Syllabus
M.Sc. (Mathematics)
(w.e.f. 2014-15)

DEPARTMENT OF MATHEMATICS

Central University of Haryana
Mahendergarh

Syllabus

M.Sc. (Mathematics)

w.e.f. 2014-15

DEPARTMENT OF MATHEMATICS
CENTRAL UNIVERSITY OF HARYANA
MAHENDERGARH, HARYANA

University Logo

University Logo is conceived with a globe at its centre surrounded by holy trinity of three arcs and at the bottom is a shloka taken from 'Neeti Shatkam' written by Bhartihari.

The arc at the bottom epicts an open book and a Veena, symbolising University's commitment to meeting the quest for acquiring knowledge, learning, enlightenment and promoting art and culture.

The arc at the right that epicts processes of science, technology and adventurism symbolises the University's commitment to promoting scientific progress and creating a culture of creativity, innovation and enquiring approach.

The arc at the left that epicts nature symbolises University's commitment to promoting education inculcating respect for environment, ecology and living in harmony with nature.

The globe at the centre surrounded by the human chain and the pigeon flying above expresses University's belief that commitments represented by the trinity of three arcs shall lead to global peace, prosperity and human solidarity-the real spirit of education.

The shloka at the bottom conveys that 'education' is the unrivalled treasure of all.

Vision Statement

To develop enlightened citizenship for a knowledge society for peace and prosperity of individuals, nation and the larger world through promotion of innovation, creative endeavors and scholarly inquiry

Mission Statement

- To be a leading model by defining learning, teaching and discovery in a global, national and local context
- To strive to create a learning ambience with diverse cultural backgrounds and enhance student's acquisition of useful knowledge, skills and analytical abilities through innovative teaching and holistic learning environment
- To facilitate cutting edge research in emerging areas and expanding research in traditional areas
- To progressively expand in phases academic and research areas to be pursued by the University from time to time into their diversified focuses
- To focus on relevance, quality and excellence in each area and discipline of study that University is to pursue
- To develop partnership with international and national institutions and facilitate providing international linkages for contextual and cultural learning for both faculty and students
- To involve stakeholders including Government, Industry, Community and others in providing relevant and quality education
- To create and maintain highest level of integrity, ethics and values on Campus and ensure zero tolerance for lack of these core commitments

University Objectives

- To disseminate and advance knowledge by providing instructional and research facilities in such branches of learning as it may deem fit;
- To make special provisions for integrated courses in humanities, social sciences, science and technology in its educational programmes;
- To take appropriate measures for promoting innovations in teaching-learning process and inter-disciplinary studies and research;
- To educate and train manpower for the development of the country;
- To establish linkages with industries for the promotion of science and technology; and
- To pay special attention to the improvement of the social and economic conditions and welfare of the people, their intellectual, academic and cultural development.

Central University of Haryana

The Central University of Haryana, established by MHRD, under the Central Universities Act-2009 (Act No. 25 of 2009) made a spirited beginning under the leadership of its sagacious and visionary founder Vice Chancellor Prof. Mool Chand Sharma, from a rented building in Gurgaon as transit office and Narnaul B.Ed. college building as campus. It has now shifted to its Permanent Campus sprawling over 488 acres of land at Jant-Pali Villages, Mahendergarh district of Haryana. The University, fully funded by the UGC, is all set to emerge as a seat of great learning in the Southern Haryana under the leadership of its reverent and visionary Acting Vice-Chancellor Prof. U. P. Sinha. Being at the nascent stage of establishment, the University immediately after getting possession of the land at Jant-Pali, Mahendergarh acted through various empowered Committees and Groups to chart out the course of development. After duly considering the recommendations of various empowered committees the Executive Council of the University approved the road map for the first phase of development of the campus on the site at Jant-Pali, Mahendergarh. The first phase of development comprises the construction of boundary wall and a block of four buildings. The construction of boundary wall is complete and the four blocks are functional to run the academic programmes. These blocks host separate hostels for boys and girls, modest accommodation for faculty and other staff, academic wing with class rooms, seminar rooms, tutorial rooms, laboratories, libraries, conferencing facilities, etc. These buildings will be integrated as a part of hostel zone when the development of the Campus enters in the final phase. Marching ahead on the journey of promoting grass root research and fruitful engagement with society many brainstorming sessions of idea generation are held. After comprehensive deliberations University has adopted **"Multidisciplinary Approach to Inclusive Education"** as motto.

DEPARTMENT OF MATHEMATICS

Department of Mathematics, Central University of Haryana was opened in the academic year 2013-14 by offering M.Sc. (Physics) programme. This *Department* is functioning under the School of Physical & Mathematical Sciences and is the latest addition to the School. This School right now have the following departments

- Department of Mathematics
- Department of Physics
- Department of Statistics

Department of Mathematics offers PG programme i.e. M.Sc. (Mathematics) of two years duration which are divided into four semesters & based on choice based credit system (CBCS).

Mathematics is the backbone of the science and engineering. Its utility in the emerging areas of science, engineering and technology is increasing day by day. Considering its importance, the Department of Mathematics feels encouraged to propose the scheme and syllabi of M.Sc. (Mathematics) 2 years programme. After thorough deliberations and discussions and keeping syllabi of Indian universities in mind the proposed syllabi contains various topics on pure, applied and computational mathematics. The course would be beneficial to student community for their academic growth and employment.

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Course Structure for M.Sc. - Mathematics under Choice Based Credit System has been given on the next page.

SEMESTER-I

S. N.	PAPER CODE	Paper Title	L	T	P	Credits
1	SPMMAT 01101 C 3204	Real Analysis	3	2	0	4
2	SPMMAT 01102 C 3204	Topology	3	2	0	4
3	SPMMAT 01103 C 3204	Abstract Algebra	3	2	0	4
4	SPMMAT 01104 C 3204	Complex Analysis	3	2	0	4
5	SPMMAT 01105 C 3204	Theory of Differential Equations	3	2	0	4
		Total	15	10		20

SEMESTER-II

S. N.	PAPER CODE	Paper Title	L	T	P	Credits
1	SPMMAT 01201 C 3204	Theory of Measure and Integration	3	2	0	4
2	SPMMAT 01202 C 3204	Advanced Complex Analysis	3	2	0	4
3	SPMMAT 01203 C 3204	Advanced Abstract Algebra	3	2	0	4
4	SPMMAT 01204 C 3204	Mathematical Statistics	3	2	0	4
5	SPMMAT 01205 C3204	Object Oriented Programming With C++	3	0	2	4
		Total	15	8	2	20

SEMESTER-III

S. N.	PAPER CODE	Paper Title	L	T	P	Credits
1	SPMMAT 01301 C 3204	Number Theory	3	2	0	4
2	SPMMAT 01302 C 3024	Classical Mechanics	3	2	0	4
3	SPMMAT 01303 C 3204	Operations Research	3	2	0	4
4		Elective-I*	3	2	0	4
5		Elective-II*	3	2	0	4
		Total	15	10		20

SEMESTER-IV

S.N.	PAPER CODE	Paper Title	L	T	P	Credits
1	SPMMAT 01401 C 3204	Functional Analysis	3	2	0	4
2	SPMMAT 01402 C 3204	Fluid Dynamics	3	2	0	4
3	SPMMAT 01403 C 3204	Seminar And Problem Solving	0	0	8	4
4		Elective-III**	3	2	0	4
5		Elective-IV**	3	2	0	4
		Total	12	8	8	20

