class Test/Tutorial/Quiz etc.	:	40%
(iii)	Attendance	:	20%

Papers having practical/viva, the marks of theory and practical/viva will be reduced equally percentage wise to make room for 30% internal assessment.

Note: If a case comes to notice of Controller of Examinations where the marks awarded by the Teacher are on a very Higher/Lower side, the award will be got moderated by the following committee.

I. Paper Evaluator
II. Head of the Department
III. Controller of Examination

22.5 A candidate is required to secure at least 35% marks both in external examination (Theory and Practical/ Project work) and in internal assessment separately in each paper in order to qualify in an examination.

22.6 In case the student is dissatisfied with the marks awarded to him/her in internal assessment; he/she can approach the concerned teacher. If the student is still not satisfied he/she may approach the head of department and the Principal subsequently.

In case such a paper is dropped from the course of study as a result of any revision the department would indicate a suitable substitute paper in lieu thereof.

23. **End-Semester Examination:**

End-semester examination(s) of each theory course shall be of three hours duration and will be conducted as per norms and schedule notified by the Controller of Examination. The end semester examinations of laboratory/practical courses and other courses such as seminar, colloquium, field work, project, dissertation etc. shall be conducted as notified by the HOD.

24. **Degree Requirement:**

24.1 The result of all the examinations will be declared through the College website.

24.2 The grace marks shall be allowed according to the general ordinances relating to ‘Award of Grace Marks’. These ordinances will apply to all examinations.

(i) Up to 1% of the total marks of Part-I and II examination shall be added to the aggregate of both Part-I and Part-II examinations to award a higher division/55%marks, to a candidate.

(ii) Grace marks to be given shall be calculated on the basis of 1% of total aggregate marks of all the written and practical papers of the examination concerned. Marks for viva-voce/internal assessment/sessional work/skill in teaching/any additional /optional subject shall not be taken into account for this purpose. If a fraction works out to half or more, it shall count as one mark and fractional less than half shall be ignored

(iii) To pass in one or more written papers or subjects, and/or to make up the aggregate to pass the examination but not in sessional work, internal assessment, viva-voce and skill in teaching.

24.3 The College may from time to time revise, amend and change the regulations or the curriculum, if formed necessary.

24.4 A student who earns total specified credits according to the curriculum and fulfills such other conditions as may be mentioned in the curriculum of the programme shall be issued the DMC and shall be awarded degree by Punjabi University Patiala. He/she must also pay all College dues as per rules. Moreover, there should be no case of indiscipline pending against him/her.

25. If any student gets admission after concealing any fact or his/her certificates are found fake after verification or he/she misleads the institution as any front or because of any other reason, his/her admission will stand cancelled/ his/her result cancelled though he/she may have been declared pass.

26. In case the ordinance is silent about any issue, it will be decided by the College Principal in consultation with the Academic Advisory Committee of the college in the anticipation of approval of the same by Academic Council of the College.

APPROVED
Member Secretary
Academic Council

APPROVED
Principal
General Shivdev Singh Diwan Gurbachan Singh
Khalsa College Patiala

M.Sc. (MATHEMATICS)

PART I (SEMESTER I & II)

(CREDIT-BASED SEMESTER SYSTEM)

(SEMESTER I)

PAPER CODE	TITLE OF THE PAPER	HOURS PER WEEK			TOTAL CREDITS
		L	T	P	
MMTH 101	Mathematical Analysis	4	1	0	5
MMTH 102	Number Theory	4	1	0	5
MMTH 103	Algebra	4	1	0	5
MMTH 104	Complex Analysis – I	4	1	0	5
MMTH 105	Ordinary Differential Equations	4	1	0	5

(SEMESTER II)

PAPER CODE	TITLE OF THE PAPER	HOURS PER WEEK			TOTAL CREDITS
		L	T	P	
MMTH 201	Functional Analysis	4	1	0	5
MMTH 202	Rings & Modules	4	1	0	5
MMTH 203	Topology	4	1	0	5
MMTH 204	Number Theory-II	4	1	0	5
MMTH 205	Measure Theory	4	1	0	5

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(SEMESTER I)

MMTH 101: MATHEMATICAL ANALYSIS

Credit: 5(4H(L)+1H(T))

Duration: 3Hrs. **Max. Marks: 100**

Internal Assessment: 30

External Examination: 70

Course Objectives:

- To provide a framework for understanding the concept of real numbers.
- To demonstrate the concepts of mean value theorem, fundamental theorem of calculus in the experimental way using several specific examples.
- To make the students aware of concepts of Metric Spaces, Riemann's Integral and its applications

INSTRUCTIONS FOR PAPER SETTER/EXAMINER

The question paper covering the entire course shall be divided into three parts: A, B & C. Each of sections A and B will have 4 questions from the respective sections of the syllabus of 10 marks each and section C will consist of 1 compulsory question having 10 parts of short-answer type of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and the compulsory question from section C.

Section – A

Metric Spaces: Definition and Examples, The Euclidean Space $\mathbf{R^k}$ as a Metric Space, Neighborhoods, Open and Closed Sets, Interiors, Closures and Relative Open Sets. Compactness, Compactness of k- cells in $\mathbf{R^k}$, Weierstrass Theorem, Perfect sets, Cantor sets, Connected sets in $\mathbf{R^1}$. (RB 1 : Chapter 2, Section :- 2.15-2.47)

Riemann- Stieltjes Integration: Definition and Existence of Riemann-Stieltjes Integral, Properties of Integral, Integration and Differentiation, The Fundamental Theorem of Calculus, Change of Variables, Integration of Vector Valued Functions, Rectifiable Curves. (RB 1 : Chapter 6)

Section - B

Rearrangement of terms of a Series, Riemann's Theorem, Power Series, Uniqueness Theorem for Power Series, Abel's Theorem and Tauber's Theorem, Exponential and Logarithmic Functions, Trigonometric Functions, The Algebraic Completeness of the Complex Field, Fourier Series. (RB 1 : Chapter 3, Section :- 3.5-3.55 , Chapter 8, Section :- 8.1-8.16)

Functions of Several Variables: Linear Transformations, Derivatives in an Open Subset of R^n, ChainRule, Partial Derivatives, Interchange of the Order of Differentiation, Derivatives of Higher Orders, Contraction Principle, Inverse Function Theorem, Implicit Function Theorem. (RB 1 : Chapter 9, Section :- 9.1-9.29, 9.39-9.41)

Reference Books:

1. W. Rudin, Principles of Mathematical Analysis, 3rd edition, McGraw Hill, Kogakusha, 2017, International student edition.
2. T. Apostol, Mathematical Analysis, 2nd edition, Narosa Publishers, 2002.
3. K.A. Ross, Elementary Analysis: The Theory of Calculus, 2nd Edition Springer Int. Edition, 2013.
4. W. Fleming, Functions of Several Variables, 2nd Edition, Springer-Verlag, 1987
5. E.T. Copson, Metric Spaces, Cambridge University Press, 1988

APPROVED

MMTH 102: NUMBER THEORY-I

Credit: 5(4H(L)+1H(T))

Duration: 3Hrs. **Max. Marks: 100**
Internal Assessment: 30
External Examination: 70

Course Objectives:

- To define and interpret the concepts of prime numbers, divisibility, congruence, g.c.d., prime factorizations.
- To learn about some open problems in number theory.
- To improve the ability of mathematical thinking.
- To learn about intriguing findings related to properties of prime numbers.

INSTRUCTIONS FOR PAPER SETTER/EXAMINER

The question paper covering the entire course shall be divided into three parts: A, B & C. Each of sections A and B will have 4 questions from the respective sections of the syllabus of 10 marks each and section C will consist of 1 compulsory question having 10 parts of short-answer type of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and the compulsory question from section C.

Section – A

Divisibility and special divisibility tests by prime numbers using multipliers, The Euclidean algorithm, The Diophantine equation $a + b = c$, The Fundamental Theorem of Arithmetic, Sieve of Eratosthenes, Basic Properties of Congruence, Chinese Remainder Theorem, Fermat's Little Theorem and pseudo primes, Wilson's Theorem, Residue Classes and Reduced Residue Classes, Euler's Theorem, Primitive roots and indices.

Section-B

Arithmetic Functions $\varphi(n)$, $d(n)$, $\sigma(n)$, $\mu(n)$ and their relations, Mobius Inversion Formula, Quadratic Residues, Legendre Symbol, Quadratic Reciprocity Law, Jacobi Symbol, Perfect Numbers, Mersenne Primes and Fermat Numbers, Pythagorean Triples , History of Fermat's last theorem, The Fibonacci Sequence, The Golden Ratio, Farey Sequences.

Reference Books:

1. D. M. Burton, Elementary Number Theory, 7th Edition, Mc Graw Hill Ed., 2017
2. I. Niven, H.S. Zuckerman, H.L.Montgomery, An Introduction to Theory of Numbers, 5th Edition John Wiley & Sons, 2008
3. H. Davenport, The Higher Arithmetic, 8th Edition, Camb. Univ. Press, 2008
4. G.H.Hardy, E.M.Wright, An Introduction to the theory of numbers, 6th Edition Oxford Univ. Press, 2008.
5. J.B. Dence, T.P. Dence, Elements of the Theory of Numbers, academic Press, 1999.

MMTH 103: ALGEBRA

Credit: 5(4 H(L)+1H(T))

Duration: 3Hrs. **Max. Marks: 100**

Internal Assessment: 30

External Examination: 70

Course Objectives:

- To nurture the interests in structures of groups and rings.
- To study the fundamental results and to solve algebraic problems using appropriate techniques.
- To make the understanding of the structure of a permutation group and its applications in real life.
- To study commutative rings with unity that helps in developing basic foundation in other areas of mathematics.

INSTRUCTIONS FOR PAPER SETTER/EXAMINER

The question paper covering the entire course shall be divided into three parts: A, B & C. Each of sections A and B will have 4 questions from the respective sections of the syllabus of 10 marks each and section C will consist of 1 compulsory question having 10 parts of short-answer type of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and the compulsory question from section C.

