Department of Mathematics

School of Mathematics and Computer Sciences

Syllabus for Four year B.Sc. in Mathematics (Honours / Honours with Research)

based on Curriculum and Credit Framework for Undergraduate Programmes & NEP 2020

(For those admitted in 2025 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	MAT5011	Calculus	Core	3
I	MAT5012	Basic Computing Lab	Core	2
I	–	*Physics and Lab*	Minor	3+2
I	–	*Open Elective**	OE	3
I	–	*Language*	AECC	3
I	–	*Cyber Security*	SEC	2
I		*Environmental Science*	VAC	3
			TOTAL	**21**
II	–	*Biology and Lab*	Minor	3+2
II	–	*Chemistry and Lab*	Minor	3+2
II		*Open Elective**	OE	3
II	–	*Language*	AECC	3
II	–	*Disaster Risk reduction*	SEC	2
II	-	*Constitutional Values*	VAC	3
			TOTAL	**21**
			Cumulative Total	**42**
II	MAT5021	Calculus [@]	Minor	3
II	MAT5022	Basic Computing Lab [@]	Minor	2
For students exiting after one year (Certificate in Science)				
II	**-**	**Skill Development of the Youths and their Livelihood (NPTEL)**	**VOC**	**4**
[@] For Chemistry and Biotech students				
SECOND YEAR				
III	MAT5031	Differential Equations and Integral Transforms	Core	3
III	MAT5032	Scientific Computing Lab	Core	2
III	–	Physics	Minor	3
III	–	Chemistry	Minor	3
III	–	*Open Elective**	OE	3
III	–	*Language*	AECC	3
III	MATSE01	*Set Theory and Logic*	SEC	2
III		*Yoga and Fitness*	VAC	2
			TOTAL	**21**

IV	MAT5041	Group Theory	Core	4
IV	MAT5042	Sequences and Series	Core	4
IV	MAT5043	Probability and Statistics	Core	4
IV	MAT5044	Vector Calculus	Core	3
IV	MATSE02	Numerical Methods	SEC	3
IV	–	*Language*	AECC	3
IV		*NSS/NCC/PHS/etc.,**	Extension	1*
			TOTAL	**21**
			Cumulative Total	**84**
For students exiting after two year (Diploma in Science)				
IV	**-**	**Skill Development of the Youths and their Livelihood (NPTEL)**	**VOC**	**4**
THIRD YEAR				
V	MAT5051	Linear Algebra	Core	4
V	MAT5052	Real Analysis	Core	4
V	MAT5053	Optimization Techniques	Core	4
V	MAT5054	Number Theory	Core	4
V	MAT5055	Combinatorial Mathematics	Core	3
V	-	MOOC/NPTEL/SWAYAM Course#	DSE	3
V	-	Elective	DSE	3
			TOTAL	**25**
VI	MAT5061	Ring Theory	Core	4
VI	MAT5062	Complex Analysis	Core	4
VI	MAT5063	Graph Theory	Core	4
VI	MAT5064	Ordinary Differential Equations	Core	4
VI	-	Elective	DSE	4
VI	MATIN01	Internship**	Internship	2
			TOTAL	**22**
			Cumulative Total	**131**

For Students exiting after three years (Bachelor's Degree (B.Sc.) should earn 131 credits

Students who secure 75% marks and above in the first six semesters and wish to undertake research at the undergraduate level can choose a research stream in the fourth year. They should do a research project or dissertation under the guidance of a faculty member of the University/College. The research project/dissertation will be in the major discipline.

FOURTH YEAR

Semester	Course code	Course title	Type	Credits
VII	MAT5071	Algebra	Core	4
VII	MAT5072	Analysis	Core	4
VII	MAT5073	Ordinary and Partial Differential Equations	Core	4
VII	MAT5074	Topology	Core	4
VII	MAT5075	Elective	DSE	3
VII	-	MOOC/NPTEL/SWAYAM Course#	DSE	3
			TOTAL	**22**

				R	H
VIII	MAT5081	Field Theory	Core	4	4
VIII	MAT5082	Functional Analysis	Core	4	4
VIII	MAT5083	Multivariate Calculus	Core	-	4
VIII	MAT5084	Mini Project	Project	-	8
	MAT5085	Project	Project	12	-
			TOTAL	**20**	**20**
			Cumulative Total	**173**	**173**

1. Students who wish to complete with **4-Year B.Sc. Mathematics (Honours)** have to complete 3 Major courses (MAT5081, MAT5082, MAT5083) along with a Mini project (Course Code: MAT5084) (8 credits) during the eighth semester.
2. Students who wish to complete with **4-Year B.Sc. Mathematics (Honours with Research)** have to complete 2 Major courses (MAT5081, MAT5082) along with a Major project (Course Code: MAT5085) (12 credits) during the eighth semester.