TO THE AWARD OF POST GRADUATE DEGREES / DIPLOMAS

1. **Definitions:**
   1.1 "Course" means a Semester course.
   1.2 "Credit" (c) is the weightage assigned to a course in terms of contact hours.
   1.3 "Grade" means a letter grade assigned to a student on the basis of evaluation of a course on a ten point scale.
   1.4 "Grade point" (g) means the numerical equivalent of a letter grade assigned to a student in the ten point scale.
   1.5 Semester Grade Point Average (SGPA) means the grade point average of a student for a semester calculated in the following manner:
   SGPA = $(g_1 x c_1) + (g_2 x c_2) + \ldots$(in respect of all courses for which the student has registered in the semester concerned) divided by the total number of credits offered by the student in the semester.
   1.6 "Cumulative Grade Point Average" (CGPA) means a cumulative index grade point average of a student calculated in the following manner:
   CGPA = $(g_1 x c_1) + (g_2 x c_2) + \ldots$(in respect of all the courses for which the student has registered up to and including the semester for which the cumulative index is required) divided by the total number of credits offered by the student in the said courses.
   1.7 "Final Grade Point Average" (FGPA) is the final index of a student at the time of award of a degree, calculated in the following manner:

$$\text{FGPA} = \frac{\sum_{i=1}^{n} \text{gi}\, x \quad \text{ci}}{\text{Where } \sum_{i=1}^{n} \text{ci}}$$

   c_i = credit in the i^{th} course
   g_i = grade point secured by the student in the i^{th} course
   n = total number of courses prescribed for the student for the entire programme.

   1.8 "Final Grade" is the letter equivalent assigned to a student on the basis of his/her FGPA at the time of the award of the degree.

2. **Eligibility for admission:**
   A candidate may be admitted to the Master's programme if he/she has obtained a Bachelor's degree under 10+2+3 system recognized by the University, or a degree recognized as its equivalent, provided such a candidate has attained the minimum proficiency in the subject at the time of admission as decided by the University from time to time.
3. **Semesters:**
   3.1 An academic year shall consist of two semesters, viz.:Odd semester and Even semester.

3.2 Ordinarily an Odd semester shall extend from July to December, and an Even semester from January to May.

3.3 A semester normally extends over a period of 15 weeks, each week having 30 hours of instruction spread over a week.

4. Type of courses:

Each programme may have three types of courses, viz. core courses, elective courses and self-study-courses.

4.1. Core courses:

4.1.1 Core courses are those, knowledge of which is deemed essential for students registered for a particular Master's programme. Where feasible and necessary, two or more programmes may prescribe one or more common core courses.

4.1.2 Core courses shall be mandatory for all students registered for that Master's programme.

4.1.3 Core courses shall be spread over all the semesters of the programme.

4.2 Elective courses:

Elective courses are intended to:

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

4.3 Self-study courses:

4.3.1 Self-study courses are optional, not mandatory. They are not taken into account for awarding grades.

4.3.2 Students may also choose 3 additional courses to enable them to acquire extra credits through self-study.

4.3.3 Self-study courses shall be in advanced topics in a course (core or elective) under the supervision of a faculty member.

Note: A course (Core/Elective/Self-study) may also take the form of a Dissertation/ Project work/ Practical training/ Field work/ Internship/ Seminar, etc.

5. Credits:

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

- 1 credit = 1 hour of instruction per week (1 credit course = 15 hours of instruction per semester)
- 3 credits = 3 hours of instruction per week (3 credit course = 45 hours of instruction per week)

A Core course may carry 3 to 4 credits; an elective/ Self-study will not normally carry more than 3 credits. However, a dissertation/ project work may carry up to 6 credits; a semester-long field work may carry 10-15 credits.

6. Auditing:

Students may be permitted by the individual faculty member at his/her discretion to audit two courses without assigning any credits.

7. Course numbering:

Each course offered by a faculty/department is identified by a unique course code: e.g. SSS C 001 Eco 3003, where

- SSS stands for School of Social Sciences;
- C stands for core course;
- 001 stands for the serial number of the course;
- The figures 3,0,0,3 stand for credits attached to lectures (practical, if it is a practical course), tutorials, practical work (theory, if it is a practical course) and total number of credits for the course respectively.

8. Duration of programme:

The minimum duration for completion of a one-year Post Graduate Diploma programme shall be two consecutive semesters (one odd and one even semester), for a two-year Master's programme in any subject shall be four consecutive semesters (two odd and two even semesters) and for a three-year Master's programme - six semesters, i.e. three odd and three even semesters. The maximum period for completion shall be four semesters, six semesters and eight semesters respectively.

Provided that a semester or a year may be declared by the Academic Council zero semester or zero year in the case of a student if he/she could not continue with the academic work during that period due to illness and hospitalization, or due to accepting a foreign scholarship/fellowship, subject to fulfillment of requirements laid down in this respect by regulations. Such zero semester/year shall not be counted for calculation of the duration of the programme in case of such a student.

9. Student Advisor:

The Department in which the student gets admitted shall appoint an Advisor for him/her from amongst the members of the faculty concerned. All faculty members of the department shall function as Student Advisors and shall have more or less equal number of students. The Student Advisor shall advise the student in choosing courses and render all possible help to the student.

10. Course Registration:

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

10.2 Every student has to register in each semester (in consultation with his/her Student Advisor) for the courses he/she intends to undergo in that semester by applying in the prescribed proforma in triplicate , duly signed by him/her, the Student Advisor and

the Head of the Department, within the deadline notified for the purpose by the University.

10.3 Late registration may be permitted by the Dean of the faculty upto a maximum of two weeks after the commencement of the semester on payment of prescribed late registration fee.

10.4 A student shall register for a minimum of 15 credits and can register for a maximum of 24 credits in a semester.

10.5 Withdrawal from a course shall be permitted up to one week from the date of registration, provided the courses registered after withdrawal shall enable the student to earn a minimum of 15 credits. Withdrawal from a course shall not be allowed for those who had late registration.

10.6 A student shall be allowed to add a course or substitute a course for another course of the same type (core, elective or self-study) for valid reasons with the consent of the Student Advisor not later than two weeks from the date of commencement of the semester.

10.7 A student may take more elective courses than prescribed in the programme, in which case in the calculation of the Semester/ Cumulative/ Final Grade Point Average only the prescribed number of elective courses in the descending order of the grades obtained by him/her shall be included.

11. Evaluation & examination:

11.1 Sessional evaluation shall be done on a continuous basis, taking into account the student's class performance, fulfillment of home assignments and performance at the compulsory sessional tests (2 best out of 3 tests to be conducted in a semester). For uniformity, particularly for interdepartmental transfer of credits, there shall be a uniform procedure of examination to be adopted by all faculty members. There shall be three sessional tests and one end-semester examination in each course during every semester.

11.2 Sessional Test 1 shall be held during the sixth week of the semester for the syllabi covered till then.

11.3 Sessional Test 2 shall be held during the eleventh week for the syllabi covered between seventh and eleventh week.

11.4 Sessional test 3 shall be held during the fourteenth week of the semester for the remaining syllabus after the sessional test 2.

11.5 Sessional tests may employ one or more assessment tools such as objective tests, assignments, paper presentation, laboratory work, etc. suitable to the course.

