NEP PG

1-YEAR CURRICULUM

M.Sc. MATHEMATICS PROGRAMME

SUBJECT CODE = MAT

FOR POSTGRADUATE COURSES UNDER RANCHI UNIVERSITY, RANCHI

Implemented w.e.f.
Academic Session 2026-27 Onwards

UNIVERSITY DEPARTMENT OF MATHEMATICS
RANCHI UNIVERSITY
Morabadi Campus, Ranchi 834008, Jharkhand. (Ph. 0651-6555611)
Dr. Abrar Ahmad, Head, Associate Professor, Ranchi University, Ranchi.

Ref: **Date:** 20/08/2025

Meeting of Board of Studies

A meeting of Board of Studies was convened in the office of the Head of University Department of Mathematics, Ranchi University, Ranchi on 20/08/2025 at 02:30 PM.

The agenda of the meeting was to approve the draft syllabus of F.Y.U.G. program and Post Graduate Programme of Mathematics according to NEP 2020.

After detailed discussion, the Board of Studies have finalized and approved the draft syllabus of F.Y.U.G. program and Post Graduate Programme which is to be implemented from 2025 onwards.

1. Dr. C. S.P. Lugun, Retired & Former Head, Univ. Deptt. of Mathematics, R. U. Ranchi 20/8/25
2. Dr. Ashalata Keshri, Retired & Former Head, Univ. Deptt. of Mathematics, R. U. Ranchi 20.8.25.
3. Dr. Ashish Kumar Jha, Univ. Deptt. of Mathematics, R. U. Ranchi 20.08.25
4. Mrs. Rimil Nidhi Bhuinyan, Univ. Deptt. of Mathematics, R. U. Ranchi. 20/08/2025
5. Dr. Sheet Nihal Topno, Univ. Deptt. of Mathematics, R. U. Ranchi. 20.08.2025
6. Mr. Amit Bara, Univ. Deptt. of Mathematics, R. U. Ranchi. 20.08.25
7. Dr. B. P. Verma, Prinicipal, S. S. Memorial College, Ranchi.
8. Dr. Raman Kumar Das, HOD, Department of Mathematics, St. Xavier's College, Ranchi. 20.08.2025
9. Dr. M. R. Nagalakshmi, HOD, Department of Mathematics, Nirmala College, Ranchi. Nagalakshmi 20/8/25
10. Dr. Anita Kumari, Head, Deptt. of Mathematics, D. S. P. M.U. Ranchi 20/8/25
11. Dr. P. K. Parida, Department of Mathematics, C.U.J. Ranchi 20/8/25
12. Dr. Shyam Saurabh, HOD, Department of Mathematics, Chaibasa College, Kolhan University. S. Saurabh 20.8.25

Abrar 20/08/25

Head
Department of Mathematics
Ranchi University, Ranchi

verified 20/8/25

Dr. Abrar Ahmad
Chairman
Univ. Department of Mathematics
Ranchi University, Ranchi

Approval by the Members of the NEP Implementation and Monitoring Committee of Ranchi University, Ranchi

The prepared Curriculum of the Master's Degree has been approved by the NEP Implementation and Monitoring Committee of R.U., duly forwarded by the Head of the Department; it will be offered to the Students of the 1-year and 2-year Postgraduate Programme. It is implemented from the 1st Semester of the Academic Session 2025-26 and onwards.

10/9/25 10/9/25 10/9/2025

Anushka Rani
10/09/25 10/9/25 10/9/25

10/9/25 10/9/25 10/09/2025

10/09/2025

10/09/25

Member Secretory

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HIGHLIGHTS OF NEP PG CURRICULUM

CREDIT OF COURSES

The term 'credit' refers to the weightage given to a course, usually in terms of the number of instructional hours per week assigned to it. The workload relating to a course is measured in terms of credit hours. It determines the number of hours of instruction required per week over a semester (minimum 15 weeks).

a) One hour of teaching/ Lectures or two hours of laboratory /practical work will be assigned per class/interaction.
   One credit for Theory = 15 Hours of Teaching
   One credit for Practicum = 30 Hours of Practical work
   One credit for Internship = 02 Weeks of Practical experience

b) For credit determination, instruction is divided into three major components:
   Hours (L) – Classroom Hours of one hour duration.
   Tutorials (T) – Special, elaborate instructions on specific topics of one hour duration
   Practical (P) – Laboratory or field exercises in which the student has to do experiments or other practical work of a two-hour duration.

   Internship – For the Exit option after 1st year of the 2-year P.G. Programme for the award of P.G. Diploma, Level 6.5, Students can either complete two 4-week internships worth 2 credits each or one 8-week internship for all 4 credits. This practical experience connects academic learning with real-world applications, offering valuable exposure to professional environments in their fields of study

PG CURRICULUM

1. The PG Curriculum will be either of 1-year duration for students who studied the four-year UG Programme (FYUGP) or a 2-year duration for students who studied a three-year UG programme from a CBCS/LOCF/FYUGP Curriculum.
2. There is a flexible mode in the PG programme offered to the students of Ranchi University, Ranchi. The total credit for any semester will be 20 credits.
3. **Two-year PG curriculum:** The First year of the PG curriculum offers coursework only. There will be 3 courses at level 400 and 2 courses at level 500 in the first and the second semesters of any 2-year PG programme.
4. **One-year PG curriculum:** The Courses in the 1-year PG programme and the second year of the 2-year PG programme are the same.
   a. **Course work only**: There will be 5 courses at level 500 of 4 credits each in every semester for the coursework offered in the programme.
   b. **Course work and Research**: There will be 5 courses at the level 500 bearing 4 credits each in the first semester of a 1-year PG or in the third semester of a 2-year PG. Research work will be offered in the next semester for this mode of the programme. The eligibility for this mode is available in the NEP PG curriculum of Ranchi University, Ranchi.
   c. **Research work only**: The eligible student will be offered this mode to conduct extensive research under the supervision of a guide. Each semester will be equivalent to 20 credits. The selection of a candidate for the research mode will depend upon the eligibility of the student, availability of the guide and seat in the department/institution of Ranchi University, Ranchi.

PROMOTION CRITERIA

One Year Post-graduation programme having coursework only:

i. Each course shall be of **100 marks** having two components: **30 marks for Sessional Internal Assessment (SIA), conducted by the Department/College and 70 marks shall be assigned to the End Semester University Examination (ESUE), conducted by the University**.
ii. The marks of SIA shall further break into, 20 for Internal Written Examinations, 05 for Written Assignment/ Seminar presentation and 05 for overall performance of a student including regularity in the classroom lectures and other activities of the Department/College.

iii. The Requisite Marks obtained by a student in a particular subject will be the criterion for promotion to the next Semester.

iv. There shall be two written internal examinations, each of 1 hour duration and each of 20 marks, in a semester, out of which the '**Better One out of Two**' shall be taken for computation of marks under SIA.

v. If a student failed to secure pass marks in the Mid Semester, he/she has to reappear in Mid & End Semester Examinations.

vi. In case a student fails to secure pass marks in End Semester Examination, then he/she has to appear only in the End Semester Examination of the following session within the period of Upper Limit of Two Years and the Marks of the Mid Semester will be carried for the preparation of the result.

vii. Students' final marks and the result will be based on the marks obtained in the Mid Semester and End Semester Examination taken together.

viii. The pass marks in the programme will be 45% of the total marks obtained in each Core/ Elective/ Other Courses offered.

ix. In absolute terms of marks obtained in a course, **a minimum of 28 marks is essential in the ESUE** and **a minimum of 17 marks is to be secured in the SIA** to clear the course. In other words, a student shall have to pass separately in the ESUE and in the SIA by securing the minimum marks prescribed here.

x. Every candidate seeking to appear in the ESUE shall be issued an Admit Card by the University. **No candidate will be permitted to appear in the examination without a valid admit card.**

xi. A candidate shall be permitted to proceed in the next Semester (2^{nd}), **provided he/she has passed at least <u>3 courses</u> out of 5 courses** in the respective semester in theory and practical/ project courses taken together.

xii. A student will have to clear all his papers within a maximum of <u>Two Years of duration</u> to qualify for the degree.

However, it will be necessary to procure pass marks in each of the papers before completion of the programme.

VALUE ADDED COURSES

1. The Value-added course will be of **2 credits** to be covered during the first semester.
2. There will be objective-type questions asked in the End Semester University Examination (ESUE).
3. There will be an OMR-based examination and the correct answer is to be marked by a black ballpoint pen only on the OMR sheet provided by the University.
4. For **50 Marks Examination,** the student will be provided **two hours** for marking their responses.
5. Students are not allowed to choose or repeat courses already undergone at the undergraduate level in the proposed major and minor streams.
6. The performance in this course will not influence the SGPA or CGPA of the PG Programme where the student is registered to obtain the Master's Degree. <u>However, it will be mandatory to secure minimum pass marks in the course before exiting from the PG Programme.</u>
7. If the student fails to secure the minimum pass marks in the Value-added course in the first semester, he may appear in the examination of the said course with the following batch of the next session.
8. The student may appear in the examination of the said course further if they could not clear the course in the following attempt, subject to the date of validation of the Registration.

The Regulations related to any concern not mentioned above shall be guided by the existing Regulations of the PG Curriculum of Ranchi University, Ranchi.

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COURSE STRUCTURE FOR **'PG DIPLOMA/ COURSEWORK ONLY/ COURSEWORK WITH RESEARCH/ RESEARCH ONLY'**

Table 1: Credit Framework for One Year Postgraduate Programme (PG) [Total Credits = 80]

Academic Level	**Level of Courses**	**Semester**	**Coursework** Level 400	**Coursework** Level 500	**Research Preparedness**	**Research thesis/ Project/ Patent**	**Total Credits**
YEAR 1							
Level 6.5	**Coursework**	**III**	**---**	**4+4+4+4+4**	**---**	**---**	**20**
		IV	**---**	**4+4+4+4+4**	**---**	**---**	**20**
OR							
Level 6.5	**Coursework + Research**	**III**	**---**	**4+4+4+4+4**	**---**	**---**	**20**
		IV	**---**	**---**	**20**		**20**
OR							
Level 6.5	**Research**	**III**	**---**	**---**	**20**	**---**	**20**
		IV	**---**	**---**	**---**	**20**	**20**
							Total credits of P.G. Programme = **80**

Note: **There is no 'Exit' allowed in the One-year PG Curriculum**.

AIMS OF MASTER'S DEGREE PROGRAMME IN MATHEMATICS

The aim of Master's degree programme in Mathematics is intended to provide:

1. A rigorous and broad-based understanding of advanced mathematical concepts, including real and complex analysis, algebra, topology, differential equations, functional analysis, and mathematical modelling, building upon the foundational knowledge acquired at the undergraduate level.
2. The ability to think critically and abstractly, formulate precise mathematical arguments, and construct rigorous proofs, thereby deepening the student's capacity for independent inquiry and research.
3. Advanced exposure to the rich **Indian contributions to mathematics**—such as the works of Aryabhata, Bhāskara, Madhava, and others—embedding elements of the **Indian Knowledge Systems (IKS)** into the curriculum to foster historical, philosophical, and cultural awareness of the subject.
4. Training in the use of mathematics in solving real-world problems arising in natural sciences, engineering, and data sciences, alongside a firm grasp of modern mathematical methods including conformal mapping, variational principles, and computational techniques.
5. Preparation for careers in higher education, scientific research, and industry by cultivating technical skills, academic writing proficiency, and the ability to conduct independent research culminating in a dissertation.
6. A commitment to ethical reasoning, intellectual integrity, and appreciation of mathematics as both a universal and culturally grounded discipline, nurturing a lifelong love for learning and discovery.

PROGRAMME LEARNING OUTCOMES

The broad aims of Master's degree programme in Mathematics are:

1. **Advanced Mathematical Competence**: Acquire in-depth understanding of core areas such as real and complex analysis, abstract algebra, functional analysis, differential equations, and topology, and apply this knowledge to both theoretical investigations and applied contexts.
2. **Analytical and Logical Thinking:** Demonstrate expertise in formulating precise mathematical statements, constructing proofs, solving abstract problems, and developing algorithms for both classical and contemporary mathematical challenges.
3. **Research and Communication Skills:** Gain proficiency in mathematical writing, literature review, and research methodology. Communicate mathematical ideas clearly through presentations and a structured dissertation based on independent or guided research.
4. **Mathematical Modelling and Applications:** Apply mathematical techniques to real-world scenarios, including problems from physics, fluid dynamics, engineering, and finance. Develop and analyze models using tools such as differential equations, numerical methods, and complex functions.
5. **Integration of Indian Knowledge Systems (IKS):** Appreciate the historical development and indigenous contributions to mathematics in India, including ancient number systems, combinatorics, calculus precursors, and astronomical mathematics, thereby recognizing mathematics as a culturally embedded discipline.
6. **Ethical and Professional Responsibility:** Adhere to high standards of academic integrity, responsible use of mathematics in social and technological applications, and sensitivity to the ethical dimensions of quantitative reasoning.
7. **Career and Higher Education Readiness:** Be well-prepared for doctoral research, academic and teaching careers, as well as roles in government, data science, finance, and industries that value analytical and quantitative skills.
8. **Lifelong Learning and Interdisciplinary Outlook:** Cultivate curiosity, adaptability, and a mindset of lifelong learning, with openness to new areas such as mathematical computing, data-driven mathematics, and interdisciplinary collaboration.

The Courses in One Year P.G. Programme and in the Second year of Two years P.G. Programme are Common.

Table 2: Semester-wise Course Code and Credit Points

Sem	Core, AE/ GE/ DC/ EC & Compulsory FC Courses				Examination Structure		
	Paper	**Paper Code**	**Credit**	**Name of Paper**	**Mid Semester Evaluation (F.M.)**	**End Semester Evaluation (F.M.)**	**End Semester Practical/ Viva (F.M.)**
I	Core Course	CCMAT301	4	IKS in Mathematics	30	70	----
	Skill Enhancement Course	ECMAT302	4	A. Fourier and Wavelet Analysis/ B. Hadamard Matrices and Combinatorial Designs/ C. Advance Discrete Mathematics/ D. Fluid Dynamics	30	70	----
	Core Course	CCMAT303	4	Advanced Algebra	30	70	----
	Core Course	CCMAT304	4	Differential Geometry and Tensor Analysis	30	70	----
	Core Course	CCMAT305	4	Partial Differential Equations	30	70	----
II	Elective	ECMAT401	4	A. Optimization Techniques/ B. Integral Transforms/ C. Stochastic Process	30	70	----
	Elective	ECMAT402	4	A. Operations Research/ B. Integral Equations/ C. Mathematical Modeling	30	70	----
	Core Course	CCMAT403	4	Functional Analysis	30	70	----
	Core Course	CCMAT404	4	Numerical Solutions of PDE	30	70	----
	PROJECT	PRMAT405	4	Dissertation/ Project Work/ Teaching Aptitude	----	----	100

Note: **There is no 'Exit' allowed in the One-year PG Curriculum.**

INSTRUCTION TO QUESTION SETTER

SEMESTER INTERNAL EXAMINATION (SIE):

There **Marks Weightage of a Course:** Each non-practical/non-project course shall be of **100 marks** having two components: **70 marks shall be assigned to the End Semester University Examination (ESUE), conducted by the University, and, 30 marks for Sessional Internal Assessment (SIA), conducted by the Department/College**.

The marks of SIA shall further break into, 20 for Internal Written Examinations, 05 for Written Assignment/ Seminar presentation and 05 for overall performance of a student including regularity in the class room lectures and other activities of the Department/College. There shall be two written internal examinations, each of 1-hour duration and each of 20 marks, in a semester out of which the **'Better One out of Two'** shall be taken for computation of marks under SIA.

In absolute terms of marks obtained in a course, **a minimum of 28 marks is essential in the ESUE and a minimum of 17 marks is to be secured in the SIA to clear the course**. In other words, a student shall have to pass separately in the ESUE and in the SIA by securing the minimum marks prescribed here.

A. (SIE 20+5=25 marks):

There will be a uniform pattern of questions for mid semester examinations in all the courses and of all the programmes. There will be **two** groups of questions in 20 marks written examinations. **Group A is compulsory** and will contain five questions of **very short answer type** consisting of 1 mark each. **Group B will contain descriptive type five** questions of five marks each, out of which any three are to be answered. Department may conduct Sessional Internal Examinations in other format as per need of the course.

The Semester Internal Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 20 Marks, (b) Class Attendance Score (CAS) of 5 marks.

Conversion of Attendance into score may be as follows:
Attendance Upto 45%, 1mark; 45<Attd.<55, 2 marks; 55<Attd.<65, 3 marks; 65<Attd.<75, 4 marks; 75<Attd, 5 marks.

END SEMESTER UNIVERSITY EXAMINATION (ESUE):

A. (ESUE 70 marks):

There will be a uniform pattern of questions for all the courses and of all the programmes. There will be **two** groups of questions. **Group A is compulsory** and will contain two questions. **Question No.1 will be very short answer type** consisting of five questions of 1 mark each. **Question No.2 will be short answer type** of 5 marks. **Group B will contain descriptive type six** questions of fifteen marks each, out of which any four are to be answered. The questions will be so framed that examinee could answer them within the stipulated time.

[**Note:** There may be subdivisions in each question asked in Theory Examinations]

B. (ESUE 100 marks):

Practical/ Project courses would also be of 100 marks but there **shall be no internal written examinations** of the type specified above. The total 100 marks will have two components: **70 marks for the practical ESUE and 20 marks for the Viva-voce examination** conducted during the ESUE to assess the applied and practical understanding of the student.

The written component of the project (**Project Report**) shall be of **70 marks and 20 marks will be for the Viva-voce examination** jointly conducted by an external examiner, appointed by the University, and the internal supervisor/guide.

10 marks will be assigned on cumulative assessment of examinee during the semester and will be awarded by the department/faculty concerned.

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FORMAT OF QUESTION PAPER FOR MID/ END SEMESTER EXAMINATIONS

Question format for **20 Marks**:

Subject/ Code

F.M. =20 **Time**=1Hr. Exam Year

General Instructions:

i. **Group A** carries very short answer type compulsory questions.
ii. **Answer 1 out of 2** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [5x1=5]
   i. ....
   ii. ....
   iii. ....
   iv. ....
   v. ....
2. .... [5]

Group B

3. .... [10]
4. .... [10]

Note: There may be subdivisions in each question asked in Theory Examination.

Question format for **70 Marks**:

Subject/ Code

F.M. =70 **Time**=3HrS. Exam Year

General Instructions:

i. **Group A** carries very short answer type compulsory questions.
ii. **Answer 4 out of 6** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [5x1=5]
   i. ....
   ii. ....
   iii. ....
   iv. ....
   v. ....
2. .... [5]

Group B

3. .... [15]
4. .... [15]
5. .... [15]
6. .... [15]
7. .... [15]
8. .... [15]

Note: There may be subdivisions in each question asked in Theory Examination.

SEMESTER I

I. CORE COURSE [CCMAT301]

IKS IN MATHEMATICS

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

At the end of the course, students will be able to:

1. Explain and interpret mathematical concepts and problem-solving methods from *Brāhmasphuṭasiddhānta*, including algebraic, geometric, and indeterminate equation techniques.
2. Analyze and apply advanced algebraic methods from *Bījagaṇita*, especially the Cakravāla method and solutions of quadratic indeterminate equations.
3. Explore and utilize mathematical results from *Gaṇitakaumudī*, including combinatorics, number theory, and algorithmic solutions to Diophantine problems.
4. Apply iterative approximations, infinite series, and logical proof methods in the Indian mathematical tradition to solve complex computational problems.

Course Learning Outcomes:

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

1. Solve problems involving surds, progressions, plane figures, cyclic quadrilaterals, and indeterminate equations using Brahmagupta's rules and methods.
2. Implement and compare solutions of Pell's-type equations using the Cakravāla method, continued fractions, and related historical approaches.
3. Construct and analyze combinatorial structures, sequences, and number factorization techniques as presented by Nārāyaṇa Paṇḍita.
4. Compute approximations of π, Rsine series, and other infinite series, and critically evaluate the role of *upapatti* in mathematical reasoning and proofs.

Course Content:

UNIT-I: Brähmasphuṭasiddhänta of Brahmagupta (17 Hours) [2 Questions]

Introduction. Twenty logistics. Cube root. Rule of Three, Five Seven, etc. Mixtures. Interest calculations, etc. Progressions: Arithmetic and Geometric. Plane figures. Triangles, right triangles and quadrilaterals Diagonals of a cyclic quadrilateral. Rational triangles and quadrilaterals. Chords of a circle. Volumes with uniform and tapering cross-sections. Pyramids and frustum. Shadow problems. Mathematical operations with plus, minus and zero. Rules in handling surds (karani) Operations with unknowns (uvyakta-ṣadvidha). Equations with single unknowns (ekavarna-samikaraṇa). Equations with multiple unknowns (anekavarṇa-samikaraṇa). Equations with products of unknowns (bhävita). Brahmagupta on kuttaka. The Second order indeterminate equation (Vargapraksti). Bhavană principle and its applications

UNIT-II: Bijagaṇita of Bhaskarācārya (13 Hours) [1 Question]

Development of Bijaganita or Avyaktagaṇita (Algebra) and Bhaskara's treatise on it. Understanding of negative quantities. Development of algebraic notation. The Vargaprakṛti equation X^2 - $DY^2 = K$ and Brahmagupta's bhāvanä process. The Cakraväla method of solution of Jayadeva and Bhaskara. Bhliskara's examples $X^2 - 61Y^2 = 1$, $X^2 - 67Y^2 = 1$. The equation $X^2-DY^2 = -1$ Solution of general quadratic indeterminate equations. Bhäskara's solution of a bi-quadratic equation Review of the Cakravila method. Analysis of the Cakraväla method by Krishnaswami Ayyangar. History of the solution of the "Pell's Equation" $X^2- Y^2 = 1$ Solution of "Pell's equation" by expansion of $\sqrt{D}$ into a simple continued fraction. Bhäskara semi-regular continued fraction expansion of $\sqrt{D}$. Optimality of the Cakravila method.

UNIT-III: Ganitakaumudi of Narayana Pandita (12 Hours) [1 Question]

Importance of Gaṇitakaumudi Solutions of quadratic equations. Double equations of second and higher degree rational solutions. Determinations pertaining to the mixture of things, Interest calculations-payment in installments Meeting of travelers. Progressions. Vārasankalita: Sum of sums. The kth sum. The kth sum of a series in A.P. The Cow problem.

Diagonals of a cyclic quadrilateral Third diagonal, area of a cyclio quadrilateral. Construction of rational triangles with rational sides, perpendiculars, and segments whose sides differ by unity Generalisation of binomial coefficients and generalized Fibonacci numbers. Vargaprakrti Näräyana's variant of Cakravāla algorithm. Solutions of Vargaprakṛti and approximation of square roots. Bhagadana Näräyana's method of factorisation of numbers. Ankapāśa (Combinatorics). Enumeration (prastara) of generalised mäträ-vrttas (moric metres with more syllabic units in addition to Laghu and Guru). Some sequences (pankti) and tabular figures (meru) used in combinatorics Enumeration (prastira) of permutations with repetitions. Enumeration (prastärm) of combinations

UNIT-IV: Iterative Approximations, Rsine Series and the Logic of Proofs (18 Hours) [2 Questions]
Irrationals and iterative approximations Second order differences and interpolation in computation of Rsines. Summation of infinite geometric series. Instantaneous velocity (tätkälika-gati). Surface area and volume of a sphere. Irrationality of x (Nilakantha). Nilakantha and the notion of the sum of infinite geometric series, Binomial series expansion. Estimating the sum $1^k+2^k+\ldots+n^k$ for large n. Madhava Series for π. End-correction terms and Mädhava continued fraction. Transformed series for which are rapidly convergent. Nilakantha's derivation of the Aryabhata relation for second-order Rsine differences. Madhava series for Rsine and Reosine. Nilakantha and Acyuta formulae for instantaneous velocity Upapattis or proofs in Indian mathematical tradition. Bhäskarācārya II on the nature and purpose of upapatti. Upapatti of bhuja-koṭi-karna-nyaya (Baudhayana-Pythagoras theorem). Upapatti of kuttaka process. Restricted use of tarka (proof by contradiction) in Indian Mathematics. The cyclic quadrilateral. Expression for the diagonals in terms of the sides. Expression for the area in terms of the diagonals.

Reference Books:

1. Datta and A. N. Singh (1938). *History of Hindu Mathematics*, 2 Parts, Lahore.
   Reprint, Asia Publishing House, Bombay 1962, Reprint, Bharatiya Kala Prakashan, Delhi 2004
2. N. Srinivasiengar (1967). *History of Indian Mathematics*, The World Press, Calcutta.
3. TA. Saraswati Amma (1979). *Geometry in Ancient and Medieval India*, Motilal Banarsidass, Varanasi.
4. S. Balachandra Rao (2004). *Indian Mathematics and Astronomy Some Landmarks*, 3rd Ed. Bhavan's Gandhi Centre, Bangalore.
5. G. G. Emch, M. D. Srinivas and R. Sridharan, Eds. (2005). *Contributions to the History of Mathematics in India*, Hindustan Book Agency, Delhi.
6. S. Seshadri, Ed. (2010). *Studies in History of Indian Mathematics*, Hindustan Book Agency, Delhi.
7. G. G. Joseph (2016). Indian *Mathematics Engaging the World from Ancient to Modern Times*, World Scientific, London.
8. PP Divakaran (2018). *The Mathematics of India Concepts Methods Connections*, Hindustan Book Agency 2018. Rep Springer New York.
9. Ganitayuktibhāsā (c.1530) of Jyesthadeva (in Malayalam), Ed. with Tr. by K. V. Sarma with Explanatory Notes by K. Ramasubramanian, M. D. Srinivas and M. S. Sriram, 2 Volumes, Hindustan Book Agency, Delhi, 2008

II. SKILL ENHANCEMENT COURSE - A [ECMAT302A]
FOURIER AND WAVELET ANALYSIS

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

By the end of the course, students will be able to:

1. Understand and apply the theory of Fourier series and integrals for periodic and non-periodic functions.
2. Study the properties and applications of the Fourier Transform and its discrete versions.
3. Explore the Haar system and its role in function approximation and image analysis.
4. Analyze wavelet bases, discrete and continuous wavelet transforms, and multiresolution analysis.

Course Learning Outcomes:

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

1. Compute Fourier coefficients and apply convergence theorems using Dirichlet and Fejér kernels.
2. Apply Fourier and inverse Fourier transforms, convolution, and Plancherel's theorem to solve problems in function analysis.
3. Construct Haar bases, implement discrete Haar transforms, and use them for signal/image analysis.
4. Build orthonormal wavelet bases, perform discrete and continuous wavelet transforms, and apply multiresolution analysis to finite signals.

Course Content:

UNIT-I: Fourier series of periodic functions (13 Hours) [1 Question]

Fourier Coefficients, partial sums, the Dirichlet and Fejer kernels, convergence theorems. Fourier integrals: convolution, inversion, Plancherel's formula. Generalized Fourier Series, Orthogonality and completeness

UNIT-II: The Fourier Transform (17 Hours) [2 Questions]

Basic properties, Inversion, Convolution, Plancherrel Theorem, The Fourier Transform for L2 functions, Dilatations, Translations, and Modulations. Windowed Fourier Transform, Discrete Fourier Transform.

UNIT-III: Haar System And Haar Transform (13 Hours) [1 Question]

The Haar System, Dyadic Step Functions, Haar bases on [0, 1]. Comparison of Haar series and Fourier Series. The Discrete Haar Transform (DHT), the DHT in two dimensions, Image analysis with the DHT.

UNIT-IV: Orthognormal wavelet bases and Multi resolution analysis (17 Hours) [2 Questions]

Definition and examples, Construction of Orthonormal wavelet bases, Scaling functions and their properties. The Discrete Wavelet Transform, Wavelet frames, Multiscale Analysis, DWT for finite signals.The Continuous Wavelet Transform, Inverse CWT and admissibility conditions.

Reference Books:

1. D F Walnut (2004), *An Introduction to Wavelet Analysis*, Birkhauser
2. M A Pinsky (2001). *Introduction to Fourier Analysis and Wavelets*,AMS.
3. J S Walker (1999). *A Primer on Wavelets and Their Scientific Applications*, CRC.
4. R M Rao, A S Bopardikar (2010). *Wavelet Transforms*, Pearsons, India.
5. I. Daubechies (1992). *Ten Lectures on Wavelets*, SIAM.
6. Y Meyer (1993). *Wavelets: Algorithms and Applications*, SIAM.

OR SKILL ENHANCEMENT COURSE - B [ECMAT302B]

HADAMARD MATRICES AND COMBINATORIAL DESIGNS

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	**Pass Marks: (MSE: 17 + ESE: 28) = 45**

(Credits: Theory-04, 60 Hours)

Course Objectives:

By the end of the course, students will be able to:

1. Understand the foundational structure, properties, and equivalence notions of Hadamard matrices.
2. Apply classical and modern construction techniques to build Hadamard and generalized matrices.
3. Analyze the interplay between Hadamard matrices, orthogonal designs, and matrix structures like weighing and conference matrices.
4. Explore and implement applications of Hadamard matrices in combinatorial designs and coding theory.

Course Learning Outcomes:

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

1. Define and distinguish various forms of Hadamard matrices (symmetric, skew, regular, circulant) and explain the Hadamard conjecture.
2. Construct Hadamard and generalized Hadamard matrices using Paley, Williamson, Goethals–Seidel, and difference-set-based methods.
3. Describe and build orthogonal designs, weighing matrices, and conference matrices, and relate them to Hadamard matrices.
4. Construct BIBDs and GDDs from Hadamard matrices and explain their applications in error-correcting codes.

Course Content:

UNIT-I: Foundations of Hadamard Matrices (13 Hours) [1 Question]

Definition and basic properties of Hadamard matrices, Symmetric and skew Hadamard matrices. Regular hadamard matrix, Order of Hadamard matrices and the Hadamard Conjecture, Equivalence of Hadamard matrices, Sylvester's construction and Kronecker product method, Determinant bound. Circulant, Back-Circulant, Type I and Type II matrices.

UNIT-II: Construction and Generalizations (17 Hours) [2 Questions]

Classical Construction Methods*:* Paley Type I and Type II constructions using finite fields, Williamson's construction, Goethals–Seidel construction, Difference set-based constructions. Enumeration of inequivalent Hadamard matrices. ***Generalizations****:* Definitions and examples of Quaternion Hadamard matrices, Complex Hadamard matrices, Butson type Hadamard matrices and Generalized Hadamard Matrices (GHM) over finite groups.

UNIT-III: Orthogonal Designs and Matrix Structures (12 Hours) [1 Question]

Orthogonal Designs*:* Definition, examples, and link with Hadamard matrices, ***Weighing Matrices****:* Definition and properties, Construction using Kronecker product technique, circulant matrices and Paley-type ideas. ***Conference Matrices****:* Definition (symmetric/skew-symmetric), existence conditions, Construction using Paley method. ***Baumert–Hall Arrays*** for constructing Hadamard matrices.

UNIT-IV: Combinatorial Designs and Applications (18 Hours) [2 Questions]

Classical Application: Maximum Determinant Theorem. ***Balanced Incomplete Block Designs (BIBDs)****:* Definitions, parameters, examples, Construction of BIBDs from Hadamard matrices, *Group Divisible Designs (GDDs)*: Definition, parameters, examples, Constructions of GDDs from Hadamard matrices. ***Coding Theory****:* Construction of error-correcting codes (Hadamard codes).

Reference Books:

1. Marshal Hall (Jr.) (1986). *Combinatorial Theory*, Blaisdel Publishing house.
2. **K. J. Horadam** (2007). *Hadamard Matrices and Their Applications.* Princeton University Press.
3. A. Hedayat and W. D. Wallis (1978). *Hadamard Matrices and Its Applications*. The Annals of Statistics, Vol. 6(6).
4. **C. J. Colbourn and J. H. Dinitz (Eds.)** (2006). *Handbook of Combinatorial Designs,* 2nd ed. CRC Press.
5. **Jennifer Seberry and Mieko Yamada (1972).** *Hadamard Matrices, Sequences, and Block Designs*
6. **Douglas R. Stinson (2004)**. *Combinatorial Designs: Constructions and Analysis.*Springer.

OR SKILL ENHANCEMENT COURSE - C [ECMAT302C]

ADVANCE DISCRETE MATHEMATICS

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

By the end of the course, students will be able to:

1. Explain the principles of automata theory and describe the working of various finite automata and Turing machines.
2. Identify and analyze properties of Eulerian and Hamiltonian graphs using appropriate characterizations and conditions.
3. Apply graph theory concepts to planar graphs, vertex coloring, and related theorems to solve classification and coloring problems.
4. Implement and evaluate algorithms in graph theory for shortest path, network connectivity, and optimization problems.

Course Learning Outcomes:

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

1. Define and differentiate between deterministic, non-deterministic finite automata, Moore machines, Mealy machines, and Turing machines.
2. Determine whether a given graph is Eulerian or Hamiltonian using theoretical characterizations and sufficient conditions.
3. Compute chromatic numbers, chromatic polynomials, and apply vertex/edge coloring theorems, including the Five Color Theorem.
4. Apply and implement algorithms such as Kruskal's, Dijkstra's, and solutions for NP-complete graph problems like the Chinese Postman Problem.

Course Contents:

UNIT-I: Automata Theory (17 Hours) [2 Question]

Finite state automata & types of automata, deterministic and non deterministic finite state automata, non deterministic finite state automata (NDFSA), transition diagram. Moor Machine, Mealy Machine Turing Machine.

UNIT-II: Eulerian and Hamiltonian Graphs (13 Hours) [1 Question]

Eulerian graph and its characterizations, Hamiltonian graph and sufficient conditions for a graph to be Hamiltonian.

UNIT-III: Planar graph and vertex coloring of a graph (13 Hours) [1 Question]

Planar graphs, Platonic graphs. Euler's theorem for planar graphs. Vertex coloring, chromatic number, chromatic polynomial, Brooks theorem, edge coloring, chromatic index, map coloring, Five color theorem.

UNIT-IV: Algorithms in graph theory (17 Hours) [2 Questions]

NP - complete problems, good algorithms, Connector problem and Kruskal's algorithm. Algorithms for Chinese postman problem. The Shortest path problem, Dijkstra's algorithm.

Reference Books:

1. R. J. Wilson (2012). *Introduction to Graph Theory,* 5th ed., Addison Wesley.
2. John Clark and Derek Allan Holton (1991). *A first look at Graph Theory*. World Sc.
3. Narsingh Deo (2012). *Graph theory*, PHI New Delhi.
4. Uday Singh Rajpoot (2012). *Advanced Discreet Mathematics,* PHI (Eastern economic edition).

OR SKILL ENHANCEMENT COURSE - D [ECMAT302D]
FLUID DYNAMICS

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

By the end of the course, students will be able to:

1. Understand various models of finite automata and Turing machines to analyze formal languages.
2. Learn foundational concepts of Eulerian and Hamiltonian graphs along with their properties.
3. Explore key results in planar graphs and vertex coloring, including famous theorems.
4. Apply graph theory algorithms to solve optimization problems like shortest paths and traversals.

Course Learning Outcomes:

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

1. Describe and distinguish between DFA, NFA, Moore, Mealy, and Turing machines with appropriate transition diagrams.
2. Analyze graphs to determine whether they are Eulerian or Hamiltonian using necessary and sufficient conditions.
3. Apply Euler's formula, chromatic number, chromatic polynomials, and theorems such as Brooks' and the Five Color Theorem in planar graphs.
4. Implement and evaluate graph algorithms such as Kruskal's algorithm, Dijkstra's algorithm, and algorithms for NP-complete problems like the Chinese Postman problem.

Course Content:

UNIT-I: Kinematics (18 Hours) [2 Question]

Lagrangian and Eulerian methods, Equation of continuity in different coordinate systems, Boundary surfaces, Stream lines, Path lines and streak lines. Velocity potential, Irrotational and rotational motions. Vortex lines.

UNIT-II: Equations of Motion (18 Hours) [2 Question]

Lagrange's and Euler's equations of motion. Bernoulli's theorem. Equation of motion by flux method. Impulsive actions. Stream function, Irrotational motion.

UNIT-III: Complex Potential and Conformal Mapping (12 Hours) [1 Question]

Complex velocity potential. Sources, sinks doublets and their images in two dimension. Conformal mapping. Milne-Thomson circle theorem.

UNIT-IV: Flow Around Bodies and Applications (12 Hours) [1 Question]

Two-dimensional Irrotational motion produced by motion of circular, co-axial and elliptic cylinders in an infinite mass of liquid. Theorem of Blasius. Motion of a sphere through a liquid at rest at infinity. Liquid streaming past a fixed sphere. Equation of motion of a sphere.

Reference Books:

1. W. H. Besant,A. S. Ramsey (2006). *A Treatise on Hydro Mechanics Part II*. CBS Publ.
2. G. K. Batchelor (2000). *An Introduction of Fluid Mechanics*. Camb. UnIv. Press.
3. F. Choriton (1985). *Textbook of Fluid Dynamics*. C.B.S. Publishers.Delhi.
4. R. K. Bansal (2008). *A Text Book of Fluid mechanics*, Laxmi Publ.
5. M. D. Raisinghania (2003). *Fluid dynamics*, S Chand Publ.

III. CORE COURSE [CCMAT303]
ADVANCED ALGEBRA

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

By the end of this course, students will be able to:

1. Understand group actions, conjugacy, and apply Sylow theorems and solvability concepts in abstract algebra.
2. Analyze linear transformations using canonical forms and apply structural theorems in vector spaces.
3. Explore various types of field extensions and classify them based on algebraic properties.
4. Understand the structure of finite fields and apply Galois theory to study field automorphisms and extensions.

Course Learning Outcomes:

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

1. Apply class equations, orbit-stabilizer theorem, and Sylow theorems to determine properties of finite groups.
2. Represent linear transformations using matrices and reduce them to Jordan and diagonal forms using canonical methods.
3. Distinguish between algebraic and transcendental extensions and construct splitting and normal extensions.
4. Prove results about finite fields, find primitive elements, and apply the Fundamental Theorem of Galois Theory to field extensions.

Course Content:

Unit-I: Solvable Groups and Sylow Theorems (18 Hours) [2 Questions]

Finite permutation groups S_n and A_n, Group action, Conjugate class, Class equation, Orbit -stabilizer theorem, Sylow's theorems (proofs using group actions), Normal and Subnormal series, Composition Series, Jordan-Holder theorem, Solvable groups, Nilpotent groups.

Unit-II: Linear Algebra (12 Hours) [1 Question]

Matrix of a linear transformation, Canonical Forms – Similarity of linear transformations, Quadratic Forms, Invariant subspaces, Reduction to diagonal, triangular and Jordan forms, The primary decomposition theorem.

Unit-III: Field Extension (18 Hours) [2 Questions]

Extension fields, Finite extension, Algebraic and transcendental extensions, Splitting fields, Existence and uniqueness, Separable and inseparable extension, Normal extensions, Perfect fields.

Unit-IV: Finite Field (12 Hours) [1 Question]

Finite fields, Theorems on finite fields, Primitive elements, Algebraically closed fields, Automorphism of extensions, Galois extension, Fundamental theorem of Galois Theory.

Reference books:

1. D.S. Dummit and R.M. Foote (2003). *Abstract Algebra*. John Wiley & Sons.
2. I.N. Herstein (1975). *Topics in Algebra.* Wiley Eastern Ltd., New Delhi.
3. M. Artin (1991). *Algebra.* Prentice-Hall of India.
4. K. Hoffman and R. Kunze (1997). *Linear Algebra* (2nd edition). Prentice Hall of India, New Delhi.
5. N.S. Gopala Krishnan (2008). *University Algebra.* New Age Int. Publ.
6. William J Gilbert (2005). *Modern Algebra with Applications.* Wiley India.
7. K. B. Dutta (2004). *Matrix and Linear Algebra*. PHI.

IV. CORE COURSE [CCMAT304]

DIFFERENTIAL GEOMETRY AND TENSOR ANALYSIS

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	**Pass Marks: (MSE: 17 + ESE: 28) = 45**

(Credits: Theory-04, 60 Hours)

Course Objectives:

By the end of the course, students will be able to:

1. Understand the geometry of curves in space using curvature, torsion, and Serret-Frenet formulas.
2. Analyze curves and directions on surfaces through fundamental magnitudes and curvature concepts.
3. Study and describe one-parameter families of surfaces and curvature properties such as Gaussian curvature.
4. Gain foundational knowledge of tensor algebra and apply it to metric geometry and vector analysis.

Course Learning Outcomes:

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

1. Compute curvature, torsion, and osculating elements of space curves, and characterize special curves like helices and Bertrand curves.
2. Analyze curves on surfaces, determine principal curvatures and directions, and apply theorems such as Euler's and Dupin's.
3. Identify and construct envelopes and developable surfaces, and evaluate Gaussian curvature and properties of surfaces of constant curvature.
4. Perform basic tensor operations, including contraction and application of the quotient theorem, and compute angles using metric tensors.

Course Content:

UNIT-I: Curves in Space (18 Hours) [2 Questions]

Curvature and torsion. Serret-Frenet formula. Circular helix, the circle of curvature. Osculating sphere, Bertrand curves.

UNIT-II: Curves on a Surface (18 Hours) [2 Questions]

Curves on a surface-parametric curves. fundamental magnitude, curvature of normal section. Principal directions and principal curvatures, lines of curvature, Rodrigue's formula. Dupin's theorem, theorem of Euler, Conjugate directions and Asymptotic lines.

UNIT-III: Family of Surfaces (12 Hours) [1 Question]

One parameter family of surfaces – Envelope the edge of regression, Developables associated with space curves. Gaussian curvature, Surface of constant curvature.

UNIT-IV: Basics of Tensor (12 Hours) [1 Question]

Tensors, Tensor Algebra, Contraction, Quotient theorem. Metric Tensor, Angle between two vectors.

Reference Books:

1. C. E. Weatherburn (1955). *Differential geometry of three dimensions*. Cambridge University Press.
2. C.E. Weatherburn (1938). *Tensor calculus*. Cambridge University press.
3. R.S. Mishra (1965). *Tensor Calculus and Riemanian Geometry*. Pothishala Pvt. Ltd.

V. CORE COURSE [CCMAT305]

PARTIAL DIFFERENTIAL EQUATIONS

Marks: 30 (MSE: 20 Th. 1Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE :28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

By the end of the course, students will be able to:

1. Classify second-order partial differential equations and reduce them to canonical forms.
2. Derive and solve the heat and wave equations in one-dimensional Cartesian form.
3. Apply separation of variables and transform methods to solve standard PDEs.
4. Use Green's function and Laplace transform methods to solve boundary value problems.

Course Learning Outcomes:

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

1. Classify second-order PDEs and reduce them to their canonical forms using appropriate transformations.
2. Derive the one-dimensional heat and wave equations and find their fundamental solutions.
3. Solve partial differential equations using separation of variables, Fourier transform, and Laplace transform techniques.
4. Apply Green's function and Laplace transformation methods to solve boundary value problems arising in physical applications.

Course Content:

UNIT-I: Classification of 2nd order PDE & Laplace equation (18 Hours) [2 Questions]

Classification of second order PDE & reduction to Canonical forms, Fundamental solutions of two dimensional Laplace equation in Cartesian form.

UNIT-II: Heat equation (12 Hours) [1 Question]

Derivation and fundamental solution of one dimensional Heat equation in Cartesian form. Application problems.

UNIT-III: Wave equation (12 Hours) [1 Question]

Derivation and fundamental solution of one dimensional wave equation in Cartesian form. Application problems.

UNIT-IV: Integral Transforms and Green's function Methods of Solution (18 Hours) [2 Questions]

Solutions of PDE using Separation of variables, Fourier transform and Laplace transform, Green's function and solutions of boundary value problems using Laplace transformation.

Reference Books:

1. L.C. Evans (1998). *Partial Differential Equations*, Graduate Studies in Mathematics, Volume 19,AMS.
2. I.N. Sneddon (1972). *Use of integrals transforms*, McGraw Hill.
3. P. Prasad and R. Ravindran (1984). *Partial Differential equation*. Wiley Eastern Ltd.
4. K. Sankara Rao(2011). Partial diffential eqution, PHI.
5. E. Kreyszing (2011). *Advanced Engineering Mathematics*, John Wiley & Sons. .

SEMESTER II

I. ELECTIVE COURSE-A [ECMAT401A]
OPTIMIZATION TECHNIQUES

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

By the end of the course, students will be able to:

1. Understand and apply the dual simplex method to solve linear programming problems with infeasible initial solutions.
2. Analyze the impact of changes in the parameters of a linear programming problem through sensitivity analysis.
3. Study basic concepts of game theory and solve two-player zero-sum games using strategic and linear programming approaches.
4. Understand and analyze various queueing models and evaluate their steady-state performance measures.

Course Learning Outcomes:

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

1. Solve linear programming problems using the dual simplex method and compare its efficiency with the simplex method.
2. Perform sensitivity analysis to understand the effects of modifications in the objective function, variables, and constraints.
3. Formulate and solve two-person zero-sum games using maximin and minimax strategies, and apply linear programming techniques for games without saddle points.
4. Analyze M/M/1 and M/M/C queueing models (with and without capacity limitations) and compute key performance metrics.

Course Content:

UNIT-I: Dual Simplex Method (12 Hours) [1 Question]
Infeasible optimal initial solution, Dual simplex method, Its advantage over simplex method, difference between simplex and dual simplex method.

UNIT-II: Sensitivity Analysis (18 Hours) [2 Questions]
Changes in coefficients in the objective function, Changes in the structure of the LPP due to addition of new variable/Deleting of existing variable/ Addition of new constraints/Deletion of existing constraints.

UNIT-III: Theory Of Games (12 Hours) [1 Question]
Characteristics of game theory, maximin criteria and optimal strategy, solution of game with saddle points, Rectangular games without saddle points and its solutions by linear programming.

UNIT-IV: Queuing Theory (18 Hours) [2 Questions]
Basic characteristics of queueing system, different performance measures, Steady state solution of Markovian queueing models: M/M/1, M/M/1 with limited waiting space, M/M/C, M/M/C with limited waiting space.

Reference Books:

1. S.D.Sharma (1972). *Operation Research*, Kedar Nath, Ram Nath and Company.
2. H.A.Taha (2003). *Operations Research*, Prentice-Hall of India Private Limited.
3. R. K. Gupta (2023). *Operations Research*, Krishna Prakashan.

OR ELECTIVE COURSE-B [ECMAT401B]

INTEGRAL TRANSFORMS

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	**Pass Marks: (MSE: 17 + ESE: 28) = 45**

(Credits: Theory-04, 60 Hours)

Course Objectives:

By the end of the course, students will be able to:

1. Understand the definitions, convergence theorems, and applications of Laplace and Stieltjes transforms.
2. Study Fourier transforms and their properties, and apply them to solve problems involving integral equations and transforms.
3. Learn the fundamental concepts and properties of Mellin transforms and apply them to integral equations.
4. Explore the theory and applications of the Hankel transform and understand its relation to other transforms.

Course Learning Outcomes:

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

1. Apply Laplace and Stieltjes transforms to analyze functions, prove convergence results, and use inversion and convolution theorems.
2. Compute Fourier, cosine, and sine transforms, and apply Parseval's and inversion theorems to suitable problems.
3. Use Mellin transforms and their properties to evaluate transforms of derivatives and integrals and solve integral equations.
4. Evaluate Hankel transforms of elementary functions, apply inversion theorems, and relate Hankel transforms to Fourier transforms.

Course Content:

UNIT-I: Laplace and Stieltjes Transforms (17 Hours) [2 Questions]

Laplace Transform: Definition and convergence theorems, Absolute convergence, Uniform Convergence, Complex inversion formula. Convolution theorem, Tauberian Theorems. Stieltjes Transform: Definition and convergence theorem, Hardy and Littlewood theorem.

UNIT-II: Fourier Transforms (32 Hours) [1 Question]

Fourier Transform, Fourier Cosine Transform, Fourier Sine Transform, Conditions for existence of Fourier Transforms, Convolution Integral, Parseval's Theorem, Inversion Theorem.

UNIT-III: Mellin Transform (13 Hours) [1 Question]

Definition and elementary properties of Mellin transform, Mellin Transform of derivatives and integrals, The Mellin inversion theorem, Convolution theorems, solution of some integral equations via Mellin transform.

UNIT-IV: Hankel Transform (17 Hours) [2 Questions]

Definition and elementary properties of Hankel Transform, Inversion theorem, Transform of elementary functions, Transform of derivatives of functions, Parseval relation, Relation between Fourier and Hankel transform.

Reference Books:

1. D V Widder (1946). *The Laplace Transform*, Princeton Univ. Press.
2. Ian N. Sneddon (1979). *The use of Integral Transforms*, McGraw Hill.
3. Ian N. Sneddon (2010). *Fourier Transforms*, Dover Publications.
4. Loknath Debnath (2006). *Integral Transforms and their Applications*, Chapman and Hall/CRC; 2nd ed.

OR ELECTIVE COURSE-C [ECMAT401C]

STOCHASTIC PROCESS

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

By the end of the course, students will be able to:

1. Understand the core concepts and classifications of stochastic processes.
2. Learn the principles of Poisson processes, renewal theory, and Markov models.
3. Apply stochastic calculus methods including martingales and Brownian motion.
4. Gain an introductory understanding of fractional calculus in stochastic modeling.

Course Learning Outcomes:

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

1. Classify and describe the properties of various stochastic processes.
2. Solve applied problems using Poisson, renewal, and Markovian models.
3. Apply martingale theory and Brownian motion in stochastic problem-solving.
4. Explain basic fractional calculus concepts and their applications in stochastic processes.

Course Content:

UNIT–I: Stochastic Process (12 Hours) **[1 Questions]**

Introduction to Stochastic Process, Poisson Process: Homogeneous and Non-homogeneous Poisson Process, Compound and Conditional Poisson Processes. Moment Generating and Characteristic Functions. Lack of Memory and Hazard Rate Functions.

UNIT–II: Renewal Theory (12 Hours) **[1 Questions]**

Introduction to Renewal Theory, Wald's Equation, Important Renewal Theorem and its Applications, Alternating Renewal Processes, Age-Dependent Branching Processes, Delayed Renewal Processes, Renewal Reward Processes, Regenerative Processes, Stationary Point Processes.

UNIT–III: Markovian Chains (18 Hours) **[2 Questions]**

Introduction to Markov Chains, Chapman–Kolmogorov Equations with Classification of States, Transitions among Classes, Gambler's Ruin Problem and Mean Times in Transient States, Applications of Markov Chains, Time-Reversible Markov Chains, Semi-Markov Processes, Continuous-Time Markov Chains, Kolmogorov Differential Equations and Computation of Transition Probabilities, Time Reversibility, Stochastic Population Model.

UNIT–IV: Stochastic Calculus (18 Hours) **[2 Questions]**

Introduction to Stochastic Calculus, Martingales, Stopping Times, Azuma's Inequality for Martingales, Submartingales, Martingale Convergence Theorems, Introduction to Fractional Calculus, Introduction to Brownian Motion, Variations on Brownian Motion, Brownian Motion with Drift, Backward and Forward Diffusion Equations, Markov Shot-Noise Process, Stationary Processes.

Reference Books:

1. J. Medhi (2009). *Introduction to Stochastic Processes*. New Age International Publishers.
2. Sheldon M. Ross (2014). *Stochastic Processes*. Wiley India Pvt. Ltd.
3. Liliana Blanco Castañeda, Viswanathan Arunachalam, Selvamuthu Dharmaraja (2014). *Introduction to Probability and Stochastic Processes with Applications*. Wiley India Pvt. Ltd.
4. K. B. Oldham and J. Spanier (1974). *The Fractional Calculus: Theory and Applications of Differentiation and Integration to Arbitrary Order*, Academic Press.
5. Igor Podlubny (1999). *Fractional Differential Equations*, Academic Press.

II. ELECTIVE COURSE-A [ECMAT402A]

OPERATIONS RESEARCH

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

By the end of the course, students will be able to:

1. Learn methods for solving integer programming problems using branch-and-bound and cutting plane techniques.
2. Understand the theory and techniques of unconstrained and constrained nonlinear programming.
3. Explore deterministic and probabilistic inventory models for effective inventory management.
4. Apply project planning and control techniques using PERT and CPM for efficient time and resource management.

Course Learning Outcomes:

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

1. Solve integer programming problems using branch-and-bound and Gomory's cutting plane methods.
2. Apply Kuhn-Tucker conditions, and solve nonlinear and quadratic programming problems using Wolfe's and Beale's methods.
3. Formulate and analyze inventory models under known and probabilistic demand conditions.
4. Construct project networks, compute critical paths, and evaluate project schedules using PERT and CPM techniques.

Course Content:

UNIT-I: Integer Programming (18 Hours) [2 Questions]

Branch and bound technique, Gomory's cutting plane method.

UNIT-II: Non Linear Programming (18 Hours) [2 Questions]

One and multi variable, Unconstrained optimization, Kuhn-Tucker Conditions for costrained optimization, Quadratic programming, Wolf's and Beal's method.

UNIT-III: Inventory (12 Hours) [1 Question]

Known demand, probabilistic demand, Deterministic Models and probabilistic models without lead-time.

UNIT-IV: Project Planning and Control With PERT-CPM (12 Hours) [1 Question]

Rules of network construction, Time calculation in networks, Critical path method, PERT, PERT calculation, advantages of network (PERT/CPM), Difference between CPM and PERT.

Reference Books:

1. S.D.Sharma (1972). *Operation Research*, Kedar Nath, Ram Nath and Company.
2. H.A.Taha (2003). *Operations Research*, PHI,
3. R. K. Gupta, *Operations Research,* Krishna Prakashan.

OR ELECTIVE COURSE-B [ECMAT402B]

INTEGRAL EQUATIONS

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

By the end of the course, students will be able to:

1. Classify various types of integral equations and understand their relation to differential equations.
2. Explore analytical and numerical techniques for solving Fredholm integral equations.
3. Study and apply methods for solving Volterra integral equations using various approximation techniques.
4. Solve singular integral equations and analyze existence and uniqueness of solutions using fixed-point theory and transform methods.

Course Learning Outcomes:

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

1. Classify Fredholm, Volterra, integro-differential, and singular integral equations, and convert initial/boundary value problems into equivalent integral equations.
2. Solve Fredholm integral equations using decomposition methods, direct computation, successive approximation, and substitution techniques.
3. Apply Adomian decomposition, series solutions, and other iterative methods to solve Volterra integral equations, and compare the effectiveness of different methods.
4. Solve singular and generalized Abel-type integral equations, and analyze solution existence using fixed-point theorems and transform-based techniques such as Laplace and Fourier methods.

Course Content:

UNIT-I: Classification of Linear Integral Equations (13 Hours) [1 Question]

Fredholm, Volterra, Integro-Differential Equations, Singular Integral Equations, Converting Volterra Equation to ODE, Conversion of IVP to Volterra equation, Conversion of BVP to Fredholm equation.

UNIT-II: Fredholm Integral Equations (17 Hours) [2 Questions]

Decomposition method, Modified decomposition method, Direct Computation method, successive approximation method, method of successive substitutions, Homogeneous Fredholm Equations, Comparison between alternative methods.

UNIT-III: Volterra Integral Equation (17 Hours) [2 Questions]

Solution of VIE, Adomain Decomposition method, Modified Decomposition method, Series solution method, Successive Approximation method, Successive substitution method, Comparison between alternative methods.

UNIT-IV: Singular Integral Equations (13 Hours) [1 Question]

Abel problem, Generalized Abel Integral Equation, Existence and uniqueness of solutions using fixed-point theorems in case of Linear and nonlinear Volterra and Fredholm integral equations. Solution of Integral equations by Laplace, Fourier transforms methods.

Reference Books:

1. Murry R. Spiegal (1965). *Laplace Transform* (SCHAUM Outline Series), McGraw-Hill.
2. Abdul J. Jerri (1985). *Introduction to integral equations with applications*, Marcel Dekkar Inc. NY.
3. R. P. Kanwal (1997). *Linear Integral equations*, Springer Sc.
4. Harry Hochsdedt (1989). *Integral Equations*, John Wiley & Sons.

OR ELECTIVE COURSE-C [ECMAT402C]

MATHEMATICAL MODELING

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

By the end of the course, students will be able to:

1. Understand the fundamental concepts, types, and limitations of mathematical modeling.
2. Develop mathematical models using ordinary differential equations for dynamic systems.
3. Construct and analyze discrete models using linear difference equations.
4. Apply mathematical modeling techniques to problems in economics, finance, genetics, and population dynamics.

Course Learning Outcomes:

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

1. Identify real-world problems suitable for mathematical modeling and describe the classification and features of different models.
2. Develop and solve continuous-time models such as growth, decay, and compartmental systems using first-order differential equations.
3. Formulate and analyze discrete-time models using linear difference equations with constant coefficients.
4. Apply difference equation-based models to problems in economics, finance, genetics, and population dynamics.

Course Content:

UNIT-I: Introduction to mathematical modeling (12 Hours) [1 Question]

Simple situations requiring mathematical modeling, techniques of mathematical modeling, classifications, characteristics and limitations of mathematical models, some simple illustrations.

UNIT-II: Mathematical modeling through differential equations (18 Hours) [2 Questions]

Linear growth and decay models, nonlinear growth and decay models, Compartment models, Mathematical modeling in dynamics through ordinary differential equations of first order.

UNIT-III: Mathematical models through difference equations (18 Hours) [2 Questions]

Some simple mathematical models, basic theory of linear difference equations with constant coefficients

UNIT-IV: Application of mathematical modeling in economics, finance & genetics (12 Hours) [1 Question]

Mathematical modeling through difference equations in economics and finance, mathematical modeling through difference equations in population dynamics and genetics.

Reference Books:

1. J. N. Kapur (1998). *Mathematical Modeling*, Wiley Eastern.
2. D. N. Burghes (1980). *Mathematical modeling in social Management and Life Science*, Ellie Herwood and John Wiley.
3. F. Charlton (1965). *Ordinary Differential and Difference Equations*, Van Nostrand..

III. CORE COURSE [CCMAT403]
FUNCTIONAL ANALYSIS

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

By the end of the course, students will be able to:

1. Understand the structure and properties of normed linear spaces and Banach spaces.
2. Study bounded linear transformations, dual spaces, and fundamental theorems in functional analysis.
3. Explore inner product spaces, orthonormal systems, and properties of Hilbert spaces.
4. Analyze linear operators on Hilbert spaces, including self-adjoint, unitary, and positive operators.

Course Learning Outcomes:

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

1. Define and work with normed linear spaces, determine completeness, and compare equivalent norms.
2. Identify and analyze bounded linear transformations and dual spaces, and apply the Hahn-Banach, open mapping, and closed graph theorems.
3. Utilize orthonormal sets in Hilbert spaces and apply the Projection Theorem and Parseval's identity.
4. Evaluate different classes of operators in Hilbert spaces, such as adjoint, self-adjoint, unitary, and positive operators.

Course Content:

UNIT-I: Normed Linear Spaces (18 Hours) [2 Questions]

Normed Linear Space: Definition and Examples, NLS as a metric space, Open sets, closed sets etc in a NLS, Convergence and Continuity. Banach spaces and examples. Quotient space of normed linear spaces and its completeness, equivalent norms.

UNIT-II: Transformation on Linear Spaces (17 Hours) [2 Questions]

Bounded linear transformations, normed linear spaces of bounded linear transformations, dual spaces with examples. Hahn-Banach theorem Open mapping and closed graph theorem, the natural imbedding of N in N**. Reflexive spaces.

UNIT-III: Hilbert Space (13 Hours) [1 Question]

Inner product spaces. Hilbert spaces. Orthonormal Sets. Bessel's inequality. Complete orthonormal sets and Parseval's identity. Projection theorem. Rietz representation theorem Reflexivity of Hilbert spaces

UNIT-IV: Operators in Hilbert Space (12 Hours) [1 Question]

Linear transformation & linear functionals. Adjoint of an operator on a Hilbert space. Self-adjoint operators. Positive, normal and Unitary operators.

Reference Books:

1. G.F. Simmons (1983). *Topology and modern analysis* TMH.
2. G. Bachman and L. Narici (1966). *Functional Analysis*, Academic Press.
3. R.E. Edwards (1995). *Functional Analysis. Holt Rinehart and Winston*, Dover.
4. C. Goffman and G. Pedrick (1983). *First Course in Functional Analysis*, PHI.
5. E. Kreyszig (1989). *Functional analysis with application*, John Wiley and sons.

IV. CORE COURSE [CCMAT404]
NUMERICAL SOLUTIONS OF PDE

Marks: 30 (MSE: 20 Th. 1Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE :28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

By the end of the course, students will be able to:

1. Understand finite difference methods for solving parabolic partial differential equations (PDEs) in one space dimension and analyze their convergence and stability.
2. Apply implicit and alternating direction implicit (ADI) methods for solving parabolic PDEs in higher dimensions and in curvilinear coordinates.
3. Learn explicit and implicit schemes for solving hyperbolic PDEs in one and two space dimensions.
4. Develop numerical methods for solving elliptic equations and boundary value problems involving Laplace and biharmonic operators.

Course Learning Outcomes:

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

1. Formulate and implement two- and three-level explicit and implicit finite difference schemes for parabolic PDEs, and analyze their stability and convergence.
2. Apply ADI methods and handle nonlinear boundary value problems for second-order parabolic PDEs, including solutions in cylindrical and spherical coordinates.
3. Develop and analyze explicit and implicit numerical schemes for hyperbolic PDEs in one and two space dimensions, including first-order equations.
4. Solve elliptic PDEs numerically using difference approximations of Laplace and biharmonic operators, and address Dirichlet, Neumann, and mixed boundary conditions.

Course Content:

UNIT-I: Numerical solutions of parabolic PDE in one space (18 Hours) [2 Questions]

Two and three levels explicit and implicit difference schemes. Convergence and stability analysis.

UNIT-II: Numerical solutions of parabolic PDE of second order in two space dimension (18 Hours) [2 Question]

Implicit methods, alternating direction implicit (ADI) methods. Nonlinear initial BVP. Difference schemes for parabolic PDE in spherical and cylindrical cooprdinate systems in one dimension.

UNIT-III: Numerical solutions of hyperbolic PDE in one and two space dimension (12 Hours) [1 Questions]

Explicit and implicit schemes. ADI methods. Difference schemes for first order equations.

UNIT-IV: Numerical Solutions of some equations and Operators (12 Hours) [1 Question]

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

Note: *Use of Scientific calculator is allowed in the exam.*

Reference Books:

1. M. K. Jain, S. R. K. Iyenger and R. K. Jain (1994), *Computational Methods for Partial differential equations*, Wiley eastern.
2. M. K. Jain (1984). *Numerical solution of Differential Equations*, second edition, Wiley Eastern.
3. S. S. Sastry (2002). *Introductory methods of Numerical Analysis*, Prentice Hall India.
4. V. Griffiths and I. M. Smith (1993). *Numerical Methods of Engineers*, Oxford University Press.
5. F. General and P.O. Wheatley (1998). *Applied Numerical Analysis*, Addison-Wesley.
6. K E Atkinson (1989). *An Introduction to Numerical Analysis*, John Wiley & Sons.

V. PROJECT [PRMAT405]
DISSERTATION/ PROJECT/ TEACHING APTITUDE

Marks: 30 (MSE: 20 Viva + 5 Attd. + 5 Record) + 70 (ESE Pr: 6 Hrs) = 100	Pass Marks: = 45

(Credits: Theory-04, 120 Hours)

Guidelines for Dissertation / Project

1. **Types of Work Permitted**
   Students may undertake one of the following:
   a) **Theoretical Research Project**
      - Development of new theorems, proofs or methods.
      - Exploration or extension of existing mathematical results.
      - Critical review of advanced topics in pure or applied mathematics.

   b) **Computational / Experimental Mathematics Project**
      - Implementation of mathematical algorithms using tools such as Python, MATLAB, SageMath etc.
      - Simulation and numerical analysis for real-world or theoretical models.

   c) **Application-Oriented Project**
      - Mathematical modeling of problems in science, engineering, economics or social sciences.
      - Use of statistical, optimization or data analysis techniques for practical problem-solving.

2. **Approval of Topic**
   - The project/dissertation topic must be approved by the **Supervisor** or **Head of the Department.**
   - Topics should align with the student's area of specialization or interest.
   - Interdisciplinary topics are encouraged, provided there is substantial mathematical content.

3. **Project Team**
   - Work may be undertaken **individually** or in **groups of up to five students**.
   - In the case of group projects, individual contributions must be clearly indicated in the final report.

4. **Supervision & Monitoring**
   - A faculty supervisor will be assigned to each project/group.
   - Progress will be reviewed at **regular intervals** (as scheduled by the Supervisor).
   - Students are expected to maintain a project logbook or progress report.

5. **Structure of the Dissertation**
   A typical PG mathematics dissertation should follow this structure:
   - **Title Page**
   - **Certificate from Supervisor**
   - **Acknowledgements**
   - **Abstract** (300–500 words)
   - **Table of Contents**
   - **List of Figures / Tables (if applicable)**

   Chapter 1 – Introduction & Motivation

      - Problem statement
      - Motivation and relevance
      - Scope and limitations
   - **Chapter 2 – Literature Review**
      - Summary of existing work
      - Identification of research gaps
   - **Chapter 3 – Methodology**
      - Theoretical framework
      - Mathematical tools and techniques

    - Model development / Algorithm design
- **Chapter 4 – Results and Discussion**
    - Analytical or numerical results
    - Interpretation and implications
- **Chapter 5 – Conclusions and Future Scope**
- **References** (as per a recognized citation style, e.g., APA, AMS, IEEE)
- **Appendices** (if required)

6. **Evaluation Criteria**

The final project/dissertation will be evaluated under the following heads:

Project model (if any) and the Project record notebook	= 70 marks
Project presentation and viva-voce	= 30 marks

7. **Presentation & Viva-Voce**

- Each student/group must present their work to an evaluation panel.
- Presentations should include problem background, methodology, results, and conclusions.
- Viva-voce will assess both conceptual understanding and technical execution.

8. **Submission Requirements**

- Three hard-bound copies and one digital copy in PDF format.
- All codes, datasets and supplementary materials (if applicable) should be submitted alongside.

9. **Project Based on Special Paper**

- If the project is based on any one of the **special papers** studied, it should demonstrate the application of theory learned in that paper to a well-defined problem or case study.

Teaching Aptitude: Only selected candidates, in alternative to the Dissertation, may be provided duty to teach the assigned topics in selected colleges. The performance may be evaluated based on the organized feedback for the candidate.