* The course offered by other departments

\# Students should study two online courses different from the curriculum, each in V and VII Semesters, offer by MOOC/NPTEL/SWAYAM/e_Pathshala, etc.,

** Students should undergo an Internship/Apprenticeship at the end of IV 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 6th semester.

Courses	**Major**	**Minor**	**DSE**	**Open Elective**	**AECC**	**SEC**	**VAC**	**Extension**	**Project**	**Internship**	**Total**
Min req. credits	**80**	**16**	**16**	**9**	**8**	**9**	**6-8**	**-**	**12**	**2-4**	**160**
Actual credits	88/84	21	16	9	12	9	8	1*	8/12	2	**173**

*Credit not included

COURSE-WISE CREDIT DISTRIBUTION

1. Four-Year B.Sc. Honours with Research in Mathematics

SEM	CC	DSE	Minor	OE	AEC	SEC	VAC	EXT	INT	PROJ	TOTAL
I	5	-	5	3	3	2	3	-	-	-	**21**
II	-	-	10	3	3	2	3	-	-	-	**21**
III	5	-	6	3	3	2	2	-	-	-	**21**
IV	15	-	-	-	3	3	-	1*	-	-	**21**
V	19	6	-	-	-	-	-	-	-	-	**25**
VI	16	4	-	-	-		-	-	2	-	**22**
VII	16	6	-	-	-		-	-	-	-	**22**
VIII	8	-	-	-	-		-	-	-	12	**20**
TOTAL	**84**	**16**	**21**	**9**	**12**	**9**	**8**	**1***	**2**	**12**	**173**

2. Four-Year B.Sc. Honours in Mathematics

SEM	CC	DSE	Minor	OE	AEC	SEC	VAC	EXT	INT	PROJ	TOTAL
I	5	-	5	3	3	2	3	-	-	-	**21**
II	-	-	10	3	3	2	3	-	-	-	**21**
III	5	-	6	3	3	2	2	-	-	-	**21**
IV	15	-	-	-	3	3	-	1*	-	-	**21**
V	19	6	-	-	-	-	-	-	-	-	**25**
VI	16	4	-	-	-		-	-	2	-	**22**
VII	16	6	-	-	-		-	-	-	-	**22**
VIII	12	-	-	-	-	-	-	-	-	8	**20**
TOTAL	**88**	**16**	**21**	**9**	**12**	**9**	**8**	**1***	**2**	**8**	**173**

3. Three-Year B.Sc. Mathematics

SEM	CC	DSE	Minor	OE	AEC	SEC	VAC	EXT	INT	TOTAL
I	5	-	5	3	3	2	3	-	-	**21**
II	-	-	10	3	3	2	3	-	-	**21**
III	5	-	6	3	3	2	2	-	-	**21**
IV	15	-	-	-	3	3	-	1*	-	**21**
V	19	6	-	-	-	-	-	-	-	**25**
VI	16	4	-	-	-		-	-	2	**22**
TOTAL	**60**	**10**	**21**	**9**	**12**	**9**	**8**	**1***	**2**	**131**

4. Two-Year Diploma in Science

SEM	CC	Minor	OE	AEC	SEC	VAC	EXT	VOC	TOTAL
I	5	5	3	3	2	3	-	-	**21**
II	-	10	3	3	2	3	-	-	**21**
III	5	6	3	3	2	2	-	-	**21**
IV	15	-	-	3	3	-	1*	4	**25**
TOTAL	**25**	**21**	**9**	**12**	**9**	**8**	**1***	**4**	**88**

5. One-Year Certificate in Science

SEM	CC	Minor	OE	AEC	SEC	VAC	VOC	TOTAL
I	5	5	3	3	2	3	-	**21**
II	-	10	3	3	2	3	4	**25**
TOTAL	**5**	**15**	**6**	**6**	**4**	**6**	**4**	**46**