11.6 The pattern of assessment of sessional work, including the weightages to be given to different elements like class performance, home assignments and the sessional tests, for each course shall be prescribed by the School Board on the recommendation of the Board of Studies of the Department concerned and shall be made known to the students at the commencement of each semester.

11.7 A student cannot repeat sessional tests.

11.8 The sessional work and the end semester examination shall have equal weightage i.e. 50% each. The 50% weightage allotted to sessional work shall consist of 30%

for class performance and home assignments and the remaining 20% for the two compulsory sessional tests (i.e. 10% each), or 20% for class performance and home assignments and 30% for the two sessional tests, depending upon the nature of the course.

11.9 A student clears the sessional work in a course if he / she has participated in the sessional work and secured a grade higher than F in it.

11.10 End semester Examinations covering the entire syllabus prescribed for the course and carrying 50% of weightage shall be conducted under the direction of the Dean of the School.

11.11 Examiners or Board of Examiners shall be appointed for each course by the School Board on the recommendation of the Board of Studies of the Department concerned.

11.12 The distribution of weightage for the valuation of semester-long project work/ dissertation shall be:

i) Periodic presentation : 20%
ii) Concise dissertation : 60%
iii) Viva voce : 20%

Or as decided by the School Board on the recommendations of the Board of Studies of the Department concerned.

11.13 An application for admission to the semester examination shall be made in the prescribed form and forwarded to the Dean of the School through the HOD concerned and shall be accompanied by the following documents:

i) Clearance in sessional evaluation;
ii) Clearance of all dues.

12. Grades and Grade points:

The students shall be graded in sessional tests, end semester examinations, etc. in each course on the following ten point scale:

Grade	Grade Point
A+	**9.00**
A	**8.25**
A-	**7.50**
B+	**6.75**
B	**6.00**
B-	**5.25**
C+	**4.50**
C	**3.75**
C-	**3.00**
F	**0**

Note:

1. There shall be no rounding of SGPA/CGPA/FGPA.
2. The SGPA/CGPA/FGPA obtained by a student is out of a maximum possible 9 points.

The Final Grade Point Average obtained by a student shall be classified into the following divisions:

FGPA	Class/ Division
8.5 and above	First Class with Distinction
7.0 and above, but less than 8.5	First Class
5.0 and above, but less than 7.0	Second Class
4.0 and above, but less than 5.0	Pass

13. Credit requirements:

13.1 For a one-year Post Graduate programme, the credit requirements for the award of the Post Graduate Diploma shall be 40 credits (±10%), including a minimum of 9 credits from elective courses (of which at least 3 credits shall be from elective course offered by another Department).

13.2 For a two-year Master's programme, the credit requirements for the Master's degree shall be 80 credits (±10%), including a minimum of 18 credits from elective courses (**of which at least 6 credits shall be from elective courses offered by other Departments**).

13.3 For a three-year Master's programme, the credit requirements for the Master's degree shall be 120 credits (±10%), including 27 credits from elective courses (of which 9 credits shall be from elective courses offered by other Departments).

14 Grade point requirements:

A student in order to be eligible for the award of the Master's degree of the University must have fulfilled the following requirements:

i) He/she has taken and passed all the prescribed courses as laid down;

ii) He/she has obtained a FGPA of 4.00 at the end of the programme.

Provided that students who are otherwise eligible for the award of the degree / diploma but have secured a FGPA less than 4.00 at the end of the permissible period of semesters may be allowed by the Department / School concerned to repeat the same course/s or other courses of the same type in lieu thereof in the two extra semesters provided in clause 8 on "Duration of Programme".

15 Removal of name of a student from the programme:

a. The name of a student falling under the following categories shall automatically stand removed from the rolls of the University:
   (a) A student who fails to fulfill the minimum grade point requirements under clause 14.
   (b) A student who has already exhausted the maximum duration allowed for completion of the Programme and has not fulfilled the requirements for the award of the degree / diploma.

b. The School Board, on the recommendation of the Board of Studies of the Department concerned, may remove the name of a student from the programme of study if

(a) he / she fails to clear at least 50% of the prescribed core courses at the end of the 1st semester.

(b) he / she has still to clear courses which cannot possibly be cleared in the remaining period of the programme which he/ she is allowed to register for the normal load in the said period.

Notwithstanding what is contained in the foregoing clauses of this Ordinance, the Academic Council may, in exceptional circumstances and on the recommendations of the Board of Studies of the Department and the School Board as well as on the merits of each individual case, consider at its discretion and for reasons to be recorded relaxation of any of the provisions except those prescribing CGPA / FGPA requirements.

M.Sc. (Mathematics)
SEMESTER–I

REAL ANALYSIS SPMMAT 01101 C 3204

L T P
3 2 0

UNIT-I

Elementary set theory, finite, countable and uncountable sets. Metric spaces: definition and examples, open and closed sets, Compact sets, elementary properties of compact sets, k- cells, compactness of k-cells, compact subsets of Euclidean space R^k. Perfect sets, Cantor set, Separated sets, connected sets in a metric space, connected subsets of real line.

UNIT-II

Convergent sequences (in Metric spaces), Cauchy sequences, subsequences, Complete metric space, Cantor's intersection theorem, category of a set and Baire's category theorem. Examples of complete metric space, Banach contraction principle

UNIT-III

Limits of functions (in Metric spaces), Continuous functions, continuity and compactness, Continuity and connectedness, Discontinuities, Monotonic functions, Uniform continuity

UNIT-IV

Riemann Stieltje's Integral : definition and existence of Integral, Properties of integral, integration and differentiation, Fundamental theorem of Calculus, 1^{st} and 2^{nd} mean value theorems for Riemann Stieltje's integral.

Books Recommended :

1. Walter Rudin, Principles of Mathematical Analysis, 3^{rd} edition, McGraw Hill, Kogakusha, 1976, International student edition
2. H. L. Royden , Real Analysis, 3^{rd} edition, Macmillan, New York & London 1988.
3. Tom M. Apostol, Mathematical Analysis , Addition –Wesley.
4. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Ltd.

SPMMAT 01102 C 3204 TOPOLOGY

L T P
3 2 0

UNIT-I

Definition and examples of topological spaces, closed sets, Closure, Dense subsets, Neighborhoods, Interior, exterior and boundary. Accumulation points and derived sets. Bases and sub bases. Subspaces and relative topology. Alternative methods of defining a topology in terms of Kuratowski closure operator and neighborhood systems.

UNIT –II

Continuous functions and homomorphism, Open Mappings, Closed Mappings, Compactness and local compactness. One –point compactification. Connected and arcwise connected spaces. Components. Locally connected spaces.

UNIT –III

T_0 and T_1 spaces, T_2 -spaces and sequences. Hausdorffness of one point compactification. Axioms of Countability and Separability . Equidistance separable, second axion and Lindelof in metric spaces. Equivalence of Compact and countably compact sets in metric spaces.

UNIT –IV

Regular, completely regular, normal and completely normal spaces. Metric spaces as $\mathbf{T_2}$, completely normal and first axiom spaces. Urysohn's Lemma. Tietze Extension theorem.

Books Recommended

1. K.D. Joshi : General Topology
2. J.R. Munkres : Topology
3. W.J. Pervin : Foundation of General Topology .
4. G. F. Simmons, Introduction to Topology and Modern Analysis.

SPMMAT 01103 C 3204 ABSTRACT ALGEBRA

L T P
3 2 0

UNIT-I

Groups : Zassenhaus lemma, Normal and subnormal series, Composition series, Jordan-Holder theorem, Solvable series, Derived series, Solvable groups, Solvability of S_n – the symmetric group of degree $n \geq 2$.

UNIT - II

Nilpotent group: Central series, Nilpotent groups and their properties, Equivalent conditions for a finite group to be nilpotent, Upper and lower central series, Sylow-p sub groups, Sylow theorems with simple applications. Description of group of order p^2 and pq, where p and q are distinct primes(In general survey of groups upto order 15).

UNIT - III

Field theory, Extension of fields, algebraic and transcendental extensions. Splitting fields, Separable and inseparable extensions, Algebraically closed fields, Perfect fields.

UNIT - IV

Finite fields, Automorphism of extensions, Fixed fields, Galois extensions, Normal extensions and their properties, Fundamental theorem of Galois theory, Insolvability of the general polynomial of degree $n \geq 5$ by radicals.

Books Recommended :

1. I.N.Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
2. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, Basic Abstract Algebra (2nd Edition), Cambridge University Press, Indian Edition, 1997.
3. P.M. Cohn, Algebra, Vols. I, II & III, John Wiley & Sons, 1982, 1989, 1991.
4. N. Jacobson, Basic Algebra, Vol. I & II, W.H Freeman, 1980 (also published by Hindustan Publishing Company).
5. S. Lang, Algebra, 3rd editioin, Addison-Wesley, 1993.
6. I.S. Luther and I.B.S.Passi, Algebra, Vol. I-Groups, Vol. II-Rings, Narosa Publishing House (Vol. I – 1996, Vol. II –1990).
7. D.S. Malik, J.N. Mordenson, and M.K. Sen, Fundamentals of Abstract Algebra, McGraw Hill, International Edition, 1997.
8. Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House, 1999.

SPMMAT 01104 C 3204 COMPLEX ANALYSIS

L T P
3 2 0

UNIT-I

Review of Complex number system, Function of a complex variable, Limit, Continuity, Uniform continuity, Differentiability, Analytic function, Cauchy- Riemann equations, Harmonic functions and Harmonic conjugate.

UNIT-II

The exponential function, Trigonometric function, Logarithmic function, Branches of multi-valued functions with reference to $\arg z$, $\log z$, z^c. Mobius transformation, Conformal mapping.

UNIT-III

Conformal integration, Cauchy-Goursat theorem, Cauchy integral formula, Higher order derivatives, Morera's theorem, Liouville's theorem, Fundamental theorem of algebra, Zeroes of analytic function, maximum modulus principle, Schwarz's Lemma.

UNIT-IV

Taylor's series, Laurent's series, Singularities of analytic functions, Casorati-Weierstrass theorem, Poles, Residues, Residue theorem and its applications to contour integrals of the form i) $\int_0^{2\pi} F(\cos\theta, \sin\theta)d\theta$ ii) $\int_{-\infty}^{\infty} R(x)dx$ iii) $\int_0^{\infty} x^{\alpha} R(x)dx$ where F is a rational function of $\cos\theta$ and $\sin\theta$, $R(x)$ is a rational function of x and α is a real number. Argument principle, Rouche's theorem.

Books Recommended :

1. E. T. Copson, An Introduction to Theory of Functions of a Complex variable.
2. L. V. Ahlfors, Complex Analysis, Tata McGraw Hill, 1979.
3. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, 2007.
4. R. V. Churchill & J. W. Brown, Complex Variables and Applications, Tata McGraw Hill, 1996.
5. W. Tutschke and H.L. Vasudeva, An Introduction to complex analysis: Classical and Modern Approaches, CRC Publications.

SPMMAT 01105 C 3204 THEORY OF DIFFERENTIAL EQUATIONS

L T P
3 2 0

UNIT-I

Initial value problem, Existence of solutions of ordinary differential equations of first order, Existence and Uniqueness theorem, Picard-Lindelof theorem, Peano's existence theorem, Existence of independent solutions, Wronskian, Method of successive approximation, method of Variation of parameters.

UNIT-II

Regular and singular points, Power series solution of differential equation at regular and regular singular points, Bessel's and Legendre's equations and their solutions.

UNIT-III

The phase plane and its phenomena, Existence and uniqueness of solution (statement only), Stability, Lyapunov function, Critical points and their nature, Stability in the sense of Lyapunov.

UNIT-IV

Classification of first order PDE, Classification of second order PDE, Lagrange's linear PDE, Charpit's method. Well - posed and Ill-posed problems, Monge's method, Separation of variables method for parabolic, hyperbolic and elliptic equations.

Books Recommended :

1. E.A. Codington and N. Levinson, Theorey of Differential Equations, McGraw Hill
2. G.F. Simmons, Differential Equation with Applications and Historical Notes, Tata McGraw-Hill.
3. S.G. Deo and V. Raghavendra, Ordinary Differential Equations and Stability Theory, Tata McGraw-Hill.
4. I.N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill.
5. S.L. Ross, Differential Equations, Wiley.

M.Sc. (Mathematics)
SEMESTER–II

SPMMAT 01201 C 3204 THEORY OF MEASURE AND INTEGRATION

L T P
3 2 0

UNIT-I

Preliminaries, Lebesgue outer measure. Measurable sets.Regularity, Lebesgue measure, Non measurable sets.

UNIT-II

Measurable functions. Borel and Lebesgue measurability. Housdorff measures on the real line, Integration of non negative functions. The general Integral, Integration of series, Riemann and Lebesgue integrals.

UNIT-III

The Four derivates, continuous non differentiable functions. Functions of bounded variation. Lebesgue Differentiation theorem. Differentiation and integration. The Lebesgue set

UNIT-IV

The L^p-spaces, convex functions, Jensen's inequality, Holder and Minkowski inequalities. Completeness of L^p, Convergence in Measure. Almost uniform convergence.

Books Recommended :

1. H.L. Royden, Real Analysis, Macmillan, New York, 1988.
2. G.de Bara, Measure Theory and Integration, Ellis Horwood Limited, England
3. G.B. Folland, Real Analysis, second edition, John Wiley, New York, 1999.
4. E. Kreyszig Introductory Functional Analysis with Applications, John Wiley, 1989.

SPMMAT 01202 C 3204 ADVANCED COMPLEX ANALYSIS

L T P
3 2 0

UNIT-I

Analytic continuation, Analytic continuation by power series method, Natural boundary, Schwarz reflection principle, Analytic continuation along a path, Monodromy theorem, Runge's theorem, simple connectedness, Mittag-Leffler's theorem.

UNIT-II

Maximum principle, Schwarz's Lemma, Hadamard's three circle theorem, Phragmen-Lindelof theorem, Weierstrass factorization theorem, Factorization of sine function, Gamma function. Entire functions, Jensen's formula, The genus and order of an entire function, Hadamard factorization theorem.

UNIT-III

Harmonic functions, Basic properties, Harmonic functions on a disc, Subharmonic and Superharmonic functions, The Dirichlet problem, Green's function.

UNIT-IV

Normal families of analytic functions, Montel's theorem, Hurwitz's theorem, Riemann mapping theorem, Univalent function, Distortion and Growth theorem for the class of normalized univalent functions, Covering theorem, starlike functions, convex functions, Subordination principle.

Books Recommended :

1. Zeev Nihari, Conformal Mapping.
2. E.T. Copson, An Introduction to Theory of Functions of a Complex Variable.
3. J. B. Conway, Functions of One Complex Variable.
4. T. W. Gamelin, Complex Analysis.

SPMMAT 01203 C 3204 ADVANCED ABSTRACT ALGEBRA L T P
3 2 0

UNIT - I

Cyclic modules, Simple and semi-simple modules, Schur's lemma, Free modules, Fundamental structure theorem of finitely generated modules over principal ideal domain and its applications to finitely generated abelian groups.

UNIT - II

Neotherian and Artinian modules and rings with simple properties and examples, Nil and Nilpotent ideals in Neotherian and Artinian rings, Hilbert Basis theorem.

UNIT - III

$Hom_R(R,R)$, Opposite rings, Wedderburn – Artin theorem, Maschk's theorem, Equivalent statement for left Artinian rings having non-zero nilpotent ideals, Uniform modules, Primary modules and Neother- Lasker theorem.

UNIT - IV

Canonical forms : Similarity of linear transformations, Invariant subspaces, Reduction to triangular form, Nilpotent transformations, Index of nilpotency, Invariants of nilpotent transformations, The primary decomposition theorem, Rational canonical forms, Jordan blocks and Jordan forms.

Books Recommended :

1. I.N.Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
2. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, Basic Abstract Algebra (2nd Edition), Cambridge University Press, Indian Edition, 1997.
3. M. Artin, Algebra, Prentice-Hall of India, 1991.
4. P.M. Cohn, Algebra, Vols. I, II & III, John Wiley & Sons, 1982, 1989, 1991.
5. I.S. Luther and I.B.S.Passi, Algebra, Vol. I-Groups, Vol. II-Rings, Narosa Publishing House (Vol. I – 1996, Vol. II –1990).
6. D.S. Malik, J.N. Mordenson, and M.K. Sen, Fundamentals of Abstract Algebra, McGraw Hill, International Edition, 1997.
7. K.B. Datta, Matrix and Linear Algebra, Prentice Hall of India Pvt., New Dlehi, 2000.
8. Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House, 1999.
9. T.Y Lam, Lectures on Modules and Rings, GTM Vol. 189, Springer-Verlag, 1999.

SPMMAT 01204 C 3204 MATHEMATICAL STATISTICS

L T P
3 2 0

UNIT - I

Probability: Definition of probability-classical, relative frequency, statistical and axiomatic approach, Addition theorem, Boole's inequality, Conditional probability and multiplication theorem, Independent events, Mutual and pairwise independence of events, Bayes' theorem and its applications.

UNIT - II

Random Variable and Probability Functions: Definition and properties of random variables, discrete and continuous random variables, probability mass and density functions, distribution function. Concepts of bivariate random variable: joint, marginal and conditional distributions.
Mathematical Expectation: Definition and its properties. Variance, Covariance, Moment generating function- Definitions and their properties. Chebychev's inequality.

UNIT - III

Discrete distributions: Uniform, Bernoulli, binomial, Poisson and geometric distributions with their properties.
Continuous distributions: Uniform, Exponential, Gamma and Normal distributions with their properties. Central Limit Theorem (Statement only).

UNIT - IV

Statistical estimation: Parameter and statistic, sampling distribution and standard error of estimate. Point and interval estimation, Unbiasedness, Efficiency.
Testing of Hypothesis: Null and alternative hypotheses, Simple and composite hypotheses, Critical region, Level of significance, One tailed and two tailed tests, Two types of errors.
Tests of significance: Large sample tests for single mean, single proportion, difference between two means and two proportions; Definition of Chi-square statistic, Chi-square tests for goodness of fit and independence of attributes; Definition of Student's 't' and Snedcor's F-statistics, Testing for the mean and variance of univariate normal distributions, Testing of equality of two means and two variances of two univariate normal distributions

Books Recommended :

1. Mood, A.M., Graybill, F.A. and Boes, D.C., Mc Graw Hill Book Company.
2. Freund,J.E., Mathematical Statistics, Prentice Hall of India.
3. Gupta S.C. and Kapoor V.K., Fundamentals of Mathematical Statistics, S. Chand Pub., New Delhi.
4. Speigel, M., Probability and Statistics, Schaum Outline Series.

SPMMAT01205 C3204 OBJECT ORIENTED PROGRAMMING WITH C++

L T P
3 0 2

UNIT - I

Basic concepts of Object-Oriented Programming (OOP). Advantages and applications of OOP. Object-oriented languages. Introduction to C++. Structure of a C++ program. Creating the source files. Compiling and linking.
C++ programming basics: Input/Output, Data types, Operators, Expressions, Control structures, Library functions.

UNIT - II

Functions in C++ : Passing arguments to and returning values from functions, Inline functions, Default arguments, Function overloading.
Classes and objects : Specifying and using class and object, Arrays within a class, Arrays of objects, Object as a function arguments, Friendly functions, Pointers to members.

UNIT - III

Constructors and destructors. Operator overloading and type conversions.
Inheritance : Derived class and their constructs, Overriding member functions, Class hierarchies, Public and private inheritance levels.
Polymorphism, Pointers to objects, this pointer, Pointers to derived classes, virtual functions.

UNIT - IV

Streams, stream classes, Unformatted I/O operations, Formatted console I/O operations, Managing output with manipulators.
Classes for file stream operations, Opening and Closing a file. File pointers and their manipulations, Random access. Error handling during file operations, Command-line arguments. Exceptional handling.

Books Recommended :

1. I.S. Robert Lafore, Object Oriented Programming using C++, Waite's Group Galgotia Pub.
2. E. Balagrusamy, Object Oriented Programming with C++, 2nd Edition, Tata Mc Graw Hill Pub. Co.
3. Byron, S. Gottfried, Object Oriented Programming using C++, Schaum's Outline Series, Tata Mc Graw Hill Pub. Co.
4. J.N. Barakaki, Object Oriented Programming using C++, Prentice Hall of India, 1996.
5. Deitel and Deitel, C++: How to program, Prentice Hall of India

M.Sc. (Mathematics)
SEMESTER–III

SPMMAT 01301 C 3204 NUMBER THEORY

L T P
3 2 0

UNIT I

Divisibility, G.C.D and L.C.M., Primes, Fermat numbers, congruences and residues, theorems of Euler, Fermat and Wilson, solutions of congruences, linear congruences, Chinese remainder theorem,

UNIT II

Arithmetical functions $\varphi(n)$, $\mu(n)$ and $d(n)$and $\sigma(n)$, Moebius inversion formula, congruences of higher degree, congruences of prime power modulli and prime modulus, power residue,

UNIT III

Quadratic residue, Legendre symbols, lemma of Guass and reciprocity law. Jacobi symbols, Farey series, rational approximation, Hurwitz theorem, irrational numbers, irrationality of e and π, Representation of the real numbers by decimals.

UNIT IV

Finite continued fractions, simple continued fractions, infinite simple continued fractions, periodic continued fractions, approximation by convergence, best possible approximation, Pell's equations, Lagrange four sphere theorem.

Books Recommended :

1. G H Hardy and E M Wright, Theory of Numbers, Oxford Science Publications, 2003.
2. I Niven and H S Zuckerman, Introduction to the Theory of Numbers, John Wiley & Sons,1960.
3. D M Burton, Elementary Number Theory, Tata McGraw Hill Publishing House, 2006.
4. H. Davenport, Higher Arithmetic, Cambridge University Press, 1999.
5. T.M. Apostal, Introduction to Analytic Number Theory, Narosa Publishing House.

SPMMAT 01302 C 3204 CLASSICAL MECHANICS

L T P
3 2 0

UNIT –I

Free and constrained systems, constraints and their classification, holonomic and non-holonomic systems, degree of freedom and generalised coordinates, virtual displacement and virtual work, statement of principle of virtual work (PVW), possible velocity and possible acceleration, D' Alembert's principle,
Lagrangian Formulation **:** Ideal constraints**,** general equation of dynamics for ideal constraints, Lagrange's equations of the first kind.

UNIT –II

Independent coordinates and generalized forces, Lagrange's equations of the second kind, generalized velocities and accelerations. Uniqueness of solution, variation of total energy for conservative fields.
Lagrange's variable and Lagrangian function L(t, q_i, $\dot{q}_i$), Lagrange's equations for potential forces, generalized momenta p_i , Hamiltonian variable and Hamiltonian function H(t, q_i, p_i), Donkin's theorem, ignorable coordinates.

UNIT -III

Hamilton canonical equations, Routh variables and Routh function R, Routh's equations, Poisson Brackets and their simple properties, Poisson's identity, Jacobi – Poisson theorem.
Hamilton action and Hamilton's principle, Poincare – Carton integral invariant, Whittaker's equations, Jacobi's equations, Lagrangian action and the principle of least action.

UNIT -IV

Canonical transformation, necessary and sufficient condition for a canonical transformation, univalent Canonical transformation, free canonical transformation, Hamilton-Jacobi equation, Jacobi theorem, method of separation of variables in HJ equation, Lagrange brackets, necessary and sufficient conditions of canonical character of a transformation in terms of Lagrange brackets, Jacobian matrix of a canonical transformation, conditions of canonicity of a transformation in terms of Poison brackets, invariance of Poisson Brackets under canonical transformation.

Books Recommended

1. F. Gantmacher, Lectures in Analytic Mechanics, MIR Publishers, Moscow, 1975.
2. P.V. Panat, Classical Mechanics, Narosa Publishing House, New Delhi, 2005.
3. N.C. Rana and P.S. Joag, Classical Mechanics, Tata McGraw- Hill, New Delhi, 1991.
4. Louis N. Hand and Janet D. Finch , Analytical Mechanics, CUP, 1998.
5. K. Sankra Rao , Classical Mechanics, Prentice Hall of India, 2005.
6. M.R. Speigal, Theoretical Mechanics, Schaum Outline Series.

SPMMAT 01303 C 3204 OPERATIONS RESEARCH

L T P
3 2 0

UNIT - I

Operations Research: Origin, definition and its methodology and scope.
Linear Programming: Formulation and solution of linear programming problems by graphical and simplex methods, Big-M and two phase methods, Degeneracy, Duality in linear programming.

UNIT - II

Transportation Problems: Basic feasible solutions, optimum solution by stepping stone and modified distribution methods, unbalanced and degenerate problems, transhipment problem. Assignment problems: Solution by Hungarian method, unbalanced problem, case of maximization, travelling salesman problem.

UNIT - III

Queuing models: Basic components of a queuing system, General birth-death equations, steady-state solution of Markovian queuing models with single and multiple servers (M/M/1. M/M/C, M/M/1/k, M/MC/k)
Inventory control models: Economic order quantity (EOQ) model with uniform demand and with different rates of demands in different cycles, EOQ when shortages are allowed, EOQ with uniform replenishment, Inventory control with price breaks.

UNIT - IV

Game Theory : Two person zero sum game, Game with saddle points, the rule of dominance; Algebric, graphical and linear programming methods for solving mixed strategy games. Sequencing problems: Processing of n jobs through 2 machines, n jobs through 3 machines, 2 jobs through m machines, n jobs through m machines.

Books recommended :

1. Taha, H.A., Operation Research-An introducton, Printice Hall of India.
2. Gupta, P.K. and Hira, D.S., Operations Research, S. Chand & Co.
3. Sharma, S.D., Operation Research, Kedar Nath Ram Nath Publications.
4. Sharma, J.K., Mathematical Model in Operation Research, Tata McGraw Hill.

ELECTIVE PAPERS FOR SEMESTER-III

SPMMAT 01304 E 3204 DIFFERENTIAL GEOMETRY

L T P
3 2 0

UNIT-I

Tensor and their transformation laws, Tensor algebra, Contraction, Quotient law, Reciprocal tensors, Kronecker delta, Symmetric and skew- symmetric tensors, Metric tensor, Riemannian space, Christoffel symbols and their transformation laws, Covariant differentiation of a tensor, Riemannian curvature tensor and its properties, Ricci-tensor.

UNIT-II

Theory of space curves. Serret-Frenet formulas for curves in space. Parametric representation of curves, Helix , Curvilinear coordinates in E_3. Tangent and first curvature vector. Intrinsic equations & differentiation, Parallel vector fields.

UNIT-III

Parametric representation of a surface, Tangent and Normal vector field on a surface, The first and second fundamental tensor. The third fundamental form, Gaussian curvature , Isometry of surfaces, Equation of Gauss, Principal curvature, Normal curvature.

UNIT-IV

Definition. Differential equation of geodesics. Nature of Geodesics. Canonical equations. Normal property. Geodesic polar coordinate, curvature and torsion.

Books Recommended :

1. I. S. Sokolnikoff, Tensor Calculus and Application to Geometry and Mechanics.
2. T. T. Wilmore, An Introduction to Differential Geometry.
3. Bary Spain, Differential Geometry. Arthur L. Besre, Einstein manifolds, Springer Verlag, Berlin, New York.

SPMMAT 01305 E 3204 FINITE ELEMENT ANALYSIS

L T P
3 2 0

UNIT I

General theory of finite element methods, Difference between finite element and finite difference, Review of some integral formulae, Concept of discretization, Convergence requirements, Different coordinates, One dimensional finite elements, shape functions, stiffness matrix, connectivity, boundary conditions, equilibrium equation, FEM procedure.

UNIT II

Generalization of the finite element concepts-weighted residual and variational Approaches (Ritz method, Galerkin method, collocation method etc.) Numerical integration, Interpolation formulas and shape functions, Axis symmetric formulations, solving one-dimensional problems.

UNIT III

Two dimensional finite element methods, Element types: triangular, rectangular, quadrilateral, sector, curved, isoperimetric elements and numerical integration, two dimensional boundary value problems, connectivity and nodal coordinates, theory of elasticity, variational functions, triangular elements and area coordinates, transformations, cylindrical coordinates.

UNIT IV

Three dimensional finite elements, higher order finite elements, element continuity, plate finite elements, Application of finite element methods to elasticity problems and heat transfer problems, Computer procedures for Finite element analysis.

Books Recommended :

1. Braess, Dietrich.,Schumaker, Larry L., Finite Elements: Theory, Fast Solvers, and Applications in Solid Mechanics (2nd edition),Cambridge University Press, 2001.
2. C.S.Desai, Introductory Finite Element Method, CRC Press, 2001.
3. G. D. Smith: Numerical solution of Partial Differential Equations.
4. B. Bradie: A friendly introduction to Numerical Analysis.
5. J. N. Reddy: An introduction to Finite Element Methods.

SPMMAT 01306 E 3204 **WAVELET ANALYSIS** **L T P**
3 2 0

UNIT-I

Review of vector spaces. Inner products, Orthonormal bases. Reiz systems and frames. Continuous Fourier transform (CFT), Basic properties. Fourier inversion. Continuous time-frequency representation of signals.

UNIT-II

Wavelet, origin and history. Examples of wavelets. L^2 (R) and approximate identities. Continuous wavelet transform (CWT) as a correlation. Constant Q-factor filtering interpretation and time frequency resolution. CWT as an operator. Inverse CWT.

UNIT-III

Discrete wavelet transform. Haar scaling functions and function spaces. Wavlet bases of multiresolution analysis (MRA). Daubechies wavelets. Refinement relation with respect to normalized bases. Support of a wavelet system.

UNIT-IV

Evaluation of Scaling and wavelet functions. Designing wavelets (direct approach): Restriction on filter coefficients Decomposition filters and reconstructing the signal. Interpreting orthonormal MRAs for discrete time signals.

Books Recommended :

1. M.W. Frazier, An Introduction to Wavelets Through Linear Algebra, Springer, 1999.
2. M.W. Altaisky, Wavelets: Theory, Applications, Implementation, Universities Press, 2005.
3. R.M. Rao and A.S. Bopardikar, Wavelet Transforms: Theory and Applications, Pearson, 2008.
4. M.A. Pinsky, Introduction to Fourier Analysis and Wavelet Analysis, Thomson, 2002.

SPMMAT 01307 E 3204 DISCRETE MATHEMATICS

L	T	P
3	2	0

UNIT-I

Mathematical Logic: Statement and notations, proposition and logic operations, connectives (conjunction, disjunction, negation), statement formulas and truth tables, propositions generated by set, equivalence of formulas and implication laws of logic, mathematical systems, propositions over a universe, principal of mathematical induction, variables, quantifiers.

UNIT-II

Relation and Function: Binary relations, Properties of binary relation in a set, Equivalence relations, Composition of binary relations, Partial ordering and Partial Order set, Hasse diagram, Function and Pigeon hole Principle. Recursion definition, many faces of recursion, Recurrence relations, common recurrence relations, generating functions and their solutions.

UNIT-III

Posets, lattice and basic properties of Boolean algebraic, Principle of duality, distributive and complemented lattices, uniqueness of finite Boolean algebra, Boolean functions and Boolean expressions, Normal forms of Boolean expression and simplifications of Boolean expressions, Basic circuits and theorems, Logical gates and relations of Boolean function.

UNIT-IV

Basic terminology of graph theory, Paths, Circuits, Graph connectivity, Eulerian paths, Multigraphs, Weighted graphs. Trees, Spanning trees, Binary trees, Rooted trees. Planar graphs, Eulers theorem. The Konigsberg Bridge problem and Eulerian graphs,Hamiltonian graphs.

Books Recommended :

1. J. P. Trembley and R. Manohar, A First Course in Discrete Structure with applications to Computer Science, Tata McGraw Hill (1999).
2. Vijay K. Khanna, Lattices and Boolean Algebras.
3. Babu Ram, Discrete Mathematics, Vinayak Publications.
4. C. L. Liu, Elements of Discrete Mathematics, Tata McGraw Hill.

SPMMAT 01308 E 3204 MATHEMATICAL METHODS

L T P
3 2 0

UNIT-I

Linear integral equations of the first and second kind of Fredholm and Volterra type.
Solutions by methods of successive substitutions and successive approximations. Fredholm First theorem, Hadamard's Theorems, Fredholm Second and third theorems. Integral Equation with Degenerate Kernals, Hibert Schmidt theory: Bessel's inequality. Riesz- Fischer Theorem. Hibert Schmidt theorem.

UNIT-II

Functional, Euler-Lagrange equation, variational methods of boundary value problems in ordinary and partial differential equations.

UNIT-III

Laplace transforms, properties and theorems. Inversion. Convolution theorem. Laplace transforms of unit step and unit impulse functions. Heaviside inversion formula. Applications to initial boundary value ordinary and partial differential equations.

UNIT-IV

Fourier integral, Fourier transform & properties. Fourier sine and cosine transforms and theorems. Convolution theorem. Applications to boundary value ordinary and partial differential equations.

Books Recommended :

1. J. W. Brown and R. Churchill, Fourier Series and Boundary Value Problems.
2. M. R. Spiegal, Shaum's Outline of Theory and Problems of Laplace Transforms.
3. Peter V. O'Neil, Advanced Engineering Mathematics.
4. I. N. Sneddon, The Use of Integral Transforms, Tata McGraw Hill, 1985

M.Sc. (Mathematics)
SEMESTER–IV

SPMMAT 01401 C 3204 FUNCTIONAL ANALYSIS **L T P**
3 2 0

UNIT-I

Normed linear spaces. Banach spaces. Examples of Banach spaces and subspaces. Continuity of linear maps. Equivalent norms. Normed spaces of bounded linear maps. Bounded linear functionals. Hahn-Banach theorem and its applications.

UNIT-II

Uniform boundedness principle. Open mapping theorem, Projections on Banach spaces, Closed graph theorem. Dual spaces of l_p and C [a, b], Reflexivity.

UNIT-III

Hilbert spaces, examples, Orthogonality, Orthonormal sets, Bessel's inequality, Parsevals's theorem. The conjugate space of a Hilbert space.

UNIT-IV

Adjoint operators, Self-adjoint operators, Normal and Unitary operators. Projection operators. Weak convergence. Completely continuous operators.

Books Recommended :

1. G.F.Simmons, Introduction to Topology and Modern Analysis.
2. Erwin Kreyszig, Introductory Functional Analysis with Applications.
3. G. Bachman & L. Narici, Functional Analysis.
4. C. Goeffman & G. Pedrick, First Course in Functional Analysis.
5. S. Ponnusamy, Foundation of Functional Analysis

SPMMAT 01402 C 3204 FLUID DYNAMICS

L T P
3 2 0

UNIT-I

Definition of a fluid, definition of fluid properties with dimensions and units, stream lines and path lines, compressible and incompressible flow, dimensionless numbers: Reynolds, Froude, Weber, Mach & Euler.

UNIT-II

Conservation of mass, energy equation, application of energy equation, linear momentum equation, application of linear momentum equation, continuity equation, Navier Stokes equation, Bernoulli equation, heat equation.

UNIT-III

Laminar and turbulent flow, steady flow between parallel plates, flow through circular tubes and circular annuli, turbulent flow relations, flow in open channels, flow through simple pipes, flow losses in conduits.

UNIT-IV

Definition of ideal fluid flow, Euler's equation of motion, Integration of Euler's equation, irrotational flow, stream functions and boundary conditions, two dimensional flows, source and sink. Water waves modelling.

Books Recommended :

1. V. L. Streeter, E.B. Wylie & K.W. Bedford, Fluid Mechanics, McGraw Hill, Singapore.
2. N. Curle & H. J. Davies, Modern Fluid Dynamics, Vol – I, D Van Nostrand Company Ltd, London.
3. D. E. Rutherford, Fluid Dynamics.
4. F. Charlton, Fluid Dynamics. C.B. S. Publishers Delhi.
5. M.E. O'Neil, and F Choriton, Ideal and Incompressible Fluid Dynamics John Wiley &Sons

SPMMAT 01403 C 3204 SEMINAR AND PROBLEM SOLVING (4 CREDIT)

ELECTIVE PAPERS FOR SEMESTER IV

SPMMAT 01404 E 3204 ADVANCED NUMERICAL ANALYSIS

L T P

3 2 0

UNIT-I

Cubic Spline interpolation. Error in interpolating polynomial. Iterative methods for solution of system of linear equations: Gauss-Seidel, Jacobi's and Relaxation method. Necessary and sufficient conditions for convergence. Eigen-value problem. Determination of largest and smallest eigen value and corresponding eigen vectors by Rayleigh's power method.

UNIT-II

General Newton's method. Existence of roots. Stability and convergence under variation of initial approximations. General iterative method for the system: $x = g(x)$ and its sufficient condition for convergence. Romberg's integration, Gaussian integration. Error in integration.

UNIT-III

Milne's and Adam Bashforth methods. Finite difference method for solving initial value problem. Classification of PDE. Solution of one dimensional heat conduction equation by Crank-Nicolson methods. Convergence and stability. Standard and diagonal five point formula for solving Laplace and Poisson equations.

UNIT-IV

Solution of boundary value problems by weighted residual methods Galerkin, Ritz and orthogonal collocation methods. Introduction to finite elements method. Solution of boundary value problems by finite element method.

Books Recommended :

1. Isacson and Keller, Analysis of Numerical methods.
2. M.K. Jain, Numerical Solution of Differential Equations.
3. O.C. Zienkiewics ,The Finite Element Method in Structural & Continuum Mechanics.
4. Prem K. Kytbe, An introduction to boundary element methods.
5. B. P. Demidovich and J.A.Maron, Computational Mathematics.
6. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific & Engg. Computation, New Age International.

SPMMAT 01405 E 3204 ADVANCED OPERATIONS RESEARCH

L T P
3 2 0

UNIT-I

Maximum Flow Problem (MFP) and Shortest Path Problem (SPP). Min-Cost Flow Problem (MCFP). Project planning and control with CPM (Critical Path Method) and PERT (program evaluation and Review Technique). Crashing.

UNIT-II

Classical Optimization theory. Unconstrained optimization by using Fibonacci, Golden section search & Gradient Projection method.. Constrained optimization with equality constraint by Lagrange's method & Gradient projection method. Constrained optimization with inequality constraint by Kuhn -Tucker condition.

UNIT-III

Introduction of dynamic programming. Bellman's principle for optimality. Characteristic of dynamic programming problem. Deterministic & probabilistic dynamic programming for discrete & continuous variables.

UNIT-IV

Concept of system simulation. Monte Carlo method. Simulation of continuous & discrete systems. Introduction of Goal programming, Separable programming and Geometric programming and their applications.

Books Recommended :

1. A.H. Taha, Operations Research, PHI.
2. S.D. Sharma, Operations Research, Kedar Nath Ram Nath & Co..
3. D.S. Hira, System Simulation, S. Chand & Co.
4. S.S. Rao, Operations Research, Wiley.
5. Bazaarra Mokhtar S., Jarvis John J. and Shirali Hanif D., Nonlinear Programming, John Wiley and Sons (1990)
6. Ravindran, Phillips, Operation Research: Principles & Practice, John Wiley & Sons.

SPMMAT 01406 E 3204 THEORY OF ELASTICITY

L T P
3 2 0

UNIT-I

Analysis of strain, Geometrical interpretation of the components of strain, Strain quadric of Cauchy. Principal strain and invariants. Venant's equation of compatibility. Analysis of stress: Stress tensor. Equation of equilibrium. Transformation of co-ordinates. Stress quadric of Cauchy. Principal stress and Invariants. Maximum normal and shear stresses.

UNIT-II

Equations of elasticity: Generalized Hooke's law. Homogeneous isotropic media. Elastic moduli for isotropic media. Equilibrium and dynamic equations for an isotropic elastic solid. Strain energy function and its connection with Hooke's law. Beltrami-Michell compatibility equations.

UNIT-III

Two-dimensional problems. Plane stress. Generalized plane stress. Airy stress function. General solution of Biharmonic equation. Stresses and displacements in terms of complex potentials.

UNIT- IV

Torsion: Torsion of cylindrical bars. Torsional rigidity. Torsion and stress functions. Lines of shearing stress. Simple problems related to circle, ellipse and equilateral triangle. Waves: Propagation of waves in an isotropic elastic sold medium. Waves of dilation and distortion. Plane waves. Elastic surface waves such as Rayleigh and Love waves.

Books Recommended :

1. I.S. Sokolnikoff, Mathematical Theory of Elasticity.
2. A.E.H. Love, A Treatise on Mathematical Theory of Elasticity.
3. S Timoshenko and I.N. Goodier, Theory of Elasticity.
4. Zhilun Xu, Applied Elasticity.

SPMMAT 01407 E 3204 THEORY OF LINEAR OPERATORS L T P
3 2 0

UNIT-I

Spectral theory in normed linear spaces, resolvent sets and spectrum, spectral properties of bounded linear operators, properties of resolvent and spectrum. Spectral mapping theorem for polynomials, spectral radius of a bounded linear operator on a complex Banach space.

UNIT-II

Elementary theory of Banach algebras, Resolvent set and spectrum, Invertible elements, Resolvent equation, general properties of compact linear operator.

UNIT-III

spectral properties of compact linear operators on normed space, Behaviour of compact linear operators with respect to solvabilityof operator equations. Fredholm type theorems, Fredholm alternative theorem, Fredholm alternative theorem for integral equations.

UNIT-IV

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 root of positive operators. Spectral family of a bounded self-adjoint linear operator and its properties.

Books Recommended :

1. E. Kreyszig, Functional Analysis with applications, John Wiley & Sons, New York, 1978.
2. P. R. Halmos, Introduction to Hilbert Space and Theory of Spectral Multiplicity, IInd Edition, Chelsea Publishing Co., N. Y., 1957.
3. N. I. Akhiezer and J. T. Glazman, Theory of Linear operators in Hilbert space, Frederick Unrag Pub. Co., Vol -!, 1961, Vol-II, 1963.
4. G. Bachman and L. Narici, Functional Analysis, Academic Press, !966.

SPMMAT 01408 E 3204 INFORMATION THEORY L T P
3 2 0

UNIT-I

Measure of Information – Axioms for a measure of uncertainty. The Shannon entropy and its properties. Joint and conditional entropies. Transformation and its properties. Axiomatic characterization of the Shannon entropy due to Shannon and Fadeev.

UNIT-II

Noiseless coding - Ingredients of noiseless coding problem. Uniquely decipherable codes. Necessary and sufficient condition for the existence of instantaneous codes. Construction of optimal codes.

UNIT-III

Discrete Memoryless Channel - Classification of channels. Information processed by a channel. Calculation of channel capacity. Decoding schemes. The ideal observer. The fundamental theorem of Information Theory and its strong and weak converses.

UNIT-IV

Continuous Channels - The time-discrete Gaussian channel. Uncertainty of an absolutely continuous random variable. The converse to the coding theorem for time-discrete Gaussian channel. The time-continuous Gaussian channel. Band-limited channels.

Books Recommended

1. R. Ash, Information Theory, Interscience Publishers, New York, 1965.
2. F.M. Reza, An Introduction to Information Theory, MacGraw-Hill Book Company Inc., 1961.
3. J. Aczela dn Z. Daroczy, On Measures of Information and their Characterizations, Academic Press, New York.

Department of Physics
Central University of Haryana
Jant-Pali, Mahendergarh
Website: www.cuharyana.org