Section - A

Normal and Subnormal Series, Composition Series, Jordan-Holder Theorem for Groups, Fundamental Theorem of Arithmetic, Zassenhaus Lemma, Schier's Refinement Theorem, Solvable Groups, Nilpotent Groups.(RB1: Chapter 6)

Group Action, Stabilizer, Orbit, Review of Class Equation, Permutation Groups, Cyclic Decomposition, Alternating Group A_n, Simplicity of A_n. (RB 1: Chapter 7)

Section - B

Structure theory of Groups, Fundamental Theorem of Finitely Generated Abelian Groups, Invariants of a Finite Abelian Group, Sylow's Theorems, Groups of order p^2, pq. (RB1: Chapter 8)

Review of Rings and Homomorphism of Rings, Ideals, Algebra of Ideals, Maximal and Prime Ideals, Ideal in Quotient Rings, Field of Quotients of Integral Domain. (RB 1: Chapter 10)

Reference Books:

1. Bhattacharya, Jain & Nagpaul: Basic Abstract Algebra, Second Edition ,University of Cambridge,1995
2. I.N. Herstein : Topics in Algebra, Second Edition.Wiley,2006.
3. Surjeet Singh, Qazi Zameeruddin : Modern Algebra, Vikas Publishing House, 1972.

MMTH 104: COMPLEX ANALYSIS – I

Credit: 5(4 H(L)+1H(T))

Duration: 3Hrs. **Max. Marks: 100**

Internal Assessment: 30

External Examination: 70

Course Objectives:

- To represent complex numbers algebraically and geometrically.
- To apply the concepts and consequences of analytic and meromorphic functions.
- To classify singularities and poles of functions and represent them as Taylor, power and Laurent series,
- To learn the techniques of finding residues and evaluate complex integrals

INSTRUCTIONS FOR PAPER SETTER/EXAMINER

The question paper covering the entire course shall be divided into three parts: A, B & C. Each of sections A and B will have 4 questions from the respective sections of the syllabus of 10 marks each and section C will consist of 1 compulsory question having 10 parts of short-answer type of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and the compulsory question from section C.

Section- A

Functions of Complex Variable, Analytic Function, Cauchy-Riemann Equations, Harmonic Function and Harmonic Conjugates, Branches of Multivalued Functions with reference to arg z, $\log z$ and z^c. Complex Integration, Cauchy's Theorem, Cauchy Goursat Theorem, Cauchy

Integral Formula, Morera'sTheorem, ML-Inequality, Liouville's Theorem, Fundamental Theorem of Algebra, Maximum Modulus Principle, Schwarz Lemma, Taylor's Theorem, Laurent Series in an Annulus.

Section - B

Singularities, Meromorphic Function, Cauchy's Theorem on Residues, Application to Evaluation of Definite Integrals,conformal mapping. Principle of Analytic Continuation, General Definition of an Analytic Function.Analytic Continuation by Power Series Method, Natural Boundary, Harmonic Functions on a Disc, Schwarz Reflection Principle.

Reference Books:

1. L.V. Ahlfors, Complex Analysis, Mc Graw Hill Co., Indian Edition, 2017.
2. S. Ponnusamy, Foundations of Complex Analysis, 2nd Edition, Narosa Publications, Reprint 2019
3. T.W. Gamelin, Complex analysis, Springer, 2001
4. L. Hahn, B. Epstein, Classical complex Analysis, Jones and Bartlett, 1996.
5. J.B. Conway, Functions of one complex variable, 2nd edition, Narosa, New Delhi, 1996.

MMTH 105: ORDINARY DIFFERENTIAL EQUATIONS

Credit: 5(4 H(L)+1H(T))

Duration: 3Hrs. **Max. Marks: 100**

Internal Assessment: 30

External Examination: 70

Course Objectives:

- To know about existence, uniqueness and continuity of solutions of first order ODE's.
- To understand with eigen values and eigen functions of Sturm−Liouville systems, and the solutions of initial and boundary value problems.
- To investigate the qualitative behavior of solutions of system of differential equations.
- To develop interests in solving a number of problems related to model natural phenomena, engineering systems and many other situations.

INSTRUCTIONS FOR PAPER SETTER/EXAMINER

The question paper covering the entire course shall be divided into three parts: A, B & C. Each of sections A and B will have 4 questions from the respective sections of the syllabus of 10 marks each and section C will consist of 1 compulsory question having 10 parts of short-answer type of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and the compulsory question from section C.

Section - A

Existence of Solution of ODE of First Order, Initial Value Problem, Ascoli's Lemma, Gronwall's Inequality, Cauchy Peano Existence Theorem, Uniqueness of Solutions, Method of Successive Approximations, Existence and Uniqueness Theorem.

System of Differential Equations, n^{th} order Differential Equation, Existence and Uniqueness of Solutions, Dependence of Solutions on Initial Conditions and Parameters.

Section - B

Linear System of Equations (Homogeneous & Non Homogeneous), Superposition Principle, Fundamental Set of Solutions, Fundamental Matrix, Wronskian, Abel Liouville Formula, Reduction of Order, Adjoint Systems and Self Adjoint Systems of Second Order.

Linear 2nd Order Equations, Preliminaries, Sturm's Separation Theorem, Sturm's Fundamental Comparison Theorem, Sturm Liouville Boundary Value Problem, Characteristic Values & Characteristic Functions, Orthogonality of Characteristic Functions, Expansion of a Function in a Series of Orthonormal Functions.

Reference Books:

1. S.L. Ross, Differential Equations, 3rd edition, John Wiley & sons (Asia), 2007.
2. E. Coddington & N. Levinson, Theory of Ordinary Differential Equations, Tata Mc-Graw Hill, India ,1984.
3. G.F. Simmon, Differential Equations with applications and historical notes, Taylor & Francis, 3rd ed., 2017
4. A.C. King, J. Billingham, S.R. Otto, Differential Equations, Linear, Nonlinear, Ordinary, Partial, Cambridge University Press, 2003.

SEMESTER-II
MMTH 201: FUNCTIONAL ANALYSIS
Credit: 5(4 H(L)+1H(T))

Duration: 3Hrs. **Max. Marks: 100**
Internal Assessment: 30
External Examination: 70

Course Objectives:

- To learn the properties of Banach Space and Hilbert Space and their difference.
- To study the basic concepts, properties of operators and their classification.
- To investigate the best approximation of a given vector by vectors in a given subspace.

INSTRUCTIONS FOR PAPER SETTER/EXAMINER

The question paper covering the entire course shall be divided into three parts: A, B & C. Each of sections A and B will have 4 questions from the respective sections of the syllabus of 10 marks each and section C will consist of 1 compulsory question having 10 parts of short-answer type of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and the compulsory question from section C.

Section - A

Normed Linear Spaces, Banach Spaces, Examples of Banach Spaces, Subspaces and Quotient Spaces, Continuity of Linear Maps, Equivalent Norms, Normed Spaces of Bounded Linear Maps, Bounded Linear Functional, Hahn-Banach Theorem in Linear Spaces and its Applications. Natural Embedding of N into N^{**}, Open Mapping Theorem, Projections on Banach Spaces, Closed Graph Theorem, Uniform Boundedness Principle.

Section - B

Inner Product Spaces, Hilbert Spaces, Examples, Schwarz's Inequality, Orthogonality, Orthonormal Sets, Bessel's Inequality, Parseval's Theorem, Gram Schmidt Orthogonalization Process, The Conjugate Space of a Hilbert Spaces.

Adjoint Operators, Self - Adjoint Operators, Normal and Unitary Operators, Projection Operators, Invariants and Reducibility.

Reference Books:

1. G.F.Simmons, Introduction to Toplogy and Modern Analysis, Mc. Graw Hill Ed., 2004
2. S.Ponnusamy, Foundations of Functional Analysis, Narosa Publishing House, Reprint 2017
3. G. Bachman & L. Narici, Functional Analysis, Courier Coorporation,1966.

MMTH 202: RINGS & MODULES

Credit: 5(4 H(L)+1H(T))

Duration: 3 Hrs. **Max. Marks: 100**

Internal Assessment: 30

External Examination: 70

Course Objectives:

- To familiar with rings and fields and to understand the structure theory of modules over Euclidean Domain along with its implications.
- To understand the importance of a ring as a fundamental object in algebra and the concept of a module as a generalization of a vector space.
- To develop the capability to transact with module theory which is requisite in broad arrays of mathematical areas?

INSTRUCTIONS FOR PAPER SETTER/EXAMINER

The question paper covering the entire course shall be divided into three parts: A, B & C. Each of sections A and B will have 4 questions from the respective sections of the syllabus of 10 marks each and section C will consist of 1 compulsory question having 10 parts of short-answer type of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and the compulsory question from section C.

Section - A

Homomorphism of Rings, Unique Factorization Domains, Principal Ideal Domains, Euclidean Domains, Polynomial Rings over UFD, Rings of Fractions (RB1: Ch. 11 and Section 1 of Chapter 12).

Modules: Definition and Examples, Submodules, Direct Sum of Submodules , Free Modules, Difference between Modules and Vector Spaces, Quotient Modules, Homomorphism, Simple Modules, Modules over PID (RB2: Chapter 5)

Section - B

Modules with Chain Conditions:Artinian Modules, Noetherian Modules, Composition Series of a Module, Length of a Module, Hilbert Basis Theorem (RB2: Chapter 6).

Cohen Theorem, Radical Ideal, Nil Radical, Jacobson Radical, Radical of Artinian Ring. (RB2:Chapter 6).

Reference Books:

1. Bhattacharya, Jain and Nagpaul: Basic Abstract Algebra, Second Edition, Cambridge University Press,1995.
2. C. Musili, Introduction to Rings and Modules, 2nd Edition, Narosa Publishing House, 1997.

MMTH 203: TOPOLOGY-I

Credit: 5(4 H(L)+1H(T))

Duration: 3 Hrs. **Max. Marks: 100**

Internal Assessment: 30

External Examination: 70

Course Objectives:

- To familiar with topological spaces and having a grasp on basic results on set theory.
- To determine interior, closure, boundary points, limit points of subsets and basis, sub basis of topological spaces.
- To gain knowledge of continuity of functions in general way, concepts of homeomorphism and to distinguish the spaces up to homeomorphisms.
- To determine the connectedness and path connectedness of spaces.
- To study the separation axioms of spaces.

INSTRUCTIONS FOR PAPER SETTER/EXAMINER

The question paper covering the entire course shall be divided into three parts: A, B & C. Each of sections A and B will have 4 questions from the respective sections of the syllabus of 10 marks each and section C will consist of 1 compulsory question having 10 parts of short-answer type of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and the compulsory question from section C.

Section – A

Countable and Uncountable Sets, Axioms of Choice, Hausdorff Maximal Principle, Zorn's Lemma, Well Ordering Principle (Only Statements).

Topological Spaces, Different Types of Topological Spaces, Base and Local Base for a Topology, Characterization of a Base for a Topology, The Subspace Topology, Open and Closed Sets, Limit Points, Interior, Exterior, Boundary and Closure in Topological Spaces, Dense Sets and Examples.

Section - B

First and Second Countable Spaces, Continuous Functions and Properties, Pasting Lemma, Sequential Continuity, Homeomorphism, Topological Property, Open and Closed Maps, Restriction and Extension Maps, Isometry, Separable Space and Separated Sets.

Connected and Disconnected Sets, Relation of Connectedness, Totally Connected Sets, Connected Subspaces of the Real Line, Components and Local Connectedness, Theorems Related to Components and Local Connectedness, T_0 , T_1 and T_2 spaces (Definitions only, without Theorems)

Reference Books:

1. James R. Munkres, Elements of Algebraic Topology, 2nd Edition, Westview Press, 1996.
2. J. Dugundji , Topology ,William C Brown Pub., 1966.
3. G. F. Simmons, Introduction to Topology and Modern Analysis, Krieger Publishing company, 2003.
4. J.L. Kelly, General Topology, Springer, 1975.
5. S.Willard, General Topology, Dover publications, 2004.

MMTH 204: NUMBER THEORY-II

Credit: 5(4 H(L)+1H(T))

Duration: 3 Hrs. **Max. Marks: 100**

Internal Assessment: 30

External Examination: 70

Course Objectives:

- To define and interpret the concepts of prime numbers, divisibility, congruence, g.c.d., prime factorizations.
- To learn about some open problems in number theory.
- To improve the ability of mathematical thinking.
- To learn about intriguing findings related to properties of prime numbers.

INSTRUCTIONS FOR PAPER SETTER/EXAMINER

The question paper covering the entire course shall be divided into three parts: A, B & C. Each of sections A and B will have 4 questions from the respective sections of the syllabus of 10 marks each and section C will consist of 1 compulsory question having 10 parts of short-answer type of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and the compulsory question from section C.

Section - A

Finite and Infinite Continued Fractions, Pell's Equations, Partitions, Diophantine equation $x^4 + y^4 = z^2$, sum of two squares and sum of more squares, Fermat's Two Square Theorem, Non-linear Congruences Modulo Prime Powers , Hensel' Lemma, Binary Quadratic Forms, Unimodular Substitution, Equivalent Forms, Proper Representation, Discriminant of a Quadratic Form, Definite and Indefinite Forms, Proper Representation and Equivalent Forms, Reduction of Binary Quadratic Forms, Reduced Forms of a Given Discriminant, Uniqueness of Equivalent Reduced Form, Class Number.

Section–B

Primes Expressible as a Sum of Two Squares, Integers Expressible as a Sum of Two Squares, Sum of Three Squares, Sum of Four Squares, Waring's problem, Riemann Zeta Function, Convergence, Euler Product, Mangoldt Function, Liouville's Function, The Divisor Functions, Relation Connecting $\leftrightarrow$ and $\Uparrow$, Product Formula for $\leftrightarrow(n)$, Dirichlet Product of Arithmetical Functions, Multiplicative Functions, Dirichlet Multiplication, The Inverse of a Completely Multiplicative Function, Euler's Summation Formula, Dirichlet's Theorem for Primes of the form 4n-1 and 4n+1,Dirichlet's Theorem in Primes on Arithmetical Progression, Distribution of Primes inArithmetical Progression

Reference Books:

1. D. M. Burton, Elementary Number Theory, 7th Edition, Mc Graw Hill Ed., 2017
2. I. Niven, H.S. Zuckerman, H.L.Montgomery, An Introduction to Theory of Numbers, 5th Edition John Wiley & Sons, 2008
3. H. Davenport, The Higher Arithmetic, 8th Edition, Camb. Univ. Press, 2008
4. G.H.Hardy, E.M.Wright, An Introduction to the theory of numbers, 6th Edition Oxford Univ. Press, 2008.
5. J.B. Dence, T.P. Dence, Elements of the Theory of Numbers, academic Press, 1999.

MMTH 205: MEASURE THEORY

Credit: 5(4 H(L)+1H(T))

Duration: 3 Hrs. **Max. Marks: 100**

Internal Assessment: 30

External Examination: 70

Course Objectives:

- To study the basic definition, concepts of inner and outer measure of sets.
- To demonstrate the understanding of the fundamental integral convergence theorems and its applications.
- To understand the requirement of Lebesgue integral and its difference from Riemann integral along with its properties.
- To learn and apply the Holder and Minkowski inequalities in L^p spaces and understand the completeness of L^p spaces.

INSTRUCTIONS FOR PAPER SETTER/EXAMINER

The question paper covering the entire course shall be divided into three parts: A, B & C. Each of sections A and B will have 4 questions from the respective sections of the syllabus of 10 marks each and section C will consist of 1 compulsory question having 10 parts of short-answer type of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR CANDIDATES

Candidates are required to attempt five questions in all, selecting two questions from each section A and B and the compulsory question from section C

Section – A

LebesgueMeasure : Semi- Algebras, Algebras, ∃ - Algebra, their Properties, Lebesgue Outer Measure and its Properties, Measurable Sets and Properties, A Non Measurable Set, Borel Sets, their Lebesgue Measurability, Littlewood's Three Principles.(RB 1 : Chapter 2)

Measurable Functions : Definition and Properties, Step Functions, Characteristic Functions, Simple Functions, The Lebesgue Integral of Bounded Function, Integration of Non- Negative Measurable Functions, Fatou's Lemma, Monotone Convergence Theorem, Lebesgue Convergence Theorem.(RB 1 : Chapter 3 and Chapter 4 Section-4.1-4.5).

Section – B

Differentiation and Integration: Differentiation of Monotone Functions, Differentiation of an Integral, Lebesgue Differentiation Theorem,Vitalis Lemma, Four (Dini) Derivatives , Functions of Bounded Variation, Absolute Continuity, Convex Functions,Jensens Inequality.(RB 1 : Chapter 6)

The L^pSpaces: Definition and Properties, Holder and Minkowski's Inequalities, Bounded Linear Functionals on the L^p Spaces, Completeness and Approximation of L^p Space, The Riesz Fisher Theorem, The Riesz Representation Theorem.(RB 1 : Chapter 7)

Reference Books:

1. H.L.Royden, P.M. Fitzpatrick : Real Analysis, 4th Edition, PHI and China Machine Press,2010
2. I. K. Rana, An Introduction to Measure and Integration (2nd ed.), Narosa Publishing House, New Delhi, 2004.
3. G.de Bara, Measure Theory and Integration, Ellis Horwood Limited, England, Edition 2003.
4. P.K. Jain and V.P. Gupta, Lebesgue Measure and Integration, New Age International Ltd.,2000.

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M.SC. (MATHEMATICS) - II (SEMESTER III & IV) (CHOOSE ANY FIVE SUBJECTS FROM THE FOLLOWING SEMESTER III & IV)

(SESSION 2021-22, 2022-23)

Semester	Course No.	Course Title	Hours			Total Credits
			L	T	P	
III	MMTH-301	Field Theory	4	1	0	5
	MMTH-302	Computer Fundamentals and Programming in 'C'	3	0	2	5
	MMTH-303	Mathematical Methods	4	1	0	5
	MMTH-304	Optimization Techniques-I	4	1	0	5
	MMTH-305	Mathematical Statistics-I	4	1	0	5
	MMTH-306	Category Theory-I	4	1	0	5
	MMTH-307	Fuzzy Sets and Applications	4	1	0	5
	MMTH-308	Advanced Topology	4	1	0	5
	MMTH-309	Numerical Analysis	4	1	0	5
	MMTH-310	Fluid Mechanics	4	1	0	5
	MMTH-311	Complex Analysis-II (Prerequisite: Complex Analysis-I)	4	1	0	5
	MMTH-312	Partial Differential Equations	4	1	0	5
IV	MMTH-401	Tensor Calculus	4	1	0	5
	MMTH-402	Mathematical Statistics-II (Prerequisite: Mathematical Statistics-I)	4	1	0	5
	MMTH-403	Category Theory-II (Prerequisite: Category Theory-I)	4	1	0	5
	MMTH-404	Optimization Techniques-II	4	1	0	5
	MMTH-405	Commutative Algebra	4	1	0	5
	MMTH-406	Operations Research	4	1	0	5
	MMTH-407	Non-Linear Programming	4	1	0	5
	MMTH-408	Analytic Number Theory	4	1	0	5
	MMTH-409	Theory of Linear Operators	4	1	0	5
	MMTH-410	Algebraic Coding Theory	4	1	0	5
	MMTH-411	Algebraic Topology	4	1	0	5
	MMTH-412	Solid Mechanics	4	1	0	5

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(SEMESTER III)

MMTH-301: FIELD THEORY

L	T	P		
4	1	0	**External Examination: 70**	**Internal Assessment: 30**
Time Allowed: 3 hours			**Max. Marks: 100**	

Course Objectives

- To identify and construct the examples of finite as well as infinite fields.
- To learn about constructing the algebraic, normal, separable, Galois, cyclic extensions of fields.
- To learn about the structures and extensions of given fields.
- To classify finite fields using roots of unity.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION –A

Fields and its examples, Algebraic and transcendental elements, Irreducible polynomials, Gauss Lemma, Eisenstein's criterion, Adjunction of roots, Kronecker's theorem, Algebraic extensions, Algebraically closed fields, Splitting fields, Normal extensions, Multiple roots, Finite fields, Separable extensions, Perfect fields.

SECTION – B

Automorphism groups and fixed fields, Galois extensions, Fundamental theorem of Galois Theory, Fundamental theorem of algebra, Roots of unity and Cyclotomic polynomials. Cyclic extension, Polynomials solvable by radicals, Symmetric functions, Cyclotomic extension.

RECOMMENDED BOOKS

1. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul "*Basic abstract algebra*" (Chapters 15-17, Chapter 18: excluding section 5) 2nd Edition, Cambridge University Press, 2003
2. M. Artin "*Algebra*", 2nd Edition, Pearson Prentice Hall, 2015.

MMTH- 302: COMPUTER FUNDAMENTALS AND PROGRAMMING IN 'C'

L	T	P	External Examination: 50
3	0	2	Internal Assessment: 20
External Practical: 30			Max. Marks: 100

INSTRUCTION FOR THE PAPER SETTER

The question paper will consist of three sections A, B and C. Section A and B will have four questions each from respective sections of the syllabus carrying 8 marks for each question. Section C will have 9 short answer type questions carrying total 18 marks, which will cover the entire syllabus uniformly.

INSTRUCTION FOR THE CANDIDATES

The candidates are required to attempt two questions each from section A, B and the entire section C.

SECTION A

Organization of Computers: Block Diagram of Computer, Types of Computers, Characteristics and Application areas, Problem Solving with Computers- Analysis, Design, Coding, Compilation, Testing and Debugging, Implementation and Maintenance.

Introduction to C: Character set, Constants, Variables, Rules for Defining Variables, Identifier and Keywords, Data Types.

Operators and Expressions: Arithmetic, Relational, Logical, Assignment, Conditional, Unary, Bitwise, Comma, Operator Precedence and Associativity. Instructions – Type Declaration, Input/ Output Instructions.

Control Statements: Decision Control Statements(if, if else, nested if else, switch), Jump Control Statements(break, continue, goto), Loop Control Statements (for, while , do-while), nested loops.

SECTION B

Arrays: One Dimensional Array, Two-Dimensional Array, Array Declaration and Initialization, Multi Dimensional Arrays, Strings, String Handling Functions.

Functions: Function Declaration and Prototype, Call, Definition, Types of Functions, Methods of Parameter passing - Call by Value, Call by Reference, Recursion.

Structures and Pointers: Structure Declaration, Using Structures, Array of Structures, Union, Pointer Data Type, Declaration, Pointers and Arrays, Pointers and Functions.

Files in C: Basic Operations of Files, File Opening Modes, Reading and Writing Files.

Suggested Readings :

1. E. Balagurusamy, “Programming in C”, Tata McGraw Hill.
2. Kanetkar, “Let Us C”, BPB Publications.
3. Kamthane, “Programming with ANSI and Turbo C”, Pearson Education.
4. Rajaraman, V, “Fundamentals of Computers”, PHI.
5. P.K Sinha, “ Computer Fundamentals”, BPB Publications.

SOFTWARE LAB: COMPUTER FUNDAMENTALS AND PROGRAMMING IN C

1. ***Maximum Marks: 30*** ***Maximum Time: 3 Hrs.***
2. ***Minimum Pass Marks: 35%***

This laboratory course will comprise of exercises to supplement what is learnt under paper Computer Fundamentals and Programming In "C".

The breakup of marks for the practical will be as under

i.	Viva Voce (External Evaluation)	15 Marks
ii.	Lab Record, Program Development and Execution	15 Marks

MMTH- 303: MATHEMATICAL METHODS

L	T	P	External Examination: 70
4	1	0	Internal Assessment: 30
Time Allowed: 3 hours			Max. Marks: 100

Course Objectives

- To enable the students to perform integration and other operations by approximation techniques.
- To solve wide range of problems in physical sciences using calculus of variations
- To translate a practical problem into mathematical problem and solve it by means of calculus.
- To familiarize various essential procedure and tools to solve Linear Integral Equations.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION –A

Linear integral equations of first and second kind, Abel's problem, Relation between linear differential equation and Volterra's equation, Non linear and Singular equations, Solution by successive substitutions, Volterra's equation, iterated and reciprocal functions, Volterra's solution of Fredholm's equation, Fredholm's equation as limit of finite system of linear equations, Hadamard's theorem, convergence proof, Fredholm's two fundamental relations, Fredholm's solution of integral equation when D(⇔|0, Lemmas on iterations of symmetric kernel, Schwarz's inequality and its applications.

SECTION –B

Simple variational problems, Necessary condition for an extremum, Euler's equation, End point problem, Variational derivative, Invariance of Euler's equation, Fixed end point problem for *n* unknown functions, Variational problem in parametric form, Functionals depending on higher order derivatives, Euler Lagrange equation, First integral of Euler-Lagrange equation, Geodesics, The Branchistochrone problem, Minimum surface of revolution, Snell's law, Fermat's principle and Calculus of variations.

RECOMMENDED BOOKS

1. F.B. Hildebrand, "*Method of Applied Mathematics*" Reprint by Dover Publication New York,1992.
2. I.M. Gelfand & S.V. Fomin, "*Calculus of Variations*", Dover Publications, 2000.
3. W.W. Lovitt, "*Linear Integral Equations*", Dover Publications, 2005.
4. R. Weinstock, "*Calculus of Variations with Application to Physics and Engineering*", Dover Publications, 2012.
5. M.D. Raisinghania, "*Integral Equations and Boundary Value Problem*" S. Chand & Sons publications, 2007

MMTH- 304: OPTIMIZATION TECHNIQUES-I

L	T	P	External Examination: 70
4	1	0	Internal Assessment: 30

Time Allowed: 3 hours **Max. Marks: 100**

Course Objectives

- To learn about the convex sets, their properties and the formulation of real life problem into mathematical problem.
- To understand importance of optimization of industrial process management and apply basic concepts of mathematics to formulate an optimization problem.
- To study Linear Programming with applications to transportation, assignment problems and game theory.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION-A

Introduction: Definition of Operation research, Models in operation research, General Methods for solving O.R. models, Elementary theory of convex sets.

Linear Programming Problems: Definition of LPP, Examples of LPPs, Mathematical formulation of the mathematical programming problems, Graphical solution of the problem. Simplex method, Big M method, Two Phase method, Exceptional Cases of L.P.P.

Duality in linear programming: Concept of duality, duality theorems, complementary slackness theorem, dual simplex method.

Sensitivity Analysis: Discrete changes in the cost vector, requirement vector, addition of a new variable, deletion of a variable, addition of new constraint, deletion of a constraint.

SECTION-B

Transportation Problem: Introduction, Mathematical formulation of the problem, initial basic feasible solution using North West Corner Method, Least Cost Method and Vogel's Approximation Method, Optimal solution using MODI method, degeneracy in transportation problems, some exceptional cases in transportation problems.

Assignment Problems: Introduction, Mathematical formulation of an assignment problem, assignment algorithm, unbalanced assignment problems.

Games & Strategies: Definition & characteristics of Games, Maximin-minimax principle ,Two person zero sum games, Games without saddle points, Mixed Strategies, Concept of Dominance, Graphical method for solving games 2 x n & m x 2, Rectangular game.

RECOMMENDED BOOKS

1. Kanti Swarup, P. K. Gupta and Man Mohan,"*Operations Research*", Sultan Chand and Sons, New Delhi, 14th Edition 2008.
2. H. A. Taha, "*Operations Research: An Introduction*", Pearson, 10th Edition, 2017.
3. Chander Mohan and Kusum Deep, "*Optimization Techniques*", New Age International Publishers, 2009.
4. G. Hadley, "*Linear Programming*" Narosa Book Distributors Private Ltd, 2002.
5. S.D. Sharma, "*Operations Research*", Kedar Nath and Co., Meerut, 2009.

MMTH- 305: MATHEMATICAL STATISTICS-I

L	T	P	External Examination: 70
4	1	0	Internal Assessment: 30

Time Allowed: 3 hours **Max. Marks: 100**

Course Objectives

- To frame problems using numerous mathematical and statistical depictions of appropriate structures and relationships and to **solve** using standard techniques.

- To **communicate** clearly quantitative ideas both orally and in writing.
- To define, illustrate and apply certain frequently used discrete and continuous probability distributions.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION-A

Moments, Skewness and Kurtosis, Classical and axiomatic approach to the theory of probability, additive and multiplicative law of probability, Conditional probability and Bayes theorem.

Random variable, probability mass function, probability density function, cumulative distribution function, Two and higher dimensional random variables, joint distribution, marginal and conditional distributions.

SECTION- B

Mathematical expectations and moments, moment generating function and its properties

Discrete Probability Distributions: Binomial, Poisson, Geometric distributions, Recurrence relation for Moments, Mean, Median, Mode, Moment Generating Functions, Lack of Memory in Geometric Distribution.

Fitting of Poisson distribution.

Continuous probability distributions: Normal Distribution, Uniform, Exponential, Gamma, Beta Distributions, properties of various continuous distributions, Fitting of Normal Distribution, Moment Generating Functions.

RECOMMENDED BOOKS:

1. Goon, A.M., Gupta, M.K., *An Outline of Statistical Theory, Vol- I&II*, World Press Publishers Pvt. Ltd.,2010.
2. Hogg R.V., Mckean J. and Craig A.T, *Introduction to Mathematical Statistics*, 7th Ed., Collier Macmillan Publisher, 2012.
3. Gupta S.C., *Fundamentals of Statistics*, 7th Ed., Himalaya Publishing House Private Limited, Mumbai, 2018.
4. Elhance D.N., Elhance Veena and Aggarwal B.M., *Fundamentals of Statistics*, Kitab Mahal Publishers, 2014.
5. Gupta C.B., Gupta Vijay, *An Introduction to Statistical Methods*, 23rd Ed., Publishing House Private Limited, 2004.
6. Meyer P.L., *Introductory Probability and Statistical Applications*, 2nd Ed., Addison-Wesley Publishing Company, 1970

MMTH- 306: CATEGORY THEORY - I

L	T	P	External Examination: 70
4	1	0	Internal Assessment: 30

Time Allowed: 3 hours **Max. Marks: 100**

Course Objectives

- To understand the basics concepts and methods of category theory.
- To enable the students work with commutative diagrams, and universality properties.
- To apply categorical ideas and methods in wide range of area of mathematics.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION – A

Categories: Introduction with Functions of Sets, Definition and examples of Categories: Sets, Pos, Rel, Mon, Groups, Top, Dis (X), Finite Category, Abstract Mappings, Additive Categories, The category of modules, The concept of functor and the category Cat, Functors of several variables, Isomorphism. Constructions: Product of two categories, The Dual Category, The Arrow Category, The Slice and Co- Slice Category.

Free Categories: Free Monoids and their Universal Mapping Property, The category Graphs, the category C (G) generated by a graph, Homomorphism of Graphs and the Universal Mapping Property of C (G).

Abstract Structures: Epis and mono, Initial and Terminal objects, Generalized elements, Sections and Retractions, Product diagrams and their Universal Mapping Property, Uniqueness up to isomorphism, Examples of products: Product of Sets, Product in Cat, Poset, Product in Top, Categories with Products, Hom-Sets, Covariant representable functors, Functors preserving binary product. (R.R.1: Chapter 2 excluding example 6 of section 2.6)

SECTION –B

Duality: The duality principle, Formal duality, Conceptual duality, Coproducts, Examples in Sets, Mon, Top, Coproduct of monoids, of Abelian Groups and Coproduct in the category of Abelian Groups, Equalizers, Equalizers as a monic, Coequalizers, Coequalizers as an epic, Coequalizer diagram for a monoid.

Limits and Co-limits: Subojects, Pullbacks, Properties of Pullbacks, Pullback as a functor, Limits, Cone to a diagram, limit for a diagram, Co-cones and Colimits, Preservation of limits, contra variant functors, Direct limit of groups, Functors Creating limits and Co-limits.

Naturality: Exponential in a category, Cartesian Closed categories, Category of Categories, Representable Structure, Stone Duality, ultrafilters in Boolean Algebra, Naturality, Examples of natural transformations.

RECOMMENDED BOOKS

1. Steven Awodey, "*Category Theory*", Oxford Logic Guides, 52, Oxford University Press, 2010. (Chapter 1 to 3 Excluding Example 6 of Sec 2.6 and Chapter 5 and Sections 6.1, 6.2 and Chapter 7; Sections 7.1 to 7.5).

MMTH- 307: FUZZY SETS AND APPLICATIONS

L	T	P	External Examination: 70
4	1	0	Internal Assessment: 30
Time Allowed: 3 hours			Max. Marks: 100

Course objectives

- To understand the difference between crisp set theory and fuzzy set theory
- To recognize basic knowledge of fuzzy sets and fuzzy logic membership functions.
- To handle the problems having uncertain and imprecise data.
- To find the optimal solution of mathematical programming problems having uncertain and imprecise data.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION-A

Classical Sets and Fuzzy Sets: Overview of Classical Sets, Membership Function, α-cuts, Properties of α cuts, Decomposition Theorems, Extension Principle.

Operations on Fuzzy Sets: Compliment, Intersections, Unions, Combinations of operations, Aggregation Operations.

Fuzzy Arithmetic: Fuzzy Numbers, Linguistic Variables, Arithmetic Operations on intervals and Numbers, Lattice of Fuzzy Numbers, Fuzzy Equations.

Fuzzy Relations: Crisp and Fuzzy Relations, Projections and Cylindric Extensions, Binary Fuzzy Relations, Binary Relations on single set, Equivalence, Compatibility and Ordering Relations, Morphisms, Fuzzy Relation Equations.

SECTION-B

Possibility Theory: Fuzzy Measures, Evidence and Possibility Theory, Possibility versus Probability Theory.

Fuzzy Logic: Classical Logic, Multivalued Logics, Fuzzy Propositions, Fuzzy Qualifiers, Linguistic Hedges.

Uncertainty based Information: Information and Uncertainty, Non-specificity of Fuzzy and Crisp sets, Fuzziness of Fuzzy Sets. Applications of Fuzzy Logic.

RECOMMENDED BOOKS:

1. G. J. Klir and B. Yuan, "*Fuzzy sets and Fuzzy logic: Theory and Applications*", Published by PHI Learning, 2009.
2. H. J. Zimmermann, "*Fuzzy Set Theory and its Applications"*, Kluwer Academic Publishers, 2001.
3. Chander Mohan, *"An Introduction to Fuzzy Set Theory and Fuzzy Logic*", M V Learning Publishers, New Delhi (INDIA) and London (UK), 2015.

MMTH- 308: ADVANCED TOPOLOGY

L	T	P	External Examination: 70
4	1	0	Internal Assessment: 30
Time Allowed: 3 hours			Max. Marks: 100

Course Objectives

- To learn the concepts of net and filters in a topological spaces.
- To study separation axioms more specifically.
- To familiar with the Urysohn's Lemma and Tietze's extension theorem to characterize metrizable spaces.
- To study the concepts of compactness and to learn about Bolzano- Weierstrass property of a space and Tychonoff theorem.
- To prove a selection of theorems concerning product topologies and quotient topologies.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION A

Compact spaces, Compact subspaces of the Real line, Local Compactness, Bolzano-Weirstrass property, Heine- Borel theorem, Sequential compactness, Countable compactness, Lindeloff spaces, Lindeloff theorem, one point compactification.

The separation Axioms, T_0 (Kolmogrov space), T_1 (Frechet's space), T_2 (Hausdorff Space), Regular, Normal, Completely regular, completely normal spaces and their properties, Urysohn's Lemma and its general form, The Tietze's extension theorem.

SECTION B

Product of topological spaces, Projection mapping, Box topology, Product invariant property, Short and finitely short families, Hausdorff maximal principle, Quotient topology and Quotient mapping, Theorems relating to Quotient space. Nets, Subnets, Convergence of Nets, Cluster point of a net, Theorems related to continuity, compactness and convergence of a net, Filters, Comparison of Filters, Base, sub-base, sup and inf of a Filter, Filter base and examples, Ultra Nets & Ultra Filters, Convergence of Filters.

RECOMMENDED BOOKS

1. J. R. Munkres, "*Topology*" Pearson Publishers, 2017.
2. J. Dugundji , "*Topology*" , Prentice Hall of India, New Delhi, 1975.
3. G. F. Simmons, "*Introduction to Topology and Modern Analysis*", McGraw Hill Education India Pvt. Ltd., 2017.
4. J.L. Kelly, "*General Topology*", Dovers Publications, 2017.
5. S.Willard, "*General Topology*", Dovers Publications, 2004.

MMTH- 309: NUMERICAL ANALYSIS

L	T	P	External Examination: 70
4	1	0	Internal Assessment: 30
Time Allowed: 3 hours			Max. Marks: 100

Course Objectives

- To recognize the errors, source of error and its effect on any numerical computations
- To learn how to obtain numerical solution of nonlinear equations using bisection, secant, newton, and fixed-point Iteration methods.
- To learn how to solve system of linear equations numerically using direct and iterative methods.
- To understand how to approximate the functions using interpolating polynomials.
- To learn how to solve definite integrals and initial value problems numerically.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION-A

Floating-Point Numbers: Floating-point representation, rounding, chopping, error analysis, conditioning and stability.

Non-Linear Equations: Bisection, secant, fixed-point iteration, Newton method for simple and multiple roots, their convergence analysis and order of convergence.

Linear Systems and Eigen-Values: Gauss elimination method using pivoting strategies, LU decomposition, Gauss-Seidel and successive-over-relaxation iteration methods and their convergence, ill and well-conditioned systems, Rayleigh's Power method for eigen-values and eigen-vectors.

SECTION-B

Interpolation and Approximations: Finite differences, Newton's forward and backward interpolation, Lagrange and Newton's divided difference interpolation formulas with error analysis, least square approximations.

Numerical Integration: Newton-Cotes quadrature formulae (Trapezoidal and Simpson's rules) and their error analysis, Gauss-Legendre quadrature formulae.

Differential Equations: Solution of initial value problems using Picard, Taylor series, Euler's and modified Euler's method and Runge-Kutta methods (up to fourth-order), system of first-order differential equations

RECOMMENDED BOOKS:

1. Curtis F. Gerald and Patrick O. Wheatley, Applied Numerical Analysis, Pearson, 7th Edition, 2003
2. M. K. Jain, S .R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Publishers 6th edition, 2012.
3. Steven C. Chappra, Numerical Methods for Engineers, McGraw-Hill Higher Education; 7 th edition, 2014
4. J. H. Mathew, Numerical Methods for Mathematics, Science and Engineering, Prentice Hall, 2nd edition,1992
5. Richard L. Burden and J. Douglas Faires, Numerical Analysis, Brooks Cole 8th edition, 2004.
6. K. Atkinson and W. Han, Elementary Numerical Analysis, John Willey & Sons 3rd Edition, 2004.

MMTH- 310: FLUID MECHANICS

L	T	P	External Examination: 70
4	1	0	Internal Assessment: 30
Time Allowed: 3 hours			Max. Marks: 100

Course Objectives

- To understand the concept of fluid and their classification, models and approaches to study the fluid flow.
- To familiar with three dimensional motions, Kelvin's Theorem.
- To learn the concept of stress and strain in viscous flow

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION-A

Equations of Fluid Mechanics : Real and continuous fluids, Differentiation following the motion, equation of continuity, Stream function, Stream lines, Pressure, Euler's equation of motion,
Bernoulli's theorem Steady irrotational non-viscous compressible flow, Vorticity, circulation, Kelvin's theorem on constancy of circulation, Kinetic energy, Three dimensional problems, Laplace's equation, Three dimensional sources and dipoles, Spherical obstacle in a uniform steam moving sphere, images.

SECTION-B

Application of complex variable method: Conjugate functions in plane, complex potential, incompressible flow in two dimensions, uniform stream, Source and sink, Vortex, Two dimensional dipole, Superposition, Joukowski's transformation. Milne Thomson circle theorem, Blasius theorem, Drag and lift, Source and vortex filaments, vortex pair, rows of vortices, Karman cortexstreet. Viscous flow: Navier Stokes equations, Dissipation of energy. Diffusion of vorticity in an incompressible fluid, condition of no slip, Steady flow between two parallel infinite flat plates, steady flow through a straight circular pipe (Poiseuille Flow).

RECOMMENDED BOOKS

1. D. E. Rutherford, "*Fluid Dynamics*", Oliver and Boyd Ltd. London, 1959.
2. F. Chorlton, "Text Book of *Fluid Dynamics*", (Relevant portion) , CBS Publisher, 2004.

MMTH-311: COMPLEX ANALYSIS-II (PREREQUISITE: COMPLEX ANALYSIS-I)

L	T	P	External Examination: 70
4	1	0	Internal Assessment: 30
Time Allowed: 3 hours			Max. Marks: 100

Course Objectives

- To demonstrate understanding of deeper aspects of complex analysis such as Riemann Mapping Theorem.
- To know about harmonic function theory on a disk.
- To enrich the students with concepts of convex and starlike functions, close to convex functions.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION-A

Normal families of analytic functions, Montel's theorem, Hurwitz's theorem, Riemann Mapping theorem, Univalent functions, Distortion and growth theorems for the class S of normalized univalent functions, Koebe - 1/4 theorem, Bieberbach Conjecture (statement only) Littlewood's inequality for the class S, Coefficient inequalities for functions in S in case of real coefficients only.

SECTION-B

Basic properties of harmonic functions, maximum and minimum principles, Harmonic functions on a disc, Harnack's inequality and theorem.

Convex and Starlike functions. Necessary and sufficient conditions for Convex and Starlike functions, Alexander Theorem. Growth and distortion theorem for the classes of normalized convex and starlike functions, close to convex functions, Noshiro Warschawski Theorem, Poisson Integral Formula.

RECOMMENDED BOOKS

1. Z. Nihari, "*Conformal Mapping*", Dover Publications, 2011.
2. J. B. Conway, "*Functions of one complex variable*", Narosa Publishing House, 2000.
3. E. T. Copson, "*Theory of Functions of a Complex Variable*" London Oxford University Press, 1970.
4. P.L. Duren, "*Univalent Functions*", Springer, 2001.

MMTH- 312: PARTIAL DIFFERENTIAL EQUATIONS

L	T	P	External Examination: 70
4	1	0	Internal Assessment: 30
Time Allowed: 3 hours			Max. Marks: 100

Course Objectives

- To study the solutions of one dimensional Wave and Heat equations employing the methods in Partial Differential equations.
- To study Laplace's equation in two dimension and to prove a selection of theorems.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION- A

Characteristics of Equations in three variables, the solution of linear hyperbolic equations, separation of variables, the method of integral transforms, Non-linear equations of the second order.

Laplace's Equation: The occurrence of Laplace's equation in physics, elementary solutions of Laplace's equation, Families of equipotential surfaces, boundary value problems, separation of variables, problem with Axial symmetry, Kelvin's Inversion theorem, The theory of Green function for Laplace's equation, The relation of Dirichlet's problems to the calculus of variations, mixed boundary value problems, The two-dimensional Laplace equation, Relation of the logarithmic potential to the theory of functions, Green's functions for the two dimensional equations.

SECTION- B

The Wave Equation: The occurrence of wave equation in physics, Elementary solutions of the one dimensional wave equation, The Riemann-Volterra solution of the one dimensional wave equation, Three Dimensional Problems, General solution of wave equation, Green's function for the wave equation, The non-homogeneous wave equation.

The Diffusion Equation: The occurrence of diffusion equation in physics, The Resolution of Boundary value problems for the diffusion equation, Elementary solutions of the diffusion equation, separation of variables, the use of integral transforms, the use of Green's functions, The diffusion equation with Sources

RECOMMENDED BOOKS:

1. I. N. Sneddon, "*Elements of Partial Differential Equations*", Dover Publications, 2006.
2. T. Amarnath, "*An Elementary Course in Partial Differential Equations*", Narosa Publishing House, 2014.
3. G. F. Simmons, "*Differential Equations with Applications and Historical Notes*", Tata McGraw Hill, 2017.
4. K. S. Rao, "*Introduction to Partial Differential Equations*", Prentice Hall of India, 2011.
5. C. E. Lawrence, "*Partial Differential Equations*", Graduate Studies in Mathematics, Vol. 19, American Mathematical Society, 2010.

(SEMESTER IV)
MMTH- 401: TENSOR CALCULUS

L	**T**	**P**	**External Examination: 70**
4	**1**	**0**	**Internal Assessment: 30**
Time Allowed: 3 hours			**Max. Marks: 100**

Course Objectives

- To introduce the concepts of dummy and free index and summation convention.
- To learn the transformation of co-ordinates in Tensor notation
- To enable the students to perform the matrix calculations in Tensor notation
- To learn the curvilinear co-ordinates in Tensor notation.
- To learn about properties and transformations of the Christoffel Symbols

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION-A

Tensor: Space of N Dimensions, Dummy and Free Index, Summation Convention, Kronecker Delta, Transformation of Co-ordinates, Tensor notation on Matrices, Contravariant and Co-Variant Vector and Tensors, Mixed Tensor, Invariants, Addition , Subtraction of Tensors, Multiplication by a scalar, Outer multiplication, Contraction, Inner multiplication, Quotient Law of tensors, Symmetric and Skew Symmetric Tensors, Pseudo tensors, Reciprocal Tensor, Relative Tensor, Cartesian Tensors,

The metric tensor, Associated tensors, Affine coordinates.

(Scope as in Recommended book: Prasun Kumar Nayak: Text Book of Tensor Calculus and Differential Geometry, PHI-2012.)

SECTION-B

Curvilinear Coordinates: Co-ordinate Surfaces and curves, line element, length of a vector,

Angle between two vectors, reciprocal base system, partial derivative.

Christoffel symbols: Properties and transformations. Co-variant differentiation, Gradient,

Divergence and Curl, Laplacian Operator, Intrinsic derivative.

(Scope as in Recommended book: Prasun Kumar Nayak: Text Book of Tensor Calculus and Differential Geometry, PHI-2012.)

RECOMMENDED BOOKS:

1. Prasun Kumar Nayak: Text Book of Tensor Calculus and Differential Geometry, PHI-2012.
2. Zafar Ahsan: Tensors, PHI-2015.

MMTH- 402: MATHEMATICAL STATISTICS-II (PREREQUISITE: MATHEMATICAL STATISTICS-I)

L	T	P		
4	1	0		
Time Allowed: 3 hours			**S**	

External Examination: 70
Internal Assessment: 30
Max. Marks: 100

Course Objectives

- To study the concepts of statistics those are more helpful in conducting research.
- To recognize and compute the sampling distributions of means and variances and the t- and F-distributions.
- To understand, apply and compute in one and two sample test of Hypothesis problems.
- To recognize the concept of ANNOVA techniques.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION-A

Sampling Distributions: Chi-square, t and F-distributions with their properties, distribution of sample mean and variance

Point Estimation: Estimators, Properties of unbiasedness, consistency, sufficiency, efficiency, Completeness, uniqueness, methods of estimation

SECTION- B

Testing of Hypothesis: Null hypothesis and its test of significance, simple and composite Hypothesis,Type-I &Type-II error, level of significance and size of test.

Test for mean and variance in the normal distribution (One and Two sample problems), Chi-square test, t-test, F-test.

Linear Estimation: analysis of variance, analysis of variance for one way and two way classified data with one observation per cell.

RECOMMENDED BOOKS

1. Goon, A.M., Gupta, M.K., *An Outline of Statistical Theory, Vol- I&II,* World Press Publishers Pvt. Ltd.,2010.
2. Hogg R.V.,Mckean J. and Craig A.T, *Introduction to Mathematical Statistics*, 7th Ed., Collier Macmillan Publisher, 2012.
3. Gun A.M., Gupta M.K. and Dasgupta B., *Fundamentals of Statistics, Vol.1*,8th Ed., World Press Publishers Private Limited, Kolkata, 2008.
4. Gupta S.C., *Fundamentals of Statistics*, 7th Ed., Himalaya Publishing House Private Limited, Mumbai, 2018.
5. Elhance D.N., Elhance Veena and Aggarwal B.M., *Fundamentals of Statistics*, Kitab Mahal Publishers, 2014.
6. Rohtagi, VK., *An introduction to Probability and Statistics*, 2nd Ed., Wiley, 2008

MMTH- 403: CATEGORY THEORY –II (PREREQUISITE: CATEGORY THEORY-I)

L	T	P	External Examination: 70
4	1	0	Internal Assessment: 30
Time Allowed: 3 hours			Max. Marks: 100

Course Objectives

- To understand the basics concepts and methods of category theory.
- To study the Yoneda lemma and its applications.
- To apply categorical ideas and methods in wide range of area of mathematics

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION- A

Equivalence : The functor category Fun (C D) and natural isomorphism. (R.R: Sections 6.1, 6.2 and 7.1 to 7.5) Equivalence : Exponentials of Categories, The Bifunctor Lemma, Cat is cartesian closed, Functor Categories, Equivalence of Categories, Examples of Equivalence : Setsfin and Ordfin., Pointed Set and partial maps, slice categories and indexed families, stone duality.(R.R 7.6 to 7.9)

Categories of Diagrams : Set-valued functor categories, The Yoneda embedding, The Yoneda Lemma, Applications of the Yoneda lemma, Limits, Colimits and Exponentials in Categories of diagrams. Hom (X, GP) and Hom (X x P , Q) . (R.R. : Sections 8.1 to 8.7)

SECTION- B

Adjoints: Adjunction between categories, left and right adjoints, Hom-Set definition of adjoints. Examples of Adjoints, Uniqueness up to isomorphism. Order Adjoints and interior operation in Topology as an order adjoint. Preservation of Limits (Co limits) by Right (Left) Adjoints. UMP of the Yoneda Embedding and Kan Extensions.The Adjoint Functor Theorem.

Monads and Algebras: The Triangle Identities, Monads and Adjoints, Algebras for a monad, The Elinberg- Moore Category and the Kliesli Category, Comonads and Colagebras. (R.R. Chapter 9; Sections 9.1 to 9.4, 9.6 AFT from Sec 9.8 and Chapter 10; Sections 10.1 to 10.4)

RECOMMENDED BOOKS

Steve Awodey: "*Category Theory*", Oxford University Press; 2nd edition, 2010

MMTH- 404: OPTIMIZATION TECHNIQUES-II

L	T	P	External Examination: 70
4	1	0	Internal Assessment: 30
Time Allowed: 3 hours			Max. Marks: 100

Course Objectives

- To introduce more advanced methods of Programming
- To introduce Decision Theory and Simulation.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION-A

Quadratic Programming: Wolfe's Modified Simplex Method, Beale's method, Separable, Convex programming.

Linear Complimentary Problem: Lemke's Complementary Pivoting Algorithm, Solution of Quadratic programming, Problems using Linear Complementary method.

Separable Programming: Introduction, Reduction of Separable Programming to Linear programming Problem, Separable Programming Algorithm.

Goal Programming: Introduction, formulation of linear Goal Programming, Graphical & Simplex Method for Goal Programming.

SECTION-B

Geometric Programming: Introduction, constrained & unconstrained Geometric Programming Problem, Complementary Geometric programming.

Fractional Programming: Introduction, Mathematical formulation of Linear fractional programming problem, Charnes and Cooper method, Problems of Fractional Programming.

Dynamic Programming: Introduction, nature of Dynamic Programming (DP), Solution of Discrete DPP, Application of DP in Linear Programming.

Decision Theory: Introduction & components of Decision Theory, EMV,EOL, Decision making under uncertainty, Decision making under utilities, Decision making under Risk.

Simulation: Introduction, Advantages & disadvantages, Event –type, Monte-Carlo simulation, Application to Inventory, Queueing, Capital Budgeting, Financial Planning, Maintenance, Job Sequencing, Networks.

RECOMMENDED BOOKS

1. Sharma, S.D.: *Operation Research*, Kedar Nath and Co., Meerut.,2012
2. Chander Mohan and Kusum Deep: *Optimization Techniques*, New Age International, 2009.
3. Kanti Swarup, P.K. Gupta and Man Mohan: *Operations Research*, Sultan Chand and Sons, 2010
4. Hamdy A. Taha: *Operations Research; An Introduction*, 10th Ed., PHI, New Delhi, 2017
5. Kasana H.S. and Kumar, K.D.: *Introductory Operation Research*, Springer, 2004.

MMTH- 405: COMMUTATIVE ALGEBRA

L	T	P	External Examination: 70
4	1	0	Internal Assessment: 30

Time Allowed: 3 hours **Max. Marks: 100**

Course Objectives

- To know the localization of rings at prime ideal.
- To know more closely the polynomial rings in one or more variables over a commutative ring and their prime spectrum.
- To study constructions like tensor product and basic theory of it.
- To understand the basic theory for support and associated prime ideals of modules and know primary decomposition of ideals.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION-A

Nil Radical and Jacobson Radical of Ring, Operation on Ideals, Extension and Contraction of Ideals, The Prime Spectrum of Ring, Zairiski Topology, Exact Sequence of Modules, Tensor Product of Modules, Restriction and Extension of Scalars, Exactness Property of Tensor Product, Flat Modules, Tensor Product of Algebras.

SECTION-B

Rings and Modules of Fractions, Local Properties, Extended and Contracted Ideals in Rigs of Fractions, Primary Decomposition : Primary Ideals, Decomposable Ideals, First Uniqueness Theorem, Isolated Prime Ideals, Second Uniqueness Theorem, Behavior of Primary Ideals under localization.

RECOMMENDED BOOKS

1. M.F. Atiyah, I.G MacDonald, "*Introduction to Commutative Algebra*", Westview Press Inc, 1994 (Chapter 1-4)
2. David S. Dummit, M. Foote, "*Abstract Algebra* " Wiley Publishers, 3rd edition, 2011

MMTH- 406: OPERATIONS RESEARCH

L	T	P	External Examination: 70
4	1	0	Internal Assessment: 30
Time Allowed: 3 hours			Max. Marks: 100

Course Objectives

- To enable the students to identify and develop operation research models from the real system and to understand the mathematical tools that are needed to solve optimization problems.
- To demonstrate the network models and to learn the various algorithms for their solution.
- To gain knowledge about the queuing and replacement problems.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION-A

Queueing Problems: Characteristics of Queueing System, Distribution in Queueing Systems, Poission arrivals and Exponential Service Time, Transient and Steady State, Probabilistic Queueing Models (Model I (M/M/1) (∞/FCFS), Model II (General Erlang Queueing Model), Model III (M/M/1) : (N/FCFS) , Model-IV (M/M/S):(∞/FCFS)

Inventory Models: Classification of Inventory Models, Deterministic Inventory Model (DIM),
Basic Economic Order Quantity (EOQ) models with no shortages, DIM with Shortages, EOQ with Finite Replenishment.

SECTION-B

Replacement & Maintenance Problems: Replacement policy when money value changes & does not change with time, Group Replacement of item that fails suddenly.

Network Analysis: Introduction to Networks, Minimal Spanning Tree Problem, Shortest Path Problem, Dijkastra's Algorithm, Floyd's Algorithm, Maximum Flow Problem.

Project Management: Critical Path Method, Critical Path Computations, Optimal Scheduling by CPM, PERT, Distinction between CPM and PERT.

RECOMMENDED BOOKS

1. Kanti Swarup, P. K. Gupta and Man Mohan,"*Operations Research*", Sultan Chand and Sons, New Delhi, 14th Edition 2017.
2. H. A. Taha, "*Operations Research An Introduction*", Pearson, 10th Edition, 2017.
3. Chander Mohan and Kusum Deep,"*Optimization Techniques*", New Age International Publishers, 2009.
4. G. Hadley, "*Linear Programming*" Narosa Book Distributors Private Ltd, 2002.
5. S. D. Sharma, "*Operations Research*", Kedar Nath and Co., Meerut, 2009.
6. D. S. Hira and P. K. Gupta, "*Operations Research*", S. Chand Publisher, 2014.
7. H. S. Kasana and K. D. Kumar, "*Introductory Operation Research*", Springer, 2005.

MMTH- 407: NON-LINEAR PROGRAMMING

L	T	P	External Examination: 70
4	1	0	Internal Assessment: 30
Time Allowed: 3 hours			Max. Marks: 100

Course Objectives

- To classify the non-linear programming problems.
- To study unconstrained optimization methods, constrained optimization methods, convex analysis, Lagrangian relaxation, non differentiable optimization, and applications in integer programming.
- To enhance the applications drawn from control, communications, power systems, and resource allocation problems.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION –A

Non-linear Programming: Definition & examples of non-linear programming, its formulation, unconstrained problems, constrained problems with equality & inequality constraints, Fritz John and Kuhn-Tucker optimality conditions , saddle point , Lagrange's method of solution.

Direct Search Methods: Solution of unimodal functions, Dichotomous Search, Fibonacci Search, Golden-Section Search,

Rosen Brock search Method, Methods requiring function to be differentiable: Bisection Method, Method of False Position, Newton- Raphson Method, Quadratic interpolation method, Cubic interpolation method,

Direct Search Methods for multidimensional optimization problems: Evolutionary search method.

SECTION- B

Gradient search based methods:

Unconstrained problems: Hooke & Jeeves method, Steepest Descent method, Newton-Raphson Method, Marquardt's method, Conjugate Direction Methods: Concept of Conjugate Directions, Basic Conjugate- Directions method, method of Fletcher-Reeves.

Constrained optimization Problems: Solution through Kuhn-Tucker conditions, Penalty function Methods (Interior Penalty function method and Exterior Penalty function method),

Methods of Feasible Directions: Zoutendijk method, Gradient Projection method.

RECOMMENDED BOOKS

1. Bazaraa, M.S., Sherali, Hanif D and Shetty, C.M., "*Nonlinear programming: Theory and Algorithm"*, John Wiley, Third Edition, 2006
2. Chander Mohan and Kusum Deep, "*Optimization Techniques"*, New Age International, 2009.
3. Simmons, D.M., "*Non-Linear Programming for Operations Research"*, Prentice Hall, 1993
4. Avriel, M., "*Non-linear Programming: Analysis & methods"*, Englewood Cliffs, Prentice Hall, 1976.

MMTH- 408: ANALYTIC NUMBER THEORY

L	T	P	External Examination: 70
4	1	0	Internal Assessment: 30
Time Allowed: 3 hours			Max. Marks: 100

Course Objectives

- To study the various arithmetic functions, their properties and to identify the multiplicative and completely multiplicative arithmetic functions.
- To enable the students to prove elementary result on sum over primes and use these to calculate averages of additive arithmetic functions.
- To study the Drichlet's characters and their applications.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION -A

Arithmetical Functions: Mangoldt Function, Liouville's Function, The Divisor Functions, Product Formula for ←(n), Dirichlet Product of Arithmetical Functions, Dirichlet Inverses and, Dirichlet Multiplication, The Inverse of a Completely Multiplicative Function, Generalized Convolutions, Averages of Arithmetical Functions: The big Oh notation, Asymptotic equality of Functions, Euler's Summation Formula, Elementary Asymptotic Formulas, Average Order of d(n), ←(n),∃ɜ(n), ⇑(n), o *f*n), The Partial Sums of a Dirichlet Product, Applications to ⇑(n) and o (n), Legendre's Identity.

SECTION -B

Some elementary theorems on the Distribution of Prime Numbers : Chebyshev's Functions ɜ (x) &∀(x), Relation Connecting ∀(x) and ←(x), Abel's Identity, Equivalent Forms of Prime Number Theorem, Inequalities for ←(n) and P(n), Shapiro's Tauberian Theorem, applications of Shapiro's Theorem, Asymptotic Formula for the Partial Sums ϕ$_{p\le x}$(1/p), Elementary Properties of Groups , Characters of Finite Abelian Groups, The Character Group, Orthogonality Relations for Characters, Dirichlet Characters, Dirichlet's Theorem for Primes of the form 4n-1 and 4n+1, Dirichlet's Theorem in Primes on Arithmetical Progression, Distribution of Primes in Arithmetical Progression.

RECOMMENDED BOOKS

1. T.M. Apostol," *Introduction to Analytic Number Theory*", Springer International student edition, Narosa Publishing House Pvt. Ltd. 1998
2. P.T. Bateman, Harold G. Diamond ,*" Number Theory"*, An Introductory Course, World Scientific, 2004
3. M. Ram Morty , "*Problems in Analytic Number Theory*", Springer, 2008

MMTH- 409: THEORY OF LINEAR OPERATORS

L	T	P
4	1	0

External Examination: 70
Internal Assessment: 30
Time Allowed: 3 hours **Max. Marks: 100**

Course Objectives

- To formally introduce the notion of operators and linearity.
- To discuss basic operator terminology and the linear operators.
- To study the basic know how of Null Spaces and Range Spaces.
- To study Spectral Properties of Compact Linear Operators.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION-A

Spectral theory in Normed Linear Spaces, Resolvant Set and Spectrum, Spectral Properties of Bounded Linear Operator, Properties of Resolvant and Spectrum, Spectral Mapping Theorem for Polynomials, Spectral Radius of Bounded Linear Operator on a Complex Banach Space, Elementary theory of Banach Algebras, Resolvant Set and Spectrum, Invertible Elements, Resolvant Equation, General Properties of Compact Linear Operators.

SECTION-B

Spectral Properties of Compact Linear Operators on Normed Space, Behaviour of Compact Linear Operators with respect to Solvability of Operator Equations, Fredholm Type Theorems, Fredholm Alternative Theorems, Spectral Properties of Bounded Self-Adjoint Linear Operators on a Complex Hilbert Space, Positive Operators, Monotone Sequence Theorem for Bounded Self-Adjoint Operators on a Complex Hilbert Space, Square Roots of Positive Operators.

RECOMMENDED BOOKS

1. E. Kreyszig, "*Introductory Functional Analysis with Applications"*,Wiley India Pvt. Ltd., Reprint 2017
2. Bachman and Narici," *Functional Analysis"*,Courier Corporation, 2000

MMTH- 410: ALGEBRAIC CODING THEORY

L	T	P	External Examination: 70
4	1	0	Internal Assessment: 30

Time Allowed: 3 hours **Max. Marks: 100**

Course Objectives

- To get an insight into matrix representation of a code as well as encoding and decoding.
- To understand Hamming codes, BCH codes.
- To learn about cyclic codes and their generator polynomial.
- To understand the construction of binary codes in different ways and error detection and correction by various methods.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION-A

Introduction to Error-Correcting Codes, The Main Coding Theory Problem, An Introduction to Finite Fields, Introduction to Linear Codes, Encoding & Decoding with a Linear Code, The Dual Code, The Parity-Check Matrix and Syndrome Decoding, Incomplete Decoding.

SECTION-B

Hamming Codes, Extended Binary Hamming Codes, Q-ary Hamming Codes, Perfect Codes, Binary and Ternary Golay Codes, Sphere Packing Bound, Cyclic Codes, Hamming Codes as Cyclic Codes, BCH Codes.

RECOMMENDED BOOKS

1. Raymond Hill," *A First Course in Coding Theory"*, Oxford applied mathematics and Computing Science Series (Ch 1-0 & 12) (E- book available)
2. F. J. Macwilliams & NJA Sloane, "*Theory of Error Correcting Codes"*, North-Holland Mathematical Library (Book 16), North Holland Publishing Co. (1977)

MMTH- 411: ALGEBRAIC TOPOLOGY

L	T	P	External Examination: 70
4	1	0	Internal Assessment: 30

Time Allowed: 3 hours **Max. Marks: 100**

Course Objectives

- To grasp the basics of Algebraic Topology.
- To determine fundamental groups of some standard spaces like Euclidean spaces and spheres.
- To understand the theorems like Fundamental theorem of Algebra, Brower's fixed point theorem, Borsuk-Ulam theorem

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION-A

The Fundamental group: Homotopy of paths, Homotopy classes, The Fundamental group, change of base point, Topological invariance, covering spaces, The Fundamental group of the
Circle, Retractions and fixed points, No Retraction Theorem, The Fundamental theorem of Algebra, The Borsuk - Ulam theorem, The Bisection theorem, Deformation Retracts and Homotopy type, Homotopy invariance.

SECTION-B

Direct sums of Abelian Groups, Free products of groups, uniqueness of free products, Least normal subgroup, Free groups, generators and relations, The Seifert-Van Kampen theorem, also classical version, The Fundamental group of a wedge of circles, Classification of covering spaces, Equivalence of covering spaces, The general lifting lemma, The universal covering space, covering transformation, Existence of covering spaces.

RECOMMENDED BOOKS

1. J. R. Munkres, "*Topology*" Pearson Publishers, 2017, Chapter – 9(51-58), Chapter –11 (67-71), Chapter - 13 (79-82).

MMTH- 412: SOLID MECHANICS

L	T	P	External Examination: 70
4	1	0	Internal Assessment: 30

Time Allowed: 3 hours **Max. Marks: 100**

Course Objectives

- To learn how to obtain stresses and deflection of beams on elastic foundation.
- To apply various failure criteria for general stress states at points.
- To analyze solid mechanics problems using classical methods and energy methods.
- To analyze the behavior of structural and machine components subject to various loading and support condition based on principle of equilibrium.

INSTRUCTIONS FOR THE PAPER-SETTER

The question paper will consist of three sections A, B and C. Sections A and B will have four questions each of 10 marks from the respective sections of the syllabus. Sections C will consist of one compulsory question having ten short-answer questions of 3 marks each covering the entire syllabus uniformly.

INSTRUCTIONS FOR THE CANDIDATES

Candidates are required to attempt two questions each from sections A and B and entire section C.

SECTION-A

Tensor Algebra: Coordinate-transformation, Cartesian Tensor of different order. Properties of Tensors, Isotropic tensors of different orders and relation between them, symmetric and skew symmetric tensors. Tensor Invariants, Deviatoric tensors, eigenvalues and eigen-vectors of a tensor.

Tensor analysis: scalar, vector, tensor functions, Comma notation, gradient, divergence and curl of a vector/tensor field. (Relevant portions of Chapters 2 and 3 of book by D.S. Chandrasekharaiah and L. Debnath)

Analysis of strain: Affine transformation, Infinitesimal affine deformation, Geometrical Interpretation of the components of strain. Strain quadric of Cauchy. Principal strains and invariance, General infinitesimal deformation, Saint-Venants equations of compatibility, Finite deformations

Analysis of Stress: Stress tensor, Equations of equilibrium, Transformation of coordinates, Stress quadric of Cauchy, Principal stress and invariants, Maximum normal and shear stresses. (Relevant portion of Chapter 1 & 2 of book by I.S. Sokolnikoff).

SECTION-B

Equations of Elasticity: Generalized Hooks Law, Anisotropic medium, Homogeneous isotropic media, Elasticity, moduli for Isotropic media. Equilibrium and dynamic equations, for and isotropica elastic solid, Strain energy function and its connection with Hooke's Law, Uniqueness of solution. Beltrami-Michell compatibilty equations, Saint-Venant's principle. (Relevant portion of Chapter 3 of book by I.S. Sokonikoff).

Two dimensional problems: Plane stress, Generalized plane stress, Airy stress function. General solution of biharmonic equation. Stresses and displacements in terms of complex potentials. The structure of functions of ←H(z) and (z). First and second boundary-value problems in plane elasticity. Existence and uniqueness of the solutions (Section 65-74 of I.S.Sokolnikoff).

RECOMMENDED BOOKS

1. I.S. Sokolnikoff, "*Mathematical Theory of Elasticity*", Tata-McGraw Hill Publishing company Ltd. New Delhi, 1977.
2. A.E.H. Love, "*ATreatise on the Mathematical theory of Elasticity*", Dover Publications, New York, 1927
3. Y.C. Fung, "*Foundations of Solid Mechanics*", Prentice Hall, New Delhi, 1965.
4. D.S. Chandrasekharai and L. Debnath, "*Continuum Mechanics*", Academic Press, 1994.

5. Shanti Narayan," *Text Book of Cartesian Tensor"*, S. Chand & Co., 1968
6. S. Timeshenki and N. Goodier. "*Theory of Elasticity"*, McGraw Hill, New York, 1970.
7. I.H. Shames, "*Introduction to Solid Mechanics"*, Prentice Hall, New Delhi, 2000

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