*Credit not included

List of Discipline Specific Elective Courses

Sl. No.	Course code	Course title	Credits
1	MATEC01	Integral Equations and Calculus of Variations	4
2	MATEC02	Fluid Dynamics	4
3	MATEC03	Transformation Groups	4
4	MATEC04	Design and Analysis of Algorithms	3
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	3
11	MATEC11	Commutative Algebra	4
12	MATEC12	Advanced Graph Theory	4
13	MATEC13	Mechanics	3
14	MATEC14	Discrete Dynamical Systems	4
15	MATEC15	Introduction to Game Theory	4
16	MATEC16	Fractional Differential Equations	4
17	MATEC17	Numerical Methods for Differential Equations	3
18	MATEC18	Numerical Methods – Lab	2

Multidisciplinary/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 of Kolam	3
5	MATOE05	Mental Math - Math tricks for calculations	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

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 4^{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 6^{th} semester. After completing the internship, the student has to submit the report of the internship forwarded/signed by the internship supervisor. External 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 External (20% based on the report and 20% based on the presentation given by the student in the Department) and Internal (60% by the supervisor from own or other HEIs).

M. Project

Students will carry out project work in the eighth 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. Guide allocation for the project will be done by the Department. If the student wants to do project under an external guide from other HEIs/research institutions (external guide to be approved by DRC), 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/internal 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 Course (MOOC/NPTEL/SWAYAM/e_Pathshala/etc.,)

A student should undergo two online courses one in 5th semester (3 credit) and the other in 7th semester (3 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. 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. The student has to submit a copy of the course completion certificate to the department.

O. Eligibility Criteria for the Award of Certificate / Diploma/ Degree

1. A student who wishes to exit the programme with **Certificate** in Sciences after successfully completing all the courses during the First Year of the Programme (42 credits), have to secure 4 additional credits in work based vocational courses during summer term. Total credit requirements for awarding **Certificate in Science** are 46 (42+4=46).
2. A student who wishes to exit the program with **Diploma** in Science after successfully completing all the courses during First and Second Years of the Programme (84 credits), have to secure 4 additional credits in work based vocational courses during summer term. Total credit requirements for awarding **Diploma in Science** are 88 (84+4=88).
3. A student who wishes to exit the program with **Under Graduate (B. Sc.) Degree** in Mathematics after successfully completing all the courses during First, Second and Third Years of the Programme have to secure 131 credits.
4. Students who have secured ≥75% marks in the first 6 semesters alone are permitted to undertake **4-Year B.Sc. Mathematics (Honours with Research)**. Others are permitted to undertake **4-Year B.Sc. Mathematics (Honours)**. The total credit requirements for the B.Sc. Mathematics (Honours) and B.Sc. Mathematics (Honours with Research) programs are 173.

SEMESTER – I
Subject Code: MAT5011 **Credits: 3**

Calculus

Course Outcome (CO)
On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand the concepts of derivatives and integration	Remember/ Understand
CO 2	solve problems on differentiation and integration in two and three dimensional spaces	Apply
CO 3	examine the local extremum, concavity, convexity of functions and the order of integration	Analyze
CO 4	determine tangent of a curve, area, arc length, volume and, evaluate double and triple integrals	Evaluate
CO 5	compile the application of derivatives, Beta and Gamma functions	Create

Syllabus

Units	Content	Hrs.
I	(Review of differential calculus), related rate problems, implicit differentiation, tangent of a curve (given in parametric form and in implicit form), motion on a straight line, local extremum, increasing, decreasing functions.	9
II	Envelopes, curvature, circle, radius and centre of curvature, formula for the radius of curvature when the curve is given in Cartesian and polar co-ordinates, cartesian co-ordinates of the centre of curvature, evolute and involute, p-r equations of curves.	9
III	Higher order derivatives, Taylor's series expansion of sin x, cos x, e^x, $\log(1 + x)$, $(1 + x)^m$ (with m is a negative integer or a rational number), Leibnitz theorem and its applications to problems of type e^{ax+b} sin x, e^{ax+b} cos x, $(ax + b)^n$ sin x, and $(ax + b)^n$ cos x, convex and concave functions, curve tracing.	9
IV	(Review of integral calculus: Area under curves, applications of integrals to find area, reduction formulae for powers of trigonometric functions), differentiation under integral sign by Leibnitz rule, line integrals, double integrals, change of order of integration, double integrals in polar form, Jacobian determinant, change of variables.	9
V	Gamma function and Beta function, relation between beta and gamma integrals.	9
	Textbook: 1. B. S. Grewal, Higher Engineering Mathematics, Forty fourth Edition, Khanna Publishers, 2017. **References:** 1. G. B. Thomas and R. L. Finney, Calculus and Analytic Geometry, Ninth International Edition, Addison Wesley, 2002. 2. H. Anton, I. Birens and S. Davis, Calculus, John Wiley and Sons Inc., 2002. 3. G. B. Thomas and R. L. Finney, Calculus and Analytic Geometry, Ninth International Edition, Addison Wesley,	

	2002. 4. B. S. Grewal, Higher Engineering Mathematics, Forty fourth Edition, Khanna Publishers, 2017. 5. E. Kreyszig, Advanced Engineering Mathematics, Eighth Edition, John Wiley & Sons, Singapore, 2006. 6. G. F. Simmons, Calculus with analytic geometry, Second Edition, The McGraw-Hill Companies Inc., 1996.	

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

Course Code: MAT5012 **Credit: 2**

Basic Computing Lab

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	comfortably use Libre office, VI editor and necessary basic commands of Linux.	Remember / Understand
CO 2	apply the software in basic mathematical study	Apply
CO 3	draw frequency diagram, histogram and frequency polygons	Analyze
CO 4	find various measures involved in statistics by means of Libre	Evaluate
CO 5	develop data processing skills in Libre office	Create

Syllabus

Units	Content	Hrs.
I	Open source software, open document, open document filename extensions, introduction to Libre office package, advantages of Libre office, features of Libre office, pros and cons, file formats supported by Libre office, Libre office Calc, basic structure, comparison with MS Excel, shortcut operations, creating, saving, and printing a file in Libre office Calc, inserting pictures and graphics, exporting files, format properties, creating hyperlinks.	12
II	Toolbox, basic functions, built-in functions, basic math and trigonometry functions, statistical functions, text functions, data visualization through diagrams, creating tables, data sorting and filtering, pivot tables, charts, simple bar, multiple bars, pie charts, histogram.	12
III	Creating sequences, partial sums. Creating a matrix, basic operations in a matrix, determinant, inverse of a matrix, solution to a system of equations using matrix.	12
IV	Statistical computing using open source: Measures of central tendency, mean, median and mode, quartiles, percentiles, measures of dispersion, range, variance and standard deviation.	12
V	Statistical computing using open source: Measures of skewness and kurtosis, exploratory data analysis, stem and leaf diagram and box plot.	12
	References: 1. J. H. Weber and et al., Getting started with Libre Office 7.0, 2021 https://documentation.libreoffice.org/en/ 2. J. D. Miller, Statistics for Data Science, Packt Publishing Ltd., 2017.	

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

Semester III
Subject Code: MAT5031 **Credits: 3**

Differential Equations and Integral Transforms

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	gain motivation and understandings towards the origin of ordinary differential equations, properties and solutions of first order ordinary differential equations	Remember/ Understand
CO 2	apply various methods in finding the solution spaces of ordinary differential equations, partial differential equations and Laplace transforms	Apply
CO 3	analyze of the properties of the ordinary differential equations, partial differential equations and Laplace transforms	Analyze
CO 4	obtain the solutions of first and 2^{nd} order ordinary differential equations, partial differential equations using the existing methods in the syllabus	Evaluate
CO 5	discuss about the types of solutions and the application of Laplace transform method for the given differential equations	Create

Syllabus

Units	Content	Hrs
I	First order ordinary differential equations, exact equations, integrating factors (theory and problems), orthogonal trajectories. Second order ordinary differential equations with constant coefficients (theory and problems), homogeneous, solution space, non-homogeneous, complimentary solution and particular solutions, method of variation of parameters.	9
II	Laplace transforms of standard functions, properties of Laplace transforms, inverse Laplace transform and its properties, Dirac delta function, convolution integral.	9
III	Applications of Laplace transform in solving linear ordinary differential equations with constant coefficients, ordinary differential equations with discontinuous right-hand sides.	9
IV	Introduction to partial differential equations, formation of partial differential equations, theory and problems on first order partial differential equations, classification of integrals, Lagrange's method. Homogeneous and non homogeneous linear partial differential equations with constant coefficients, higher order.	9
V	Fourier Series, half range series, applications to boundary value problems, vibration of strings, one dimensional heat equation, steady state two dimensional heat equations.	9
	Text Book: 1. E. Kreyszig, Advanced Engineering Mathematics, Ninth Edition, John Wiley and Sons, Singapore, 2006. (Unit I-III, V) 2. K. Sankara Rao, Introduction to Partial Differential Equations, Third Edition, PHI Learning Pvt. Ltd., New Delhi, 2011. (Unit IV) **References:** 1. T. Myint-U and L. Debnath, Linear Partial Differential Equations for Scientists and Engineers, Birkhäuser, Boston, 2014.	

	2. K. A. Stroud, Advanced Engineering Mathematics, Fourth Edition, Palgrave, London, 2003. 3. M. Braun, Differential Equations and their applications, Fourth Edition, Springer, 1993. 4. I. N. Sneddon, Elements of Partial Differential Equations, Dover, 2006. 5. T. Amaranath, An elementary course in partial differential equations, Narosa Publishing House, 2003.	

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

Course Code: MAT5032 **Credit: 2**

Scientific Computing Lab

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	use open source software built-in commands/functions.	Remember / Understand
CO 2	define functions and run several numerical methods in open source software.	Apply
CO 3	create and manipulate data structures like lists and dictionaries in open source software.	Analyze
CO 4	visualize graphs and other objects in two and three dimensions in open source software.	Evaluate
CO 5	perform basic statistical analysis of a given data using open source software.	Create

Syllabus

Units	Content	Hrs.
I	Introduction to open source software commands, variables, symbolic variables, first computations, elementary functions and usual constants, auto completion, simple plotting, symbolic expressions and simplification, transforming expressions, usual mathematical functions, assumptions and pitfalls, explicit solving of equations, equation with no explicit solution, sums, limits, sequences, power series expansions, series, derivatives, partial derivatives, integrals, solving linear systems, vector computations, matrix computations, reduction of a square matrix.	12
II	Programming with open source software, keywords, special symbols and their uses, function calls, algorithms, loops, approximation of sequence limits, conditionals, procedures and functions, iterative and recursive methods, input and output.	12
III	Lists and other data structures, list creation and access, global list operations, main methods on lists, examples of list manipulations, character strings, shared or duplicated data structures, mutable and immutable data structures, finite sets, dictionaries.	12
IV	2D graphics graphical representation of a function, parametric curve, curves in polar coordinates, curve defined by an implicit function, data plot, displaying solutions of differential equations, evolute of a curve, 3D graphics.	12
V	Training the commands with open source software: Basic functions random, mean, median, mode, moving average, std, variance, min, max, plot, histogram, product, sum, distributions, norm, uniform, exponential, Bernoulli, Poisson, statistical functions, geometric mean, harmonic mean, skew, kurtosis, linear regression, statistical model, linear fit, glm.	12

References:

1. P. Zimmermann et.al., Mathematical Computation with Sage, SIAM, Philadelphia, 2018. (http://sagebook.gforge.inria.fr/english.html)
2. R. A. Mezei, An Introduction to SAGE Programming: With Applications to SAGE Interacts for Numerical Methods, JohnWiley & Sons, 2015.
3. G. A. Anastassiou, R. A. Mezei, Numerical Analysis Using Sage, Springer, 2015.
4. R. A. Beezer, A First Course in Linear Algebra, University Press of Florida, 2009.
5. A. Kumar & S. G. Lee, Linear Algebra with Sage, Kyobo Books,2015. (http://matrix.skku.ac.kr/2015-Album/Big-Book- LinearAlgebra-Eng-2015.pdf).
6. https://docs.scipy.org/doc/scipy/reference/stats.html
7. N. Matloff, R for Everyone: Advanced Analytics and Graphics, Pearson Education, Second edition, Pearson India, 2018.
8. N. Matloff, The Art of R Programming, No Starch Press, First edition, 2011.
9. A. Quarteroni, F. Saleri and P. Gervasio, Scientific computing with MATLAB and Octave, Springer-Verlag, Berlin, 2010.
10. S. Nagar, Introduction to Scilab: For engineers and scientists, APress, First edition, 2017.

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

Course Code: MATSE01 **Credit: 2**

Set Theory and Logic

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand the definitions of a statement, sets and functions.	Remember / Understand
CO 2	apply the understanding to negate the statements and write logical proofs	Apply
CO 3	understand by analysis the subtleties of counterexamples and proofs by contradiction	Analyze
CO 4	evaluate the various concepts learned in the context mathematical concepts	Evaluate
CO 5	observe patterns from examples and write it as a statement and prove it with logical arguments.	Create

Syllabus

Units	Content	Hrs.
I	Statements and Logic: Quantifiers, statements with single quantifiers, negation of a statement, statement with multiple quantifiers, compound statements, proofs in mathematics sets, writing sets in roster form vs set-builder form, operation on sets, family of sets, cartesian product of sets.	6
II	Relations on sets, types of relations, functions as relations, equivalence relