Department of Mathematics

School of Mathematics and Computer Sciences

Syllabus for M.Sc. Mathematics based on NEP 2020: NCrF/CUTN

(For those admitted in 2023 and later)

Central University of Tamil Nadu

Thiruvarur – 610 005

Department of Mathematics
School of Mathematics and Computer Sciences
Central University of Tamil Nadu, Thiruvarur

A. Vision

To be an internationally acclaimed Department of Mathematics for its teaching and research that also caters to the educational and occupational needs of the local community.

B. Mission

M1 - To provide a world class teaching and research infrastructure.
M2 - To promote professional working environment that supports innovative thinking and teamwork.
M3 - To inculcate the art of asking questions, formulating the problem, solving the problem and interpreting the solution for possible applications.

C. Programme Outcomes (PO)

PO1: Acquire basic knowledge on logic, tools and techniques for formulating problems in to a model.
PO2: Motivate the students to develop problem solving skills.
PO3: Ability to work in teams via group discussion and class room interaction.
PO4: Acquire skills to qualify competitive exams.
PO5: Enhance skills to develop critical thinking
PO6: Develop innovative skills, team work, leadership quality and ethical values
PO7: Students are directed towards lifelong learning through reading course and project

D. PO to Mission Statement Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
M1	1	1	1	1	1	1	1
M2	1	1	1	1	1	1	1
M3	1	1	1	1	1	1	1

E. Programme Specific Outcomes (PSO)

PSO1: Understand the abstract concepts in Algebra, Analysis and Geometry.
PSO2: Inculcate critical and analytical thinking to solve problems.
PSO3: Students are motivated towards inter disciplinary research.
PSO4: Focus on examinations like CSIR, GATE and NBHM etc., through assignments.
PSO5: Students are encouraged to do research in reputed institutions.
PSO6: Capable of solving real world problems independently.
PSO7: Communicate Mathematical concepts efficiently.
PSO8: Develop programming skills and problem solving skills to study the mathematical concepts effectively.

F. PO to PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
PO1	1	1	0	1	1	0	1	0
PO2	1	1	0	1	1	1	1	1
PO3	0	0	1	1	0	1	1	0
PO4	1	1	0	1	1	0	1	1
PO5	1	1	1	1	1	1	1	1
PO6	0	1	1	1	0	0	1	1
PO7	1	1	1	0	0	1	0	1

G. Course Structure

Semester	Course code	Course title	Type	Credits
I	MAT2011	Groups and Rings	Major	4
I	MAT2012	Analysis	Major	4
I	MAT2013	Advanced Linear Algebra	Major	4
I	MAT2014	Advanced Complex Analysis	Major	4
I	MAT2015	Ordinary Differential Equations	DSE	4
I	MAT2016	Discrete Mathematics	DSE	3
I	MATVA02	Advanced LaTex (or) Courses can be chosen from the Times Group (Online)	VAC	2 (Not included)
II	MAT2021	Field Theory	Major	4
II	MAT2022	Topology	Major	4
II	MAT2023	Measure and Integration	Major	4
II	MAT2024	Partial Differential Equations	Major	4
II	MAT2025	Multivariate Calculus	Major	4
II	MAT2026	Number Theory	Major	3
II	MATVA03	Research Methodology and Publication Ethics	VAC	2
		Total		**48**
For Students exiting after First year Post Graduate Diploma with 48 Credits				
Semester	**Course code**	**Course title**	**Type**	**Credits**
III	MAT2031	Functional Analysis	Major	4
III	MAT2032	Probability Theory	Major	4
III	MATSE02	*Computational Mathematics*	SEC	3
III	MATON02	MOOC/NPTEL/SWAYAM Course#	DSE	4
III	–	Elective 1	DSE	4
III	–	Elective 2	DSE	4
III	–	*Open Elective**	OE	3
IV	MAT2041	Project	Major	12
IV	MAT2042	Reading Course##	Major	4
IV	MATIN02	Internship**	Internship	2
		Total		**44**

* The course offered by other departments

\# Students should study an online course different from the curriculum in IX Semester, offer by MOOC/NPTEL/SWAYAM/e_Pathshala, etc.,

** Students should undergo Internship/Apprenticeship at the end of VIII semester for at least 2 weeks duration in an industry / Organization / Lab Training with faculty or researchers in their own or other HEIs / research institutions during the summer term. The Summer Internship report submitted by the student will be evaluated during the subsequent semester and the credit shall be accounted in the 10th semester.

\#\# Seminar based course with Presentation and Discussions

Courses	Major including DSE	VAC	Project	SEC	OE	Internship	Total
Actual credits	70	2	12	3	3	2	**92**

List of elective courses

Sl. No.	Course code	Course title	Credits
1	MATEC01	Mathematical Methods	4
2	MATEC02	Fluid Dynamics	4
3	MATEC03	Transformation Groups	4
4	MATEC04	Design & Analysis of Algorithms	4
5	MATEC05	Nonlinear Programming	4
6	MATEC06	Introduction to Lie Algebras	4
7	MATEC07	Advanced Partial Differential Equations	4
8	MATEC08	Differential Geometry	4
9	MATEC09	Delay Differential equations	4
10	MATEC10	Foundations of Geometry	4
11	MATEC11	Commutative algebra	4
12	MATEC12	Advanced graph theory	4
13	MATEC13	Mechanics	4
14	MATEC14	Discrete Dynamical Systems	4
15	MATEC15	Combinatorial Mathematics	4
16	MATEC16	Introduction to Game Theory	4

Open Electives

Sl. No.	Course code	Course title	Credits
1	MATOE01	Python for Sciences	3
2	MATOE02	Mathematics for the real World	3
3	MATOE03	History of Mathematics	3
4	MATOE04	Mathematics in Kolam	3

H. Evaluation Procedure

Evaluation is based on Internal Assessment and End Semester Examination. The Internal Assessment consists of the following components:

Internal Assessment Tests, Assignments, Practical, Project works, Quiz, seminar, open-book tests, viva voce and online tests via platforms Moodle, MOOCs, Google Classroom, etc.,

	Internal Marks	End Semester Marks	Total
Theory Courses	40	60	100
Practical Courses	Continuous Internal Assessment		100
Project	60	40	100
Reading Course	40	60	100

Internal Assessment evaluation pattern will differ from course to course for each semester. This will have to be declared to the students at the beginning of each semester.

I. Evaluation Scheme

Marks \ CO	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

J. Passing Minimum

For a pass in each theory course, a student should secure a minimum of 50% marks in the End Semester Examinations (ESE) and a minimum of 50% marks in aggregate (i.e., internal and ESE marks put together). For a pass in lab course, a student should secure 50% marks and for a pass in the Project, a student should secure a minimum of 50% marks in total.

K. Practical

The assessment of practical courses will be done on the basis of Continuous Internal Assessment consists of the students' performance in the laboratory, regular attendance, the number of experiments performed, on-time submission of observation and record notes, and written/viva-voce examinations.

L. Internship

Students should undergo Internship/ Apprenticeship for at least 2-weeks duration in an Industry / Organization / Lab Training with faculty or researchers in their own or other HEIs / research institutions during the summer vacation at the end of 8^{th} semester. The Summer Internship report submitted by the student will be evaluated during the subsequent semester and the credit shall be accounted in the 10^{th} semester. After completing the internship, the student has to submit the report of the internship forwarded/signed by the internship supervisor. Internal evaluation will be done by the committee consists of three faculty members from the department nominated by DRC.

Internship evaluation is done on the basis of Internal (25% based on the report and 25% based on the presentation given by the student in the Department) and External (60% by the supervisor from own or other HEIs).

M. Project

Students will carry out project work in the tenth semester on any one of the topics under the guidance of faculty or researchers in their own or other HEIs / research institutions. Finding an advisor who is willing to supervise the work of a student is solely the responsibility of the student. Preferably, the student should have identified a supervisor by the first week of the commencement of the final year. If the student wants to do project under an external guide from other HEIs/research institutions, the internal evaluation will be done by the committee consists of three faculty members from the department nominated by DRC. The evaluation of the Project work will be based on the dissertation and a Viva-Voce examination by project evaluation committee (PEC) consisting of the (internal) supervisor, an internal examiner (other than the supervisor) and an External/internal Examiner. The internal examiner and the external examiner shall be appointed by the supervisor. The dissertation work is evaluated under two categories

(i) Internal Assessment (IA), which is a continuous assessment and will be done by his/her supervisor
(ii) End semester Assessment, which involves evaluation of dissertation and viva voce, will be done by PEC members during Project viva.

Total marks allotted for Project is 100 marks with the following criteria

Internal Assessments	: 60%
End Semester Assessments	: 40%

The students are encouraged to publish their project work in a peer-reviewed journal/ Conference/ Seminar/ Patented.

N. Online Couse (MOOC/NPTEL/SWAYAM/e_Pathshala/etc.,)

A student should undergo one online course in 9^{th} semester (4 credit). Registration has to be done in the current semester along with other courses. The student has to choose the course from the list of online courses given by the department. The list of online courses opted by the students along with students' details, content, approval from the department shall be submitted to the Academic Section. Credits earned from a University, which offers the online course can be directly transferred to the respective programme of the candidate after getting due approval from Department and Academic Section. The student has to submit a copy of the course completion certificate to the department.

O. Question Paper Pattern for ESE

Part – A

Answer *ALL* the questions **(10 x 1 = 10 Marks)**

Question Nos: 1 to 10
TEN questions – TWO questions from each unit

Part – B

Answer *ALL the* questions **(5 x 3 = 15 Marks)**
Question Nos: 11-15
FIVE questions – ONE question from each unit with internal choice (either or type)

Part – C

Answer *ALL* questions **(5 x 7 = 35 Marks)**
Question Nos: 16-20
FIVE questions – ONE question from each unit with internal choice (either or type)

P. Eligibility Criteria for the Award of Diploma/ Degree

1. Students will be eligible for the award of **Post Graduate Diploma** in Mathematics after completion of First year of 2-year PG programme. The minimum credits required is 48.
2. Students who secure a minimum of 92 credits from the first and second years of the PG programme, with a minimum of 48 credits in the first year and a minimum of 44 credits in the second year of the programme, will be eligible for the award of **M.Sc. degree** in Mathematics.

SEMESTER – I

Subject Code: MAT2011 **Credits: 4**

Groups and Rings

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	have a thorough introduction to the subject	Remember/ Understand
CO 2	appreciate Sylow's theorems and its applications	Apply
CO 3	solve problems on conjugacy classes, Sylow's theory, field extensions and solvable groups	Analyze
CO 4	apply the results in other branches of mathematics in particular number theory	Evaluate
CO 5	have a detailed knowledge on ring, ideal, Noetherian and Artinian ring.	Create

Syllabus

Units	Content	Hrs.
I	Conjugacy classes, class equations, Cauchy's theorem for abelian groups, Sylow's theorem for abelian groups, Cauchy's theorem, number of conjugacy classes in S_n, conjugate of a subgroup.	12
II	Sylow's theorem, three parts of Sylow's theorem, applications of Sylow' theorem, Structure theorem for finite abelian groups (without proof). Composition series, Jordan-Holder theorem.	12
III	Semidirect product, nilpotent group, solvable group, group action, p-groups	12
IV	Rings, ideals, maximal ideals, prime ideals, nilradical, Jacobson radical.	12
V	Chain, ascending chain condition, descending chain condition, Noetherian ring, Artinian Ring.	12
	References: 1. I. N. Herstein, Topics in Algebra, 2nd Edition, John-Wiley & Sons, 1975. 2. D. S. Dummit and R.M. Foote, Abstract Algebra, Third Edition, Wiley, 2004. 3. N. Jacobson, Basic Algebra I, Second Edition, Dover, 2009. 4. M. Artin, Algebra, Prentice Hall India, 1996. 5. J. Rotman, Galois Theory, Springer, 1998. 6. M. F. Atiyah and I. G. MacDonald, Introduction to Commutative Algebra, Addison- Wesley, 1969.	

Mapping of Program Specific Outcomes with Course Outcomes

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	1	0	1	0	0	0	0
CO2	1	1	0	1	0	0	0	0
CO3	1	1	0	1	0	0	0	0
CO4	1	1	0	1	0	0	0	0
CO5	1	1	0	1	0	0	0	0

Subject Code: MAT2012 **Credits: 4**

Analysis

Course Outcome (CO)

On completion of the course the students will be able to

	Course outcome	Level
CO 1	learn and understand the basics of topological properties of metric spaces and convergent sequences, Cauchy sequences, convergence and absolute convergence of series, limit, continuity, differentiability and Rieman-Stieltjes integrability.	Remember/ Understand
CO 2	find or check the topological properties of the given sets, limit, continuity and differentiability of given functions, convergence of given sequences and series, and proof simple results on these topics.	Apply
CO 3	learn the detailed proofs of moderate results on the keywords mentioned above	Analyze
CO 4	learn the proofs of theorems on equivalence of compact sets, and theorems on connectedness and perfect sets, mean-value theorem, Taylor's theorem, various theorems on Riemann-Stieljes integrable functions.	Evaluate
CO 5	provide non-trivial examples and counter examples on Analysis, and learn the proofs of challenging theorems such as Heine-Borel theorem, L'Hospital's rule, and some big theorems on the other topics.	Create

Syllabus

Units	Content	Hrs.
I	(Recall Convergent series, examples, series of non-negative terms). The number e, rearrangements of series, Riemann theorem (without proof). Metric space, interior point, limit point, perfect set, Cantor set, Bolzano's theorem, Heine Borel theorem, Subsequential limits, limit infimum and limit supremum, and their properties.	12
II	Limits of functions between metric spaces, continuous functions, uniformly continuous functions, examples of continuous but not uniformly continuous functions, continuity and compactness, continuity and connectedness, discontinuities, monotone functions, infinite limits and limit at infinity.	12
III	Differentiable functions, local extremums, mean-value theorems, continuity of derivatives, L'Hospital's rule, Derivatives of higher order and Taylor's theorem, derivatives of vector valued functions.	12
IV	Riemann integration, Riemann - Stieltjes integration: the definition of the Riemann - Stieltjes integral, linear properties, integration by parts, change of variable in a Riemann - Stieltjes integral, reduction to a Riemann integral, Euler's summation formula, monotonically increasing integrators, upper and lower integrals, additive and linearity properties of upper, lower integrals, Riemann's condition, comparison theorems.	12
V	Integrators of bounded variation, sufficient conditions for the existence of Riemann-Stieltjes integrals, necessary conditions for the existence of Riemann-Stieltjes integrals, mean value theorems, integrals as a function of the interval, Second fundamental theorem of integral calculus, change of variable, second mean value theorem for Riemann integral, Riemann-Stieltjes integrals depending on a parameter, differentiation under integral sign, Lebesgue criterion for existence of Riemann integrals.	12

References.

1. W. Rudin, Principles of Mathematical Analysis, Wiley International Edition, 1985.
2. T. Apostol, Mathematical Analysis, Second Edition, Narosa Publishing House, 1985.
3. R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, Third Edition, Wiley International Student Edition, 2001.
4. K. A. Ross, Elementary Analysis: The theory of Calculus, Springer International Edition, Indian Reprint, 2004.

Mapping of Program Specific Outcomes with Course Outcomes

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	0	0	1	1	0	1	0
CO2	1	1	1	1	0	1	1	1
CO3	1	1	0	0	0	0	1	1
CO4	1	1	1	1	0	1	1	1
CO5	1	0	0	1	1	0	1	0

Subject Code: MAT2013 **Credits: 4**

Advanced Linear Algebra

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	**Level**
CO 1	understand the concepts of vector spaces, subspaces and linear transformations	Remember/ Understand
CO 2	appreciate the geometry of vector spaces using parallelogram law, Pythagorean theorem and triangle inequality	Apply
CO 3	know the relation between matrices and linear transformations	Analyze
CO 4	know the concepts of diagonalization, Jordan form and rational canonical form	Evaluate
CO 5	know the difference between various kind of modules like free, quotient and finitely generated modules and construct orthonormal space	Create

Syllabus

Units	**Content**	**Hrs.**
I	(Recall: Vector spaces and its properties, span and linear independence, bases, dimension), linear maps, null spaces and ranges, rank-nullity theorem, matrix of a linear map, invertibility, review of polynomials with complex and real coefficients, eigenvalues and eigenvectors, existence of eigenvalue, triangularization and diagonalization of linear transformations, invariant subspaces.	12
II	Inner-product spaces, Pythagorean theorem, triangle inequality, parallelogram law, orthonormal basis, Gram-Schmidt process, orthogonal projections and its properties, skew-symmetric transformations. linear functionals and hyperplanes, orthogonal transformations, definition of adjoint operator and its properties.	12
III	Operators on complex vector spaces, generalized eigenvectors, characteristic polynomial and Cayley Hamilton theorem, minimal polynomial, Jordan decomposition, Jordan form, rational canonical form.	12
IV	Modules, motivation to module theory, various rings and its importance, examples, comparison of modules and vector spaces, submodules, spanning set, linear independence, free modules.	12
V	Module homomorphism, quotient modules, isomorphism theorems, operations on submodules, direct sum, finitely generated modules. Noetherian modules.	12

References:

1. K. Hoffman and R. Kunze, Linear Algebra, Second Edition, Prentice Hall of India, 2003.
2. S. H. Friedberg, A. J. Insel and L. E. Spence, Linear Algebra, Fifth Edition, Pearson, 2018.
3. S. Axler, Linear Algebra Done Right, Second Edition, Springer, 1997.
4. D. S. Dummit and R. M. Foote, Abstract Algebra, Third Edition, Wiley, 2004.
5. S. Kumaresan, Linear Algebra - A Geometric Approach, Twelfth reprint, Prentice Hall of India, 2011.
6. G. Strang, Linear Algebra and its applications, Eighth Indian reprint Indian Edition, Cengage Learning, 2011.
7. I. N. Herstein, Topics in Algebra, Wiley Eastern Ltd., Second Edition, 2006.
8. C. W. Curtis, Linear Algebra, Springer 1984, Indian reprint, 2004.
9. P. M. Cohn, An introduction to Ring Theory, Springer,1999.
10. P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, Basic abstract algebra, Second Edition, Cambridge University Press, Indian Edition by Foundation Books, 1995.
11. P. R. Halmos, Finite Dimensional Vector Spaces, Springer,1974
12. S. Lang, Introduction to Linear Algebra, Second Edition, Springer, 2005.

Mapping of Program Specific Outcomes with Course Outcomes

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	1	1	1	0	0	1	0
CO2	1	1	1	1	0	0	1	0
CO3	1	1	1	1	0	0	1	0
CO4	1	1	1	1	0	0	1	0
CO5	1	1	1	1	0	0	1	0

Subject Code: MAT2014 **Credits: 4**

Advanced Complex Analysis

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand the concepts of complex integration, series expansion of a meromorphic function, infinite product expansion of an entire functions.	Remember/ Understand
CO 2	solve problems on complex integration.	Apply
CO 3	examine the proofs of Cauchy's theorems for rectangle for disc, Cauchy's integral formula.	Analyze
CO 4	discuss the proofs of Morera's theorem, Liouville's theorem, fundamental theorem of algebra.	Evaluate
CO 5	find the complex integrals, infinite sums and series using the Cauchy's residue theorem, Weierstrass theorem and Mittag-Leffler theorem.	Create

Syllabus

Units	Content	Hrs.
I	Quick review of complex derivative, partial derivative, C-R equations, power series. branch of log and some other functions, Cauchy's theorem for rectangle, rectangle theorem with exceptional points, exact differentiable form, Cauchy's theorem for disc, winding number, Cauchy's theorem for disc with exceptional points, Cauchy's integral formula, higher order derivatives.	12
II	Morera's theorem, Liouville's theorem, fundamental theorem of algebra, Removable singularities, Taylor's theorem, zeroes and poles, essential singularity, algebraic order of isolated singularity, local correspondence theorem, open mapping theorem, maximum modulus principle.	12
III	Simply connected region, Cauchy's theorem for simply connected region, homology, Cauchy's theorem for multiply connected region, residues, Argument principle, Rouche's theorem, evaluation of definite integrals (theory with proof).	12
IV	Harmonic function, mean-value property of harmonic function, Poisson's formula, Schwartz theorem, Reflection principle, Weierstrass theorem, Taylor's series and Laurent's series.	12
V	Partial fractions, Mittag-Leffler theorem, expansion of $\pi/\sin\pi z$, infinite products, canonical products, Gamma function, infinite product expressions for $\pi\cot\pi z$ and $\sin\pi z$, Jensen's formula, Poisson-Jensen's formula.	12

References:

1. L. V. Ahlfors, Complex Analysis, Third Edition, McGraw-Hill Inc.,1979.
2. J. Bak and D. J. Newmann, Complex analysis, Second Edition, Springer Indian Edition (SIE), 2009.
3. H. A. Priestley, Complex analysis, Second Edition, Oxford University Press, Indian Edition, 2006.
4. T. W. Gamelin, Complex analysis, Springer, 2004.
5. J. B. Conway, Functions of one complex variable, Second Edition, SISE, Narosa, 1996.
6. R. E. Greene and S. G. Krantz, Function Theory of One Complex Variable, Third Edition, American Mathematical Society, 2006.

Mapping of Program Specific Outcomes with Course Outcomes

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	1	1	1	1	1	1	1
CO2	1	1	1	1	0	1	1	1
CO3	1	1	0	1	0	0	1	1
CO4	1	1	0	1	0	0	1	0
CO5	1	1	1	1	1	1	1	1

Subject Code: MAT2015 **Credits: 4**

Ordinary Differential Equations

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	recognize the relation between linear algebra, analysis and differential equations	Remember/ Understand
CO 2	apply various methods to solve ordinary differential equations	Apply
CO 3	analyze the qualitative properties of solutions of differential equations	Analyze
CO 4	evaluate the solutions using separation of variables and Fourier series	Evaluate
CO 5	develop a method to distinguish singular and ordinary points in the higher order ordinary differential equations	Create

Syllabus

Units	Content	Hrs.
I	First-order differential equations, existence and uniqueness theorem, Picard's iteration (Theory and problems). second-order Linear equations with variable coefficients, reduction of order, Wronskian theory and linear dependence, non-homogeneous equations: method of variations of parameters (Theory and problems), method of judicious guessing (or method of undetermined coefficients).	12
II	Series solution: singular points, Euler equation, regular singular points - the method of Frobenius, Equal roots, and roots differing by an integer: Bessel equation, Legendre equation, Laguerre equation, Hermite equation, Chebschev equations, higher order equations.	12
III	System of differential equations: Algebraic properties of solutions of linear systemsm the eigenvalue-eigenvector method of finding solutions, complex roots, equal roots, fundamental matrix solutions, the non-homogeneous equations, variation of parameters, method of judicious guessing.	14
IV	Qualitative theory: Stability of linear system of ordinary differential equations, stability of equilibrium solutions, the phase-plane	12
V	Self-adjoint eigenvalue problems: Sturm-Liouville systems, eigenvalues and eigenfunctions, eigenfunction expansions	10
	References: 1. M. Braun, Differential Equations and their applications, Fourth Edition, Springer, 1993. 2. T. Myint-U, Ordinary Differential Equations, Elsevier, North-Holland, 1978. 3. S. L. Ross, Differential Equation, Fourth Edition, John Wiley & Sons, 1984. 4. A. K. Nandakumaran, P. S. Datti and R. K. George, Ordinary Differential Equations: Principles and Applications, Cambridge University Press, 2017. 5. G. F. Simmons, Differential Equations with Applications and Historical Notes, Tata Mc-Graw Hill, 1979. 6. E. A. Coddington, An Introduction to Ordinary Differential	

	Equations, Dover, 1961. 7. M. W. Hirsch, S. Smale and R. L. Devaney, Differential Equations, Dynamical Systems, and an Introduction to Chaos, Third Edition, Academic Press, 2013.	

c. Mapping of Program Specific Outcomes with Course Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	0	0	1	1	1	1	1
CO2	0	1	1	1	1	1	1	0
CO3	0	1	1	1	1	1	1	0
CO4	1	1	1	1	1	1	0	0
CO5	1	1	1	1	0	1	0	1

Subject Code: MAT2016 **Credits: 3**

Discrete Mathematics

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand recurrence relations, formal languages and grammars	Remember/ Understand
CO 2	understand symbolic logic, posets and lattices	Apply
CO 3	understand Boolean algebra	Analyze
CO 4	apply Boolean Algebra to switching theory	Evaluate
CO 5	understand finite state machines	Create

Syllabus

Units	Content	Hrs.
I	Partially ordered sets (posets), Hasse diagram of partially ordered sets, linear orders, linear extension of a partially ordered set, realizer and dimension of a poset.	9
II	Mathematical induction, strong induction and well ordering principle, recurrence relations and generating functions, some number sequences, linear homogeneous recurrence relations, non-homogeneous recurrence relations, generating functions, recurrences and generating functions, exponential generating functions.	9
III	Lattices as partially ordered sets, their properties, lattices as algebraic systems. sub lattices, direct products and homomorphism, some special lattices e.g. complete, complemented and distributive lattices.	9
IV	Boolean algebras as lattices, various Boolean identities, the switching algebra. example, subalgebras, direct products and homomorphism, joint-irreducible elements, atoms and minterms, Boolean forms and their equivalence, minterm Boolean forms, sum of products, canonical forms, minimization of Boolean functions, applications of Boolean algebra to switching theory (using and, or and not gates.) the Karnaugh method.	9
V	Finite state machines and their transition table diagrams, equivalence of finite state, machines, reduced machines, homomorphism, finite automata, acceptors, non-deterministic, finite automata and equivalence of its power to that of deterministic finite automata, Moore and Mealy machines.	9
	References. 1. J. P. Tremblay and R. Manohar, A first course in discrete structures with applications to computer science, Mcgraw Hill, 1987. 2. K. H. Rosen, Discrete Mathematics and its applications, Seventh Edition,Mcgraw Hill, 2011. 3. C. L. Liu, Elements of discrete mathematics, Mcgraw Hill, New York, 1978. 4. R. P. Grimaldi and B. V. Ramana, Discrete and combinatorial mathematics- an applied introduction, Pearson Education, 2004. 5. T. Sengadir, Discrete mathematics, Pearson Education, India, 2009.	

	6. J. E. Hopcraft and J. D. Ullman, Introduction to Automata Theory, Languages and Computation, Second Edition, Addison Wesley, 2001.	

Mapping of Program Specific Outcomes with Course Outcomes

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	0	1	1	1	1	1	1	1
CO2	0	1	1	1	1	1	1	1
CO3	0	1	1	1	1	1	1	1
CO4	0	1	1	1	1	1	1	1
CO5	0	1	1	1	1	1	1	1

Subject Code: MATVA02 **Credits: 2**

Advanced LATEX

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	**Level**
CO 1	understand packages, environment used in LATEX	Remember / Understand
CO 2	prepare report, paper and articles on their own	Apply
CO 3	distinguish between images and graphics	Analyze
CO 4	apply different packages to generate new document	Evaluate
CO 5	understand Finite state machines	Create

Syllabus

Units	**Content**	**Hrs.**
I	Recall basic LATEX - invoking AMS LATEX, standard features of AMS LATEX, further AMS LATEX packages, AMS fonts, other packages.	6
II	Preparation of research articles, project reports/thesis, slides, books, etc.	6
III	BibTEX program, creating, bibliographic data base, customizing bibliographic styles.	6
IV	Picture environment in LATEX, drawing packages, inserting images, graphics packages, adding color.	6
V	Structure of error messages, some sample errors, Warnings.	6
	References. 1. H. Kopka and P. W. Daly, A Guide to LATEX and electronic publishing, Fourth Edition, Addison-Wesley, 2004. 2. G. Grätzer, Math Into Latex, Third Edition, Birkhäuser Boston, 2000. 3. L. Lamport, A Document Preparation System, Second Edition, Addison-Wesley, 1994. 4. D. F. Griffiths and D. J. Higham, Learning LATEX, SIAM, 1997.	

Mapping of Program Specific Outcomes with Course Outcomes

CO /PSO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	0	1	1	0	1	1	1	1
CO2	0	1	1	0	1	1	1	1
CO3	0	1	1	0	1	1	1	1
CO4	0	1	1	0	1	1	1	1
CO5	0	1	1	0	1	1	1	1

SEMESTER II

Subject Code: MAT2021 **Credits: 4**

Field Theory

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand the concepts of field, Galois theory and solvable by radicals.	Remember / Understand
CO 2	appreciate spitting field, Galois theory, finite fields and their applications	Apply
CO 3	solve problems on roots of polynomials, Galois theory, field extensions and solvability by radicals	Analyze
CO 4	Find the dimension of the constructed extension fields	Evaluate
CO 5	have a detailed knowledge on Galois theory	Create

Syllabus

Units	Content	Hrs.
I	Fields, Field extensions, finite extension, algebraic extension, roots of polynomials, splitting field.	12
II	More about roots, simple extension, splitting field of a polynomial, Galois theory, Galois group, fixed field, theorem on symmetric polynomials, normal extension.	12
III	Fundamental theorem of Galois theory, ruler and compass construction, Abel's theorem.	12
IV	Finite fields, Wedderburn's theorem on finite division rings.	12
V	Solvability by radicals, a theorem of Frobenius, integral quaternions and the four-square theorem.	12
	References: 1. I. N. Herstein. Topics in Algebra (II Edition) Wiley Eastern Limited, New Delhi, 1975. 2. M. Artin, Algebra, Prentice Hall of India, 1991. 3. P. B. Bhattacharya, S.K. Jain, and S.R. Nagpaul, Basic Abstract Algebra (II Edition) Cambridge University Press, 1997. (Indian Edition) 4. I. S. Luther and I. B. S. Passi, Algebra, Vol. I -Groups (1996), Vol. II Rings, Narosa Publishing House, New Delhi, 1999 5. D. S. Malik, J. N. Mordeson and M. K. Sen, Fundamental of Abstract Algebra, McGraw Hill (International Edition), New York. 1997.	

Mapping of Program Specific Outcomes with Course Outcomes

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	1	0	1	0	0	0	0
CO2	1	1	0	1	0	0	0	0
CO3	1	1	0	1	0	0	0	0
CO4	1	1	0	1	0	0	0	0
CO5	1	1	0	1	0	0	0	0

Subject Code: MAT2022 **Credits: 5**

Topology

Course Outcome (CO)

On completion of the course the students will be able to

	Course outcome	Level
CO 1	understand the concepts of topology, basis, subbasis, subspace topology, open set, closed set, interior, closure, continuous function, homeomorphism, open map and quotient map.	Remember/ Understand
CO 2	find the applications of topology.	Apply
CO 3	identify the differences among the various separation axioms	Analyze
CO 4	discuss the proofs Urysohn's lemma, Tietze's extension theorem, Urysohn's metrization theorem, Tychnoff's theorem	Evaluate
CO 5	construct examples and counter examples of various topological properties	Create

Syllabus

Units	Content	Hrs.
I	Topological space definitions and examples, basis and subbasis, order topology, continuous functions, product topology, subspace topology, closed sets, closures, limit points, cluster (accumulation) points, interior and boundary of a set, metric topology, quotient topology.	12
II	Connectedness, components, locally connectedness, and path-connectedness and locally path-connectedness.	12
III	Compactness, tube lemma, compact subspaces of real line, characterization of compact metric spaces, locally compactness.	12
IV	Countability axioms, $T1$-spaces, Hausdorff spaces, regular spaces, completely regular spaces, Normal spaces, one-point compactification, Uryosohn's lemma and Tietze extension theorem.	12
V	Urysohn Metrization Theorem, Tychonoff's theorem, Stone-Cech ˇ Compactification (statement only).	12
	References. 1. J. R. Munkres, Topology, Second Edition, Prentice Hall of India, 2000. 2. G. F. Simmons, Introduction to Topology and Modern analysis, McGraw-Hill, 1963. 3. S. Kumaresan, Topology of Metric Spaces, Second Edition, Narosa Publishing, 2011. 4. K. D. Joshi, Introduction to General Topology, Second Edition, NewAge International Publishers, 1983. 5. M. A. Armstong, Basic Topology, Springer International Edition, 2005. 6. S. Willard, General Topology, Dover Publications, 2004.	

Mapping of Program Specific Outcomes with Course Outcomes

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	0	1	0	1	0	1	0
CO2	1	1	0	0	1	0	1	1
CO3	1	1	0	1	1	0	1	1
CO4	1	1	0	0	0	0	1	1
CO5	1	1	0	1	0	0	1	1

Subject Code: MAT2023 **Credits: 4**

Measure and Integration

Course Outcome (CO)

On completion of the course the students will be able to

	Course outcome	Level
CO1	understand the definition of outer measure, measurable sets and measurable functions, Lebesgue integrals of different types of functions, abstract measure on a measurable space and signed measure.	Remember / Understand
CO2	learn simple examples and proofs of simple theorems on these topics.	Apply
CO3	learn the proofs of moderate theorems on measurable sets, measurable functions, abstract measure spaces and signs measures.	Analyze
CO4	discuss the proofs of every interval is measurable, Fatou's lemma, monotone convergence theorem, dominated convergence theorem, Hahn decomposition theorem, Jordan decomposition theorem, Holder's and Minkowski's inequalities, and other moderate theorems on these topics.	Evaluate
CO5	provide challenging examples and counterexamples such as non measurable sets, measurable but not a Borel set, and learn the detailed proofs of various challenging theorems such as completeness of L^p -spaces, Radon-Nikodym theorem.	Create
CO6	understand the definition of outer measure, measurable sets and measurable functions, Lebesgue integrals of different types of functions, abstract measure on a measurable space, signed measure.	

Syllabus

Units	Content	Hrs.
I	Definition of Lebesgue outer measure of a subset of R and its properties, definition of a Lebesgue measurable set, the sigma-algebra of Lebesgue measurable sets, every interval is Lebesgue measurable, Cantor (ternary) set, the inner and outer regularity of Lebesgue measurable sets - Borel sigma algebra.	12
II	Lebesgue measurable functions on R, liminf and limsup of measurable functions, simple functions, any non-negative measurable function is the limit of an increasing sequence of simple functions, existence of non-measurable sets.	12
III	Lebesgue integrals of simple functions, non-negative measurable functions, any real valued measurable function, Fatou's lemma, monotone convergence theorem, dominated and bounded convergence theorems.	12
IV	Integral of series, Riemann integrability implies the Lebesgue integrability (statement only). Abstract measure theory: σ-algebra B of subsets of a set X, measurable space, measure space, integral of measurable functions over abstract measure space.	12
V	Signed measure, Hahn decomposition, Jordan decomposition, Lebesgue decomposition theorem, Radon-Nykodim theorem.	12

References:

1. G. de Barra, Measure theory and integration, Wiley Eastern Ltd., 1981.
2. H. L. Royden and P. Fritzpatric, Real Analysis, Fourth Edition, Pearson Education, 2010.
3. C. D. Aliprantis and O. Burkinshaw, Principles of Real Analysis, Third Edition, Academic Press, 1998.
4. I. K. Rana, Measure theory and Integration, Second Edition, Narosa Publishing, 2000.

Mapping of Program Specific Outcomes with Course Outcomes

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	0	0	1	0	1	0	0
CO2	1	1	1	1	0	1	1	1
CO3	1	1	1	1	1	1	0	1
CO4	1	1	0	1	1	0	0	1
CO5	1	1	1	1	1	0	1	1

Subject Code: MAT2024 **Credits: 4**

Partial Differential Equations

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand the relation between the theory and modelling in the problems arising in various fields, such as, economics, finance, applied sciences and etc.,	Remember/ Understand
CO 2	enhance their mathematical understanding in representing solutions of partial differential equations.	Apply
CO 3	classify the partial differential equations and transform into canonical form	Analyze
CO 4	determine the solution representation for the three important classes of Partial Differential Equations, such as Laplace, Heat and wave equation by various methods.	Evaluate
CO 5	formulate fundamentals of partial differential equations, like Green's function, maximum principles, Cauchy problem, to take a research career in the area of partial differential equations	Create

Syllabus

Units	Content	Hrs.
I	First-order partial differential equations, well-posed problems in the sense of Hadamard, geometrical interpretation of a first-order equation, Cauchy problem, method of characteristics, compatible systems, Jacobi's method. initial value problems.	14
II	Second order partial differential equations, genesis of second order partial differential equations, classification of second order partial differential equations in to hyperbolic, elliptic, and parabolic partial differential equations, canonical forms, Cauchy-Kowalewskaya theorem	10
III	Wave Equation: D'Alembert's formula, uniqueness, and stability of solutions to the initial value problem for one-dimensional wave equation, method of spherical means, Hadamard's method of descent. Duhamel's principle for solutions of the non-homogeneous wave equation, uniqueness using the energy method, Riemann method, separation of variables.	12
IV	Laplace equation: Green's identities, the uniqueness of solutions to Dirichlet and Neumann boundary value problems, fundamental solutions, mean value property, properties of harmonic functions, maximum principle and uniqueness, regularity, Liouville's theorem, Green's function for Dirichlet boundary value problem on upper half-space and ball. Energy method: Uniqueness, Dirichlet principle, separation of variables, Laplace and beam equations.	12
V	Heat equation: Fundamental solution. Cauchy problem for homogeneous heat equation. Duhamel's principle for non-homogeneous heat equation, maximum principle and uniqueness. Energy method: Uniqueness, backward uniqueness, separation of variables.	12
	References: 1. L. C. Evans, Partial Differential Equations, AMS, Second Edition, 2010. 2. T. Amaranath, An elementary course in partial differential equations, Narosa Publishing House, 2003.	

	3. T. Myint-U, and L. Debnath, Linear Partial Differential Equations for Scientists and Engineers, Fourth Edition, Birkhauser, 2007. 4. R. Mc Owen, Partial Differential Equations: Methods and Applications, Pearson Education, 2002. 4. F. John, Partial differential equations, Fourth Edition, Springer-verlag, New York, 1991. 5. Q. Han, A Basic Course in Partial Differential Equations, AMS, 2011.	

Mapping of Program Specific Outcomes with Course Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	0	1	1	1	1	1	1
CO2	1	1	1	1	1	1	1	1
CO3	1	0	1	1	0	0	0	0
CO4	1	1	1	1	0	1	0	1
CO5	1	1	1	1	1	1	1	1

Subject Code: MAT2025 **Credits: 4**

Multivariate Calculus

Course Outcome (CO)

On completion of the course the students will be able to

	Course outcome	Level
CO 1	understand the concepts of directional derivatives, total derivatives, multiple integrals and their properties.	Remember/ Understand
CO 2	solve problems using the Gauss, Stokes, and Divergence theorems	Apply
CO 3	examine the relations among the partial derivatives and total derivative, interchanging the order of the derivatives, interchanging the order of integrations.	Analyze
CO 4	discuss the proofs of Green's theorem, Stoke's theorem and Gauss divergence theorem.	Evaluate
CO 5	find examples to explain the differences between partial derivative, directional derivative and total derivative.	Create

Syllabus

Units	Content	Hrs.
I	Partial derivatives, directional derivative and total derivative of differentiable scalar valued (and vector valued) functions on R^n, total derivative expressed in terms of partial derivatives.	12
II	Jacobian matrix, chain rule, matrix form of the chain rule, mean value theorem for differentiable functions, a sufficient condition for differentiability, a sufficient condition for equality of mixed partial derivatives, Taylor's formula for functions from $R^n \rightarrow R$, Mean-value theorem and applications.	12
III	Higher order derivatives, interchanging order of derivatives, Taylor's theorem for scalar valued functions, inverse mapping theorem, implicit mapping theorem, extrema of real-valued functions of several variables.	12
IV	Multiple integrals, partitions of rectangles and step functions, double integral, double integral as volume, integrability of functions, applications to area and volume, Pappus's theorem, Green's theorem and its applications, change of variables and transformation formula.	12
V	Surface, fundamental vector product, area of a parametric surface, surface integrals, Stoke's theorem, curl, Gradient and divergence of a vector field, divergence theorem, line integrals, proofs of theorems of Gauss.	12
	References: 1. T. M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1996. 2. T. M. Apostol, Calculus Vol.2, Multi-Variable Calculus and Linear Algebra with Applications to Differential Equations and Probability, Second Edition, John Wiley & Sons, 1969. 3. W. Rudin, Principles of Mathematical Analysis, Wiley International Edition, 1985. 4. M. Spivak, Calculus on Manifolds, W. A Benjamin, New York, 1965. 5. C. Goffman, Calculus of Several Variables, A Harper International Student reprint, 1965.	

Mapping of Program Specific Outcomes with Course Outcomes

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	0	0	1	1	1	1	0
CO2	1	1	1	1	0	1	1	1
CO3	1	1	1	1	1	1	1	1
CO4	1	1	0	0	0	0	1	0
CO5	1	1	1	1	1	0	1	1

Subject Code: MAT2026 **Credits: 3**

Number Theory

Course Outcome (CO)

On completion of the course the students will be able to

	Course outcome	Level
CO 1	understand the concepts of divisibility of integers, fundamental theorem of arithmetic.	Remember/ Understand
CO 2	apply the notion of congruence, and its properties.	Apply
CO 3	examine the Dirichlet product of two arithmetic functions, Bell series and their properties.	Analyze
CO 4	solve problems on number theory.	Evaluate
CO 5	find the properties of Euler's totient function, Mobius function, Mangoldt function, Liouville's function, multiplicative functions, and completely multiplicative functions.	Create

Syllabus

Units	Content	Hrs.
I	Natural numbers, arithmetic and order properties, law of well ordering principle, induction principle, equivalence of well ordering and induction principle, integers-ring structure.	9
II	Divisibility, division algorithm, prime numbers, GCD and LCM, Bezout's identity. Euclid's algorithm, fundamental theorem of arithmetic. linear Diophantine equations.	9
III	Congruences, residue classes, arithmetic of congruences, Chinese remainder theorem.	9
IV	Congruences with a prime-power modulus, the arithmetic of Z_p, pseudoprimes and Carmichael numbers, solving congruences mod p^l.	9
V	Euler phi function. multiplicative functions, Euler's theorem and Fermat's theorem, group of units	9
	References. 1. G. A. Jones and J. M. Jones, Elementary Number Theory, Springer,1998. 2. D. Burton, Elementary Number Theory, Seventh Edition, McGraw Hill Science, 2010. 3. G. H. Hardy, E. M. Wright, R. H. Brown, J. Silverman and A. Wile, An Introduction to the Theory of Numbers, Sixth Edition, 2008. 4. M. Artin, Algebra, Prentice-Hall of India, 1994.	

Mapping of Program Specific Outcomes with Course Outcomes

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	1	0	1	1	1	1	0
CO2	1	1	1	1	1	1	1	0
CO3	1	1	1	1	1	1	1	0
CO4	1	1	1	1	1	1	1	0
CO5	1	1	1	1	1	1	1	0

Subject Code: MATVA03 **Credits: 2**

Research Methodology and Publication Ethics

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	**Level**
CO 1	understand an objective of doing research, research process, and various kinds of research	Remember / Understand
CO 2	perform literature reviews using the available databases	Apply
CO 3	have basic knowledge on qualitative research techniques and know the limitation of certain research methods	Analyze
CO 4	be familiar with the significance of research ethics and use of research ethics into the research process	Evaluate
CO 5	develop a quality research proposal and advanced critical thinking skills	Create

Syllabus

Units	**Content**	**Hrs.**
I	Objectives of research, types of research, research approaches, Importance of knowing how research is done, research process, criteria of good research. Literature review, finding a research problem, how to read research article (a case study), methods and processes for solving the problem.	6
II	Scientific misconducts: falsification, fabrication and plagiarism. Redundant publications: duplicate and overlapping publications, predatory publishers and journals, open access publications, use of plagiarism software and other open source software tools.	6
III	Web of Science, Science Citation Index (SCI), journal impact factors, h-index, g-index, i10 index, Math Review, E-Journals and books, search engines and databases, conference, symposium, workshop, presentation, lecture notes, proceedings, volumes, issues, referees, editors, authors, single author and many authors, first author, corresponding author, percentage of author's contributions.	6
IV	Writing the abstract, the literature review. The nature and varieties of thesis, characteristics of good thesis, the intellectual content of the thesis, layout of the thesis, structure and components of research reports, technical report writing and presentation in LATEX (a case study).	6
V	Mathematical writing, writing a paper, publishing a paper, writing and defending a thesis, procedure of submitting the thesis, the structure of the viva, defending the thesis, writing a talk, preparing a poster,	6
	References: 1. C. R. Kothari, Research Methodology: Methods and Techniques, New Age International, 1990. 2. S. G. Krantz, A Primer of Mathematical Writing, Second Edition, American Mathematical Society, 2017. 3. N. J. Higham, Handbook of Writing for the Mathematical Sciences, Society for Industrial and Applied Mathematics, 1998.	

Mapping of Program Specific Outcomes with Course Outcomes

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	1	1	1	1	1	1	1
CO2	1	1	1	1	1	1	1	1
CO3	1	1	1	1	1	1	1	1
CO4	1	1	1	1	1	1	1	1
CO5	1	1	1	1	1	1	1	1

SEMESTER III

Course Code: MAT2031 **Credit: 4**

Functional Analysis

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	explain the concepts of normed linear space, continuity of a linear map, L_p-space, Banach, Hilbert spaces, four pillars	Remember/ Understand
CO 2	demonstrate the convergence in the different types of spaces	Apply
CO 3	analyze the properties of different types of normed linear space	Analyze
CO 4	determine the linear functional in terms orthonormal basis	Evaluate
CO 5	obtain the open mapping theorem from closed graph theorem and vice-versa	Create

Syllabus

Units	Content	Hrs.
I	Normed Linear spaces, Banach spaces, X is complete iff $\{x : \|x\| \leq 1\}$ is complete, direct sum of Banach spaces, quotient space, l^n_p and l_p spaces (including the proof of Holder's and Minkowski's inequalities), $\|.\|_p \to \|.\|_\infty$ as $p \to \infty$, the spaces of continuous bounded functions C(X, **R**) and C(X, **C**).	12
II	Bounded linear transformations, equivalences of continuous linear transformations, norm of a bounded linear transformation and its properties, the space B(X, Y) bounded linear transformations, completenessof B(X,Y), equivalence of different norms on a space linear space, every linear transformation from a finite dimensional normed linear space is continuous, dual space (the space of continuous linear functionals), examples: duals of l^p and l_n^p, Hahn-Banach extension theorem (for both real and complex cases), applications of Hahn-Banach theorems.	12
III	Natural imbedding of X in X^{**}, reflexive spaces, l^n_p are reflexive, weak topology on X^*, strong topology on X^*, a Banach space is reflexive iff its closed unit sphere is compact in the weak topology, weak*-topology on X^*, closed unit ball in a normed linear space is always compact Housdorff in the weak*-topology, o pen mapping theorem, projections on Banach spaces, direct sums and projections, closed graph theorem, conjugate of an operator and its properties.	12
IV	Inner product spaces, Hilbert spaces, Cauchy-Schwartz inequality, l^n_2 and l_2 spaces, parallelogram law, closed convex set has a unique vector of minimum norm, polarization identity, Pythogorean theorem, orthogonal complement and its properties, best approximation of a closed subspace of a Hilbert space exists and it is in the orthogonal complement $H = M \oplus M^\perp$, for any closed subspace M, orthonormal sets, examples, Bessel's inequality, equivalences of orthonormal basis, Fourier series, Riezs representation theorem, Gram-Schmidt's orthogonalization process, conjugate space H^*.	12

V	Adjoint of an operator and its properties, self adjoint operator-positive operators and inequality on self-adjoint operators, normal and unitary operators, projections, spectral theorem for finite dimensional Hilbert spaces.	12
	References: 1. G. F. Simmons, Introduction to Topology and Modern analysis, McGraw-Hill, 1963. 2. B. V. Limaye, Functional Analysis, Second Edition, New Age International, 1996. 3. B. Bollabas, Linear Analysis, an introductory course, Cambridge University Press, 1994. 4. E. Kreyzig, Introductory Functional Analysis with applications, Wiley Classics Library, 2001. 5. M. Thamban Nair, Functional Analysis: A First Course, Prentice-Hall of India, New Delhi, 2002. 6. K. Saxe, Beginning Functional Analysis, Springer, 2002.	

Mapping of Program Specific Outcomes with Course Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	0	1	1	1	1	1	0
CO2	1	1	1	1	1	0	1	1
CO3	1	0	1	1	1	0	1	0
CO4	1	1	1	1	0	1	1	0
CO5	1	1	1	1	1	0	1	0

Subject Code: MAT2032 **Credits: 4**

Probability Theory

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand the concept of random variables and the probability distributions	Remember / Understand
CO 2	apply Poisson, Gamma, Chi-square and other distributions to solve real life problems	Apply
CO 3	compare discrete and continuous random variables	Analyze
CO 4	derive the probability density function, distribution function of various random variables, and derive the marginal and conditional distributions of bivariate random variables	Evaluate
CO 5	translate real-world problems into probability models	Create

Syllabus

Units	Content	Hrs.
I	Random experiments and probability sample space, sample points, events, axioms of probability, probability of union of events, sample spaces with equally likely outcomes, probability as a continuous set function.	12
II	Conditional probability and independence of events: motivation for conditional probability, shrinking of sample space when it is known that a certain event occurred, conditional probability, independence of events, independent events and disjoint events, bayes' theorem and posterior probabilities.	12
III	Discrete random variables: Definition, distribution, examples, probability mass function and distribution function, properties of a distribution function, expected value, variance of a random variable, Bernoulli, binomial, geometric and negative binomial distributions, Poisson distribution and hypergeometric distribution, distribution functions, means and variances of various distributions mentioned above, Poisson random variable as an approximation of binomial random variable.	12
IV	Continuous random variables: Probability density function and distribution function, examples, expectation and variance of continuous random variables, need they always exist (Cauchydistribution), uniform distribution, normal distribution, use of the table of probabilities of standard normal distribution, normal approximation of binomial distribution, exponential distribution, gamma, chi-square, beta and F-distributions, Weibull and Cauchy distributions, Chebychev's inequality and its applications.	12

V	Joint distribution of two or more random variables, joint distribution functions, examples, covariance between two random variables, independence of random variables, uncorrelatedness and independence, pairwise independence and mutual independence, sums of independent random variables, marginal and conditional distributions, conditional distribution: discrete and continuous cases, bivariate normal distributions, weak law of large numbers, statements of central limit theorem.	12
	References: 1. S. Ross, A first Course in Probability, Sixth Edition, PearsonEducation, 2006. 2. A. Dasgupta, Fundamentals of Probability: A First Course, Springer, 2010. 3. W. Feller, An introduction to Probability Theory and its Applications, Volume 1, Second Edition, Wiley, 1969. 4. R. V. Hogg, J. McKean and A.T. Craig, Introduction to Mathematical Statistics, Pearson Education, Sixth Edition, 2005.	

Mapping of Program Specific Outcomes with Course Outcomes

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	1	1	1	1	1	1	1
CO2	1	1	1	1	1	1	1	1
CO3	1	1	1	1	0	1	1	0
CO4	1	1	1	1	0	1	0	1
CO5	1	1	1	1	1	1	1	1

Subject Code: MATSE02 **Credits: 3**

Computational Mathematics

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	remember the finite difference formulae for derivatives	Remember/ Understand
CO 2	apply the basics of analysis to estimate error while solving partial differential equations numerically	Apply
CO 3	analyze the stability property of solutions of partial differential equations	Analyze
CO 4	evaluate the robustness of the algorithms and how fast the numerical results converge to the analytical solutions.	Evaluate
CO 5	design algorithms to solve scientific problems that cannot be solved exactly	Create

Syllabus

Units	Content	Hrs.
I	Introduction to finite differences: Finite difference approximations to derivatives, notations, finite difference method, linear problem with Dirichlet and non-Dirichlet boundary conditions, nonlinear problems.	9
II	Elliptic partial differential equations: Poisson equation on a rectangular domain, Dirichlet boundary conditions, non-Dirichlet boundary conditions, solving the discrete equation, relaxation methods, convergence analysis.	9
III	Parabolic partial differential equations: The heat equation with Dirichlet boundary conditions, forward, backward and Crank-Nicolson method, absolute stability.	9
IV	Parabolic partial differential equations: General parabolic equations, non-Dirichlet boundary conditions, stability analysis, problems in two spatial domains.	9
V	Hyperbolic partial differential equations: Advection equation, upwind differencing, stability analysis, MacCormack method, the wave equation, stability analysis	9
	References: 1. R. L. Burden and J. D. Faires, Numerical Analysis, Ninth Edition, Cengage Learning, 2011. 2. B. Bradie, A friendly introduction to numerical analysis, Pearson Education, 2007. 3. G. D. Smith, Numerical Solution of P.D.E., Oxford University Press, New York, 1995. 4. C. F. Gerald and P. O. Whestley, Applied Numerical Analysis, Seventh Edition, Pearson Education, 2008.	

Mapping of Program Specific Outcomes with Course Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	0	0	1	1	1	0	1
CO2	1	1	1	1	1	1	1	1
CO3	1	1	1	1	1	1	1	1
CO4	1	1	1	1	1	1	1	1
CO5	1	1	1	1	1	1	1	1

Elective Courses

Subject Code: MATEC01 **Credits:4**

Mathematical Methods

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand the idea about functional and its properties	Remember / Understand
CO 2	solve Fredholm, Volterra and singular integral equations	Apply
CO 3	analyze the Fredholm theory	Analyze
CO 4	determine the solutions of Brachistochrone problem, geodesics problems and isoperimetric problems	Evaluate
CO 5	formulate the knowledge of calculus of variation to solve a wide range of real-world problems of applied sciences	Create

Syllabus

Units	Content	Hrs.
I	Integral equation: Introduction, types of integral equations, integral equations with separable kernels, reduction to a system of algebraic equations, Fredholm alternative, an approximate method, Fredholm integral equations of the first kind, method of successive approximations, iterative scheme, Volterra integral equation, some results about the resolvent kernel, classical Fredholm theory - Fredholm's method of solution, Fredholm's first, second, third theorems (without proof).	12
II	Applications of integral equations: Application to ordinary differential equation, reduction of initial value problems and boundary value problems to integral equations, Green's function approach, singular integral equations, Abel integral equation.	12
III	Symmetric kernels: Introduction, fundamental properties of eigenvalues and eigenfunctions for symmetric kernels, s olution of a symmetric integral equation, Rayleigh-Ritz Method. (if time permits)	12
IV	Calculus of variations: Functionals, variation of a functional, Euler-Lagrange equation, necessary and sufficient conditions for extrema, functional dependent on higher-order derivatives, functional dependent on the function of several independent variables, variational problems in parametric form, sufficient condition for weak/storing extremum.	12
V	Direct methods in variational problems: Direct Methods, Euler's finite difference methods, The Ritz method, Kantorovich's method.	12

	References: 1. I. M. Gelfand and S. V. Fomin, Calculus of Variations, PrenticeHall, New Jersey, 1963. 2. F. B. Hildebrand, Methods of Applied Mathematics, Dover, NewYork, 1992. 3. F. G. Tricomi, Integral Equations, Dover Publications, 1985 4. L. Elsgolts, Differential Equations and the Calculus of Variations, MIR Publishers, Moscow, 1970. 5. Weinstock, Calculus of Variations, with Applications to Physics and Engineering, McGraw-Hill, New York, 1952. 6. R. P. Kanwal, Linear Integral Equations: Theory & Technique, Second Edition, Birkhäuser, 2013.	

Mapping of Program Specific Outcomes with Course Outcomes

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	0	0	1	0	1	1	0
CO2	1	1	1	1	1	1	1	1
CO3	1	1	1	1	0	1	1	0
CO4	1	1	1	1	1	1	1	1
CO5	1	1	1	1	1	1	1	1

Subject Code: MATEC02 **Credits: 4**

Fluid Dynamics

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO1	understand the basic properties and principles of viscous and non-viscous fluids	Remember/ Understand
CO2	derive and deduce the consequences of the governing equations of fluids	Apply
CO3	solve kinematics problems such as finding particle paths and streamlines	Analyze
CO4	understand the basic theorems of fluid mechanics and its applications	Evaluate
CO5	derive the boundary layer equations of some basic flows and its solutions	Create

Syllabus

Units	Content	Hrs
I	Kinematics of fluids in motion: Real and ideal fluids, coefficientof viscosity, steady and unsteady flows, isotropy. orthogonal curvilinear coordinates, velocity of a fluid particle, material local and convective derivative, acceleration, stress, rate of strain, vorticity and vortex line, stress analysis, relation between stress and rate of strain, streamline, path lines, streak lines, velocity potential, Eulerian and Lagrangian forms of equation of continuity., boundary conditions and boundary surfaces.	12
II	Equations of motion of a fluid: Pressure at a point in a fluid, Euler's equations of motion, momentum equations in cylindrical and spherical polar coordinates. conservative field of force, flows involving axial symmetry, equations of motion under impulsive forces, potential theorems.	12
III	In viscid flows: Energy equation, Cauchy's integrals, Helmholtz equations, Bernoulli's equation and applications, Lagrange's hydro-dynamical equations, Bernoulli's theorem and applications, Torricelli's theorem, trajectory of a free jet, pitot tube, venturi meter.	12
IV	Two dimensional and irrotational motion: Two-dimensional flows, stream function, complex potential, irrational and incompressible flow, complex potential for standard two-dimensional flows, Cauchy Riemann equations in polar form, magnitude of velocity, sources and sinks in two dimensions, problems. kinetic energy of liquid, theorem of Blasius, complex potential due to source.	12
V	Doublet in two dimensions, Milne Thomson circle theorem, flow and circulations, Stoke's theorem, Kelvin circulation theorem, kinetic energy of infinite liquid. kelvins minimum energy theorem, permanence if irrotational motion, vortex motion, dynamical similarity, boundary layer theory.	12
	References: 1. G. K. Batchelor, An Introduction to Fluid Dynamics, Cambridge University Press, 1993. 2. F. Chorlton, Text book of Fluid Mechanics, CBS Publishers, New	

	Delhi, 1985. 3. F. White, Viscous Fluid Flow, McGraw -Hill, 1991. 4. M. D. Raisinghania, Fluid Dynamics, S Chand, New Delhi, 2000.	

Mapping of Program Specific Outcomes with Course Outcomes

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	1	1	1	1	1	1	0
CO2	1	1	1	1	1	1	1	1
CO3	1	1	1	1	1	1	1	0
CO4	1	1	0	0	1	1	0	1
CO5	1	1	1	0	1	1	0	1

Subject Code: MATEC03 **Credits: 4**

Transformation Groups

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand Groups of bijections	Remember/ Understand
CO 2	be able to prove that the isometries the plane are given by translation, rotation, reflections and glide reflections.	Apply
CO 3	understand Affine and Projective Transformations	Analyze
CO 4	understand the standard methods of solving ODEs with the help of symmetries	Evaluate
CO 5	be able solve problems on these topics	Create

Syllabus

Units	Content	Hrs.
I	Revision of group theory: Homomorphism, quotient group, groups presented by generators and relations, group actions and orbits.	12
II	Affine transformations, Isometries in $\mathbf{R}^2$, translation, rotation, reflection, and glide reflection.	12
III	Projective space, projective transformations.	12
IV	Affine and projective coordinates.	12
V	Symmetries of Differential Equation: Ordinary differential equations, change of variables, The Bernoulli equation, point transformations, one-parameter groups, symmetries of differential equations, solving equations by symmetries.	12
	References: 1. S. V. Duzhin and B. D. Chebotarevsky, Transformation Groups for beginners, AMS, 2004. 2. T. T. Dieck, Transformation Groups, Walter de Gruyter, 1987. 3. N.V. Efimov, Higher Geometry, Mir publications, 1980.	

Mapping of Program Specific Outcomes with Course Outcomes

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	1	0	0	1	0	1	0
CO2	1	1	0	0	1	0	1	0
CO3	1	1	1	1	1	0	1	0
CO4	1	1	0	0	1	1	1	0
CO5	1	1	0	0	1	0	1	0

Subject Code: MATEC04 **Credits: 4**

Design & Analysis of Algorithms

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	**Level**
CO 1	study some of the basic and key techniques to analyze and design algorithms	Remember / Understand
CO 2	see the practical applications of algorithms and the impact of the same	Apply
CO 3	have hands on experience in conducting a few challenging scientific computing	Analyze
CO 4	develop real-life problem-solving capability	Evaluate
CO 5	connect the theory and computing	Create

Syllabus

Units	**Content**	**Hrs.**
I	Introduction to algorithms, lots of examples, recurrent relations and closed form solution, tools and techniques for summation, manipulation ofsum, floor and ceiling functions, finite and infinite calculus, problem solving using the tools	12
II	Number theory an applied perspective, divisibility, introduction to relations and functions, mod and congruence relation, application of congruence, independent residues.	12
III	Permutation, permutation of multi sets, combination, application of permutation and combination, combinatorial properties of permutations.	12
IV	Design and analysis of algorithms with examples like Euclid algorithm etc.,	12
V	Sorting, insertion sort, divide and conquer approach, merge sort, quicksort, asymptotics and analysis, complexity theory, polynomial time, complexity classes, class P, NP, NPC, reducibility, NP completeness problems, scientific computing with open-source R.	12
	References: 1. T. H. Cormen, C. E. Leiserson and R.L. Rivest, Introduction to Algorithms, Prentice Hall of India, New-Delhi, 2004. 2. S. Basse, Computer Algorithms: Introduction to Design and Analysing, Addison Wesley, 1993. 3. A. Levitin, Introduction to the Design and Analysis of Algorithms, Pearson Education Pvt. Ltd, New Delhi, 2003. 4. S. Sedgewick, Algorithms, Addison Wesley, 2011.	

Mapping of Program Specific Outcomes with Course Outcomes

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	1	1	1	0	1	1	1
CO2	1	1	1	1	0	1	1	1
CO3	1	1	1	1	0	1	1	1
CO4	1	1	1	1	0	1	1	1
CO5	1	1	1	1	0	1	1	1

Subject Code: MATEC05 **Credits: 4**

Nonlinear Programming

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	learn about convex sets and functions, characterization of convex functions.	Remember / Understand
CO 2	study the characterization of global optimality of a convex program.	Apply
CO 3	study the optimality conditions of linear and nonlinear programs.	Analyze
CO 4	appreciate the beauty of Lagrangian duality, weak and strong duality theorems.	Evaluate
CO 5	understand about the algorithmic maps and its convergence.	Create

Syllabus

Units	Content	Hrs.
I	Introduction to optimization problems (real life examples, constrained and unconstrained, convex and non-convex etc.,). Convex sets, convex hull, Caratheodory's theorem, separation theoremand Farka's lemma. (Standard fixed point theorems without proof after teaching Farka's lemma), convex functions, first and second derivative convexity characterizations, Euclidean(metric) projection on a convex set.	12
II	Necessary and sufficient conditions for local and global optimality of a feasible point, Weierstrass Theorem, definition of descent direction and a sufficient condition for descent direction.	12
III	Optimality conditions, definitions of normal cone, cone of feasible directions and tangent cone, relationship between these cones.optimality conditions based on these cones. Fritz John optimality conditions and KKT optimality conditions, different constraint qualifications (Abadie's CQ, Mangasarian-Fromovitz CQ, Slater CQ, Linear independence CQ) and their relationship with KKT optimality conditions.	12
IV	Lagrangian Duality: Lagrangian dual problem, examples to find the dual of a linear as well as nonlinear programming problems, Lagrange multipliers and its relation to global optimality, convexity of dual problem, duality gap and existence of Lagrange multipliers, global optimality conditions in the absence of duality gap, saddle point and global optimality, weak and strong duality theorems for convex programs, explained how these theorems work for linear and quadratic programming problems.	12

V	Definition of sub-gradient for a convex function, example of a dual problem with non differentiable objective, sub-gradient projection algorithm for convex problems, algorithms and algorithmic maps, examples of algorithms and algorithmic maps, Zangwill's convergence theorem (without proof).	12
	References: 1. O. Mangasarian, Nonlinear programming, Mc Graw-Hill Inc., 1969. 2. M. S. Bazaraa, H. D. Sherali and C. M. Shetty, Nonlinear programming, Wiley- Blackwell, 2006 3. N. Andreasson, A. Evgrafov and M. Patriksson, An Introduction to Continuous optimization, Springer, 2013.	

Mapping of Program Specific Outcomes with Course Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	1	1	1	1	1	1	1
CO2	1	1	1	1	1	1	1	1
CO3	1	1	1	1	1	1	1	1
CO4	1	1	1	1	1	1	1	1
CO5	1	1	1	1	1	1	1	1

Course Code: MATEC06 **Credit: 4**

Introduction to Lie Algebras

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	Understand the topological groups and its properties in general and to study the group of $GL_n(R)$ and its various subgroups and their topological properties.	Remember / Understand
CO 2	know various decompositions available for different matrix classes and its applications.	Apply
CO 3	Analyze the maps like exponential and logarithm of a matrix, its properties.	Analyze
CO 4	find linear Lie groups, its Lie algebras and Campbell-Hausdorff formula.	Evaluate
CO 5	learn Lie algebras and its representations, nilpotent, solvable Lie algebras and semi-simple Lie algebras.	Create

Syllabus

Units	Content	Hrs.
I	Review of the following: exponential and logarithmic functions of real and complex variables, inverse function theorem, triangularizability, diagonalizability and simultaneous diagonalizability of matrices,Jordan canonical form, Topology: Hausdorff topology, continuity,compactness and connectedness, Groups: Normal groups, homomorphism between groups, nilpotent and solvable groups, total derivatives and chain rule.	12
II	Topological Groups, the group $GL(n,R)$, Examples of subgroups of $GL(n,R)$, polar decomposition in $GL(n,R)$, the orthogonal group, Gram decomposition.	12
III	Exponential and logarithm of a matrix, total derivative of the exponential.	12
IV	Linear Lie groups: One parameter semigroups and subgroups, Lie algebra of a linear lie group, linear lie groups as sub-manifolds, Campbell-Hausdorff formula.	12
V	Lie algebras: Definitions and examples, nilpotent and solvable Lie algebras, semi-simple Lie algebras.	12
	References: 1. J. Faraut, Analysis on Lie Groups, Cambridge Studies in Advanced Mathematics, Cambridge University Press, Cambridge, 2008. 2. B. Hall, Lie Groups, Lie Algebras, and Representations, Springer International Publishing, Switzerland, 2015. 3. A. Baker, Matrix Groups: An Introduction to Lie Group Theory, Springer-Verlag, London, UK, 2002. 4. N. J. Higham, Functions of Matrices, SIAM, Philadelphia, 2008.	

Mapping of Program Specific Outcomes with Course Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	1	0	1	1	0	1	0
CO2	1	1	0	1	1	0	1	0
CO3	1	1	0	1	1	0	1	0
CO4	1	1	0	1	1	0	1	0
CO5	1	1	0	1	1	0	1	0

Subject Code: MATEC07 **Credits: 4**

Advanced Partial Differential Equations

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand the theory of weak solutions	Remember / Understand
CO 2	apply the theory of functional analysis to study weak solutions of PDEs	Apply
CO 3	analyze existence, uniqueness and regularity of solutions for PDEs	Analyze
CO 4	determine the necessary conditions for the existence of extremals	Evaluate
CO 5	develop the relation between nonlinear partial differential equations and calculus of variations	Create

Syllabus

Units	Content	Hrs.
I	Elliptic equation: Weak solution, Lax-Milgram theorem, energy estimates, regularity, maximum principles	12
II	Parabolic equation: Weak solution, existence and uniqueness, regularity, maximum principles	12
III	Hyperbolic equation: Weak solution, existence and uniqueness, regularity, propagation of disturbances	12
IV	Calculus of variation: Basic ideas, first variation, Euler-Lagrange equation, second variation, Systems: Null Lagrangians, Brouwer's fixed point theorem	12
V	Existence of minimizers: coercivity, lower semi continuity, convexity, weak solutions of Euler-Lagrange equations, systems.	12
	References: 1. L.C. Evans Partial Differential Equations, Second Edition, AMS, Providence, 2010. 2. S. Salsa Partial Differential Equations in Action: From Modelling to Theory, Springer, New Delhi, 2008. 3. S. Kesavan Topics in Functional Analysis and Applications, New Age International, New Delhi, 2008. 4. H. Brezis Functional Analysis, Sobolev Spaces and PDEs, Springer, New York, 2011.	

Mapping of Program Specific Outcomes with Course Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	1	1	1	1	1	1	1
CO2	3	3	3	1	1	1	1	1
CO3	3	2	2	1	1	2	1	1
CO4	3	2	3	1	1	3	1	1
CO5	3	2	3	1	1	2	1	1

Subject Code: MATEC08 **Credits: 4**

Differential Geometry

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand plane curves and their curvature	Remember/ Understand
CO 2	understand surfaces, tangents and normal	Apply
CO 3	understand Quadratic Surfaces	Analyze
CO 4	understand concepts related to curvature of surfaces	Evaluate
CO 5	be able to solve problems on these topics.	Create

Syllabus

Units	Content	Hrs.
I	Plane curves and space curves, Frenet-Serret formulae, global properties of curves, simple closed curves, the isoperimetric inequality, the Four Vertex theorem.	12
II	Surfaces in three dimensions, smooth surfaces, tangents, normals and orientability, quadric surfaces.	12
III	The first fundamental form, the lengths of curves on surfaces, isometries of surfaces, conformal mappings of surfaces, surface area, Equiareal maps and a theorem of Archimedes.	12
IV	Curvature of surfaces, the second fundamental form, the curvature of curves on a surface, normal and principal curvatures.	12
V	Gaussian curvature and the Gauss' Map, the Gaussian and the mean curvatures, the pseudo sphere, flat surfaces, surfaces of constant mean curvature, Gaussian curvature of compact surfaces, the Gauss' map.	12
	References: 1. A. N. Pressley, Elementary Differential Geometry, Springer, 2010. 2. T. J. Willmore, An Introduction to Differential Geometry, Oxford University Press, 1997. 3. D. Somasundaram, Differential Geometry: A First Course, Narosa, 2005.	

Mapping of Program Specific Outcomes with Course Outcomes

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	0	1	1	0	1	1	0
CO2	1	1	0	1	1	1	1	0
CO3	1	0	0	1	1	1	1	0
CO4	1	0	1	1	1	1	1	0
CO5	1	1	0	1	0	1	1	0

Subject Code: MATEC09 **Credits: 4**

Delay Differential Equations

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	be able to solve simple delay differential equations	Remember/ Understand
CO 2	be able to apply numerical techniques to delay differential equations	Apply
CO 3	understand infinite dynamical systems via the semi-group approach	Analyze
CO 4	be able to apply Hille-Yosida Theorem to show existence of solutions to delay differential equations	Evaluate
CO 5	understand stability of delay differential equations	Create

Syllabus

Units	Content	Hrs.
I	Review of system of ordinary differential equations, solution of nonlinear system as given by groups of operators, stability and asymptotic stability.	12
II	Solution of parabolic/hyperbolic equations as semigroups/ groups.	12
III	Backward Euler method as a motivation for Hille-Yoshida theorem without proof, existence for delay differential equations.	12
IV	Models involving delay differential equations: Population model, predator model with delay, logistics equations, pantograph equations.	12
V	Asymptotic stability of linear delay differential equations, Spectral theorem for compact linear maps, compact semi-groups, growth bounds.	12
	References: 1. J. Hale, Theory of Functional Differential Equations, Springer-Verlag, New York, 1997. 2. V. J. Arnold, Ordinary Differential Equations, Springer-Verlag, Berlin, 1982. 3. S. Kesavan, Topics in Functional Analysis and Applications, John Wiley & Sons, 1989.	

Mapping of Program Specific Outcomes with Course Outcomes

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	0	1	1	0	0	1	1	0
CO2	0	1	1	0	1	1	1	1
CO3	0	1	1	0	0	1	1	0
CO4	1	1	1	0	0	1	1	0
CO5	0	1	1	0	1	1	1	0

Subject Code: MATEC10 **Credits: 4**

Foundations of Geometry

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand the five groups of Axioms of Geometry	Remember/ Understand
CO 2	understand the compatibility and mutual independence of the axioms	Apply
CO 3	understand the theory of proportion	Analyze
CO 4	understand plane areas	Evaluate
CO 5	understand Desargues's h delay differential equations theorem	Create

Syllabus

Units	Content	Hrs.
I	The elements of geometry and the five groups of axioms, Group I: Axioms of connection Axioms of Order, Consequences of the axioms of connection and order, Axiom of Parallels (Euclid's axiom), Axioms of congruence, Consequences of the axioms of congruence, Axiom of Continuity (Archimedes's axiom).	12
II	Compatibility of the axioms, Independence of the axioms of parallels. Non-euclidean geometry, Independence of the axioms of congruence, Independence of the axiom of continuity. Non-archimedean geometry.	12
III	Complex number-systems, Demonstration of Pascal's theorem, An algebra of segments, based upon Pascal's theorem, Proportion and the theorems of similitude, Equations of straight lines and of planes	12
IV	Equal area and equal content of polygons, Parallelograms and triangles having equal bases and equal altitudes, The measure of area of triangles and polygons, Equality of content and the measure of area.	12
V	Desargues's Theorem, its demonstrations and applications.	12
	References. 1. D. Hilbert, The Foundations of Geometry, MJP Publishers, 1902. 2. S. Kumaresan and G. Santhanam, An Expedition to Geometry, Hindustan Book Agency, 2011. 3. N. V. Efimov, Higher Geometry, Mir publications, 1980.	

Mapping of Program Specific Outcomes with Course Outcomes

CO / PSO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	1	1	0	0	1	0	1	0
CO2	1	1	0	0	1	0	1	0
CO3	1	1	0	0	1	0	1	0
CO4	1	1	0	0	1	0	1	0
CO5	1	1	0	0	1	0	1	0

Course Code: MATEC11 **Credit: 4**

Commutative Algebra

Course Outcome (CO)

On completion of the course, the student will be able to

	Course Outcome	Level
CO 1	understand the difference between vector space over a field and module over a commutative ring.	Remember/ Understand
CO 2	apply some operations, obtain a new module from old the old ones.	Apply
CO 3	find the fraction rings and fraction modules from given the rings and modules	Analyze
CO 4	obtain a characterization for Noetherian A-module and Artinian A-module using submodules and the chain conditions.	Evaluate
CO 5	investigate the Hilbert's basis theorem for Noetherian ring of polynomials	Create

Syllabus

Units	Content	Hrs.
I	Commutative ring with unity, zero-divisors, nilpotent elements, nilradical Jacobson radical, modules, module homomorphism.	12
II	Submodules, quotient modules, operations on submodules, direct sum, finitely generated modules, Nakayama's lemma, exact sequences	12
III	Rings and modules of fraction local properties	12
IV	Chain conditions, Noetherian A-module and its characterization, Noetherian rings, Hilbert's basis theorem	12
V	Artinian A-modules and its characterization, Artinian rings	12
	References: 1. M. F. Atiyah and I. G. MacDonald, Introduction to Commutative Algebra, Addison- Wesley, Reading, 1969. 2. N. S. Gopala Krishnan, Commutative Algebra, Second Edition, University Press, 2015. 3. D. S. Dummit and R. M. Foote, Abstract Algebra, Third edition, Wiley, 2004.	

Mapping of Program Specific Outcomes with Course Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	0	1	1	1	0	1	0
CO2	1	1	1	0	1	0	1	0
CO3	1	1	1	0	1	0	1	0
CO4	1	1	1	0	1	0	1	0
CO5	1	1	1	0	1	1	1	0

Course Code: MATEC12 **Credit: 4**

Advanced Graph Theory

Course Outcome (CO)

On completion of the course, the student will be able to

	Course Outcome	Level
CO 1	understand the concept of maximum matching and perfect matching	Remember/ Understand
CO 2	demonstrate Euler tour and Hamiltonian cycle in graphs using a characterization of Eulerian graph properties of Hamilton graphs	Apply
CO 3	find a triangle free graph with arbitrarily large chromatic number	Analyze
CO 4	determine Euler formula for a planer graph in terms of its n, m, ϕ	Evaluate
CO 5	create a schedule for a tournament in a particular game using tournament of the di-connected graphs	Create

Syllabus

Units	Content	Hrs.
I	Matching, maximum matching, Berge theorem in maximum matching. Hall's theorem, perfect matching, Tutte theorem.	12
II	Eulerian graphs and its characterization, Vizing's theorem in edge Colourings, independent sets, Gallai's theorem, Ramsey theory	12
III	Turan's theorem, Brook's theorem in vertex colourings, Hajo's conjecture, subdivision of graphs, Mycielski's construction for triangle free graphs.	12
IV	Kuratowski's theorem, face colouring, characterization of face Colouring, Tait colouring, non Hamiltonian planar graphs.	12
V	Directed graphs, existence of directed path, tournament, disconnected tournament, Moon theorem, networks, Max-flow min-cut theorem.	12
	References: 1. J. A. Bondy and U. S. R. Murty, Graph Theory with Applications,North-Holland, 1982. 2. G. Chartrand, L. Lesniak and P. Zhang, Graphs and Digraphs, Fifth Edition, CRC press, 2011. 3. D. B. West, Introduction to Graph Theory, Second Edition, PHI Learning Private Ltd, New Delhi, 2011. 4. R. Balakrishnan and K. Ranganathan, A Text book of Graph Theory, Second Edition, Springer, 2012.	

Mapping of Program Specific Outcomes with Course Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	0	1	0	0	1	1	0
CO2	1	1	1	0	1	1	1	1
CO3	1	1	1	0	1	1	1	0
CO4	1	0	1	0	1	1	1	0
CO5	1	1	1	0	1	1	1	0

Course Code: MATEC13 **Credit: 4**

Mechanics

Course Outcome (CO)

On completion of the course, the student will be able to

CO	Course Outcome	Level
CO 1	understand constraints, Kepler Problem and inverse-Square Law of Force	Remember/ Understand
CO 2	apply advanced methods to complex central-force motion problems	Apply
CO 3	distinguish the concept of the Hamilton equations of motion and the principle of least action	Analyze
CO 4	compare the conservation theorems using Hamilton's and D Alembert's principle	Evaluate
CO 5	formulate the conditions of closed orbits in a motion	Create

Syllabus

Units	Content	Hrs.
I	Mechanics of system of particles, conservation theorems, conservative forces with examples, constraints, generalized co-ordinates. D'Alembert's principle, Lagrange's equations of motion, the forms of Lagrange's equations of motion for non conservative systems and partially conservative and partially non conservative systems, kinetic energy as a homogeneous function of generalized velocities, simple applications of the Lagrangian formulation.	12
II	Cyclic co-ordinates and generalized momentum conservation theorems, calculus of variation, Euler Lagrange's equation, first integrals of Euler Lagrange's equation, the case of several dependent variables, geodesics in a plane, the minimum surface of revolution, Brachistochrome problem, isoperimetric problems, problems of maximum enclosed area.	12
III	The central force problem, reduction to the equivalent one body problem, the equation of motion and the first integrals, the equivalent one-dimensional problem and classification of orbits, the virial theorem.	12
IV	The differential equation of the orbit, the integrable power law potentials, conditions for closed orbit, Betrand's theorem, the Kepler problem, the inverse square law of force, the motion in time in the Kepler problem, Laplace Runge Lenz vector.	12
V	Legendre transformation and the Hamilton equations of motion, cyclic coordinates and conservation theorem, Hamiltonian canonical equations of motion, derivation of Hamilton's equation from variational problem, the principle of least action, Jacobi's form of the least action principle.	12
	References: 1. H. Goldstein, Classical Mechanics, Addison Wesley, 2001. 2. J. R. Taylor, Classical Mechanics, University Science Books, 2005. 3. T. W. B. Kibbie and F. H. Berkshire, Classical Mechanics, Imperial College Press, 2004	

Mapping of Program Specific Outcomes with Course Outcomes

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	1	1	1	1	1	1	1
CO2	1	1	1	1	1	0	1	1
CO3	1	1	1	1	0	0	1	1
CO4	1	1	1	1	0	1	1	1
CO5	1	1	1	1	1	0	1	1

Course Code: MATEC14 **Credit: 4**

Discrete Dynamical Systems

Course Outcome (CO)

On completion of the course, the student will be able to

	Course Outcome	Level
CO 1	appreciate the basics of topological dynamics with the help of illustrous examples, understand that not only period three maps or chaotic, there are lot more using Sarkoviskii's theorem.	Remember / Understand
CO 2	discuss on the concept of attracting, repelling periodic points and understand the theory of bifurication and apply them.	Apply
CO 3	be well versed in Symbolic dynamics, get an expertise in topological conjugacy.	Analyze
CO 4	thoroughly understand Newton's method in the preview of DDS.	Evaluate
CO 5	appreciate complex dynamics, self similarity and Mendolbortt sets.	Create

Syllabus

Units	Content	Hrs.
I	Orbits, phase portraits, periodic points and stable sets, Sarkovskii's theorem.	12
II	Attracting and repelling periodic points, differentiability and its implications, parametrized family of functions and bifurcations, the logistic map.	12
III	Symbolic dynamics, devaney's definition of Chaos, topological conjugacy.	12
IV	Newton's method, numerical solutions of differential equations.	12
V	The dynamics of complex functions, the quadratic family and the Mandelbrot set.	12
	References 1. R. A. Holmgren, A First Course in Discrete Dynamical Systems, Springer Verlag, 1994. 2. R. L. Devaney, A First Course in Chaotic Dynamical Systems, Addison-Wesley Publishing Company, Inc. 1992.	

Mapping of Program Specific Outcomes with Course Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	1	0	1	1	0	1	0
CO2	1	1	0	1	1	0	1	0
CO3	1	1	0	1	1	0	1	0
CO4	1	1	0	1	1	0	1	0
CO5	1	1	0	1	1	0	1	0

Course Code: MATEC15 **Credit: 4**

Combinatorial Mathematics

Course Outcome (CO)

On completion of the course, the student will be able to

	Course Outcome	Level
CO1	understand the concept of permutations, combinations, inclusion-exclusion principle and Polya's theory	Remember / Understand
CO2	solve some combinatorial problems using inclusion-exclusion principle and Polya's theory	Apply
CO3	form recurrence relations from combinatorial problems	Analyze
CO4	solve the recurrence relations using different techniques	Evaluate
CO5	use combinatorial ideas to solve problems from other areas of Mathematics	Create

Syllabus

Units	Content	Hrs.
I	Permutations, combinations, distribution of distinct objects, distribution of non-distinct objects.	12
II	Generating functions for permutations, distributions of distinct objects into non-distinct cells, partitions of integer, elementary relations.	12
III	Recurrence relations, linear recurrence relations with constant coefficients, solution by the technique of generating functions, recurrence relation with two indices.	12
IV	The principle of inclusion and exclusion, general formula, derangements, permutations with restrictions on relative positions.	12
V	Polya's theory of counting, equivalence classes under a permutation group, equivalence classes of functions, weights and inventories of functions, polya's fundamental theorem.	12
	References: 1. C. L. Liu, Introduction to Combinatorial Mathematics, McGraw Hill Book Company, 1968. 2. M. Bona, A walk through combinatorics, Fourth Edition, World Scientific, 2017. 3. I. Anderson, A first course in combinatorial mathematics, Clarendon Press, 1974.	

Mapping of Program Specific Outcomes with Course Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	1	0	0	1	1	1	1
CO2	1	1	0	1	1	1	1	1
CO3	1	1	0	0	1	1	1	1
CO4	1	1	0	1	1	1	1	1
CO5	1	1	1	1	1	1	1	1

Course Code: MATEC16 **Credit: 4**

Introduction to Game Theory

Course Outcome (CO)

On completion of the course, the student will be able to

	Course Outcome	Level
CO 1	study real vector spaces and linear transformations on these spaces.	Remember/ Understand
CO 2	apply linear programming and the theory of duality for the linear programs.	Apply
CO 3	analyze the simplex method, its working principle and usingthe algorithm to find the optimal of both primal and dual problems.	Analyze
CO 4	understand two person zero-sum matrix games, existence Nash equilibrium/optimal strategies for such games.	Evaluate
CO 5	apply iterated elimination of dominated strategies(IEDS) procedure on a matrix game, formulate the problem of finding Nash equilibrium as a linear program and compute the optimal strategies using simplex method.	Create

Syllabus

Units	Content	Hrs.
I	Linear algebra: Vectors, scalar product, matrices, linear inequalities, solution of linear equations, real vector spaces of finite dimensions, linear transformations.	12
II	Convex sets and polytopes, convex cones, extreme vectors and extreme solutions for linear inequalities.	12
III	Linear programming: Example problems, formulation of linear programming problem, primal and dual problem, simplex method and its variations for solving linear programming problems, duality theorem.	12
IV	Two-person games: Examples, definitions and elementary theory, solutions of games, pure and mixed strategies, value of the game and optimal strategies, saddle point and minimax theorem, symmetric games, proof of fundamental theorem of games.	12
V	Solutions to matrix games: Relation between matrix games and linear programming, solving games by the simplex method, optimal strategies and solutions.	12
	References: 1. D. Gale, The Theory of Linear Economic Models, Mc Graw-Hill Book Company, London, 1990. 2. V. Chvatal, Linear Programming, W. H. Freeman and Company, 1983.	

Mapping of Program Specific Outcomes with Course Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	1	1	1	1	1	1	0
CO2	1	1	1	1	1	1	1	1
CO3	1	1	1	1	1	1	1	1
CO4	1	1	1	1	1	1	1	1
CO5	1	1	1	1	1	1	1	1

Generic Electives

Course Code: MATOE01 **Credit: 3**

Python for Sciences

Course Outcome (CO)

On completion of the course, the student will be able to

	Course Outcome	Level
CO 1	comfortably use Linux command line, VI editor and necessary basic commands of Linux. Python basics.	Remember / Understand
CO 2	use various data types in Python for storing list of items.	Apply
CO 3	write basic Python programs and functions using conditionals and loop structures.	Analyze
CO 4	write Python programs for various numerical algorithms.	Evaluate
CO 5	work with the Numpy and Scipy libraries.	Create

Syllabus

Units	Content	Hrs.
I	Introduction to linux commands and VI Editor, overview of installing and running Python, Python interpreter and IDLE, one more text editor GEANY. Simple commands to use Python as a calculator, Python 2.x vs Python 3.x, variables, statements, getting input from the user, functions, modules, running Python scripts from a command prompt. strings, concatenating strings, string representation, repr and str, input vs raw input, string conversions, methods S ¸find, join, lower, replace, split, strip, translate.	9
II	Lists, tuples and dictionaries, lists s ¸indexing, slicing, adding sequences, multiplication, membership, length, minimum and maximum, list operations and methods, tuple operations, creating and using dictionaries, dictionary operations, string formatting with dictionaries, dictionary methods.	9
III	Conditionals and loops, importing libraries, assignment, blocks, if statement, else and elif clauses, nesting blocks. while loops, for loops, iteration, breaking, else clauses in loops, printing and output formatting, format specifiers like align, sign, width, precision, type etc.,. file operations, Python shell error handling, Python exceptions: Try and Except function.	9
IV	Various programs related to basic mathematics followed by Bisection Method, Newton Raphson Method, Regula Falsi Method, Trapezoidal Rule for integration, Simpsons 1/3rd rule, Euler's method for ODE, RK method of ODE etc.,	9
V	Numpy and Scipy: Obtaining Numpy and Scipy libraries, using Ipython, Numpy basics, array creation, printing arrays, basic operations, universal functions, indexing, slicing and iterating, changing shapes, stacking and splitting of arrays, Matplotlib and plotting. Scipy: scipy.special, scipy.integrate, scipy.optimize, scipy.interpolate, scipy.fftpack, scipy.linalg, scipy.stats.	9

	References:	
	1. M. Dawson, Python programming for the absolute beginner, 3rd Edition, Course Technology, 2010. 2. K. V. Namboothiri, Python for Mathematics Students, Version 2.1,March2013. 3. (https://drive.google.com/openid=0B27RbnD0q6rgZk43akQ0MmRXNG8). 4. Numpy tutorial - https://www.numpy.org/devdocs/user/quickstart.html 5. Beginner's Guide to matplotlib - https://matplotlib.org/users/beginner.html 6. Scipy tutorial - https://docs.scipy.org/doc/scipy/reference/tutorial/index.html	

Mapping of Program Specific Outcomes with Course Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	0	1	1	0	1	1	0	1
CO2	0	1	1	0	1	1	0	1
CO3	0	1	1	0	1	1	0	1
CO4	0	1	1	0	1	1	0	1
CO5	0	1	1	0	1	1	0	1

Subject Code: MATOE02 **Credits: 3**

Mathematics for the Real World

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand the concept of abstract mathematics.	Remember/ Understand
CO 2	apply simple tricks to write simple equations to solve puzzles mathematically	Apply
CO 3	critically analyze the effectiveness of mathematics in the real world	Analyze
CO 4	evaluate the preciseness and beauty of mathematical concepts that brings out elegant application to real life.	Evaluate
CO 5	see and recognize applications of mathematics in real life situations	Create

Syllabus

Units	Content	Hrs.
I	Mathematics and Mathematicians; what do they do? What is abstraction of ideas? From puzzles to abstract structures, the modulo arithmetic and Chinese reminder theorem.	9
II	Applications of calculus in real world problems; examples and case studies for applications of continuity of functions, integration and convergence.	9
III	Applications of linear algebra; operation research problems from industries; case study on problems from paper industry and PCB board manufacturing.	9
IV	Maxima and minima of functions, Dido's problem, a problem from optics, shortest path taken by light.	9
V	Probability and the gambler's ruin problem, Statistics and its applications in real world, Elections, election procedure, exit polls after an election; application of statistics in pharmaceutical industry etc.,.	9
	References: 1. D. M Burton, Elementary Number Theory, Mc Graw Hill, 2017. 2. V. M. Tikhomirov, Stories about maxima and minima, AMS MAA, 1990. 3. G. S. R. Murthy, Applications of Operations Research and Management Science - Case Studies, Springer - 2015. 4. K. G. Murthy, Case Studies in Operations Research Applications of Optimal Decision Making, Springer, 2015. 5. J. K. Hodge, and R. E. Klima, The Mathematics of Voting and Elections: A Hands-On Approach, AMS, 2018.	

Mapping of Program Specific Outcomes with Course Outcomes

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	0	0	1	0	1	0	1	0
CO2	0	0	1	0	1	0	1	0
CO3	0	0	1	0	1	0	1	0
CO4	0	0	1	0	1	0	1	0
CO5	0	0	1	0	1	0	1	0

Subject Code: MATOE03 **Credits: 3**

History of Mathematics

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	know the of contributions to mathematics by different ancient and modern civilizations	Remember/ Understand
CO 2	know about the development of Euclidean and non-Euclidean Geometry	Apply
CO 3	appreciate the contribution of Indians in the fields of Mathematics	Analyze
CO 4	develop gender sensitiveness by learning about the contributions of woman mathematicians	Evaluate
CO 5	appreciate the traditional knowledge of astronomy by Indian	Create

Syllabus

Units	Content	Hrs.
I	Development of Euclidean geometry and non-Euclidean geometries	9
II	The stories of π, e and i .	9
III	Mathematics in different cultures (with special emphasize on Indian Astronomy).	9
IV	Indian Mathematics - Study of Kanakkathikaram and Lilavathi, Ramanujan's contributions; Women Mathematicians - Emmy Noether.	9
V	Development of Modern Mathematics: Hilbert's 23 problems, Gödel's incompleteness theorem, Turing Machine.	9
	References. 1. G. G. Joseph, Crest of the peacock, Third Edition, Princeton University Press, Princeton, 2011. 2. E.T. Bell, Men of Mathematics, Touchstone; Reissue edition, 1986. 3. G. Gamow, One, Two, Three...Infinity: Facts and Speculations of Science, Dover Publications Inc., 1989.	

Mapping of Program Specific Outcomes with Course Outcomes

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	0	0	1	0	1	0	1	0
CO2	0	0	1	0	1	0	1	0
CO3	0	0	1	0	1	0	1	0
CO4	0	0	1	0	1	0	1	0
CO5	0	0	1	0	1	0	1	0

Subject Code: MATOE04 **Credits: 3**

Mathematics of Kolam

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand mathematical concepts such as sequence, self-similarity, closed curve, graph and symmetry used in Kolam	Remember/ Understand
CO 2	draw Kolam without lifting the hand	Apply
CO 3	apply the idea of reflection, rotation and translation, and form new Kolam	Analyze
CO 4	find relation between Kolam and number points in Kolam by using the parameters in Mathematics	Evaluate
CO 5	construct a very big self-similarity structure like space filling curves	Create

Syllabus

Units	Content	Hrs.
I	Some simple kolams, odd numbers and even numbers (Ner Pulli, Idaip Pulli)	9
II	Sequence of Kolams, building a big structure by self similarity, connection to fractals.	9
III	The idea of a simple closed curve, Kolams which can be drawn without lifting the pencil.	9
IV	Connection between graph Theory and Kolams: Eulerian and Hamiltonian graphs.	9
V	The ideas of symmetry: reflection, rotation, translation.	9
	References: 1. https://vindhiya.com/Naranan/Fibonacci-Kolams/Microsoft%20Word%20-%20Intro%20for%20Webpage-091108-ss2.pdf 2. https://www.youtube.com/watch?v=E_9FtRvGcs0 3. R. Chaki, How an Ancient Indian Art tilizes Mathematics, Mythology, and Rice.	

Mapping of Program Specific Outcomes with Course Outcomes

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	0	0	1	0	1	1	1	0
CO2	0	0	1	0	1	1	1	0
CO3	0	0	1	0	1	1	1	0
CO4	0	0	1	0	1	1	1	0
CO5	0	0	1	0	1	1	1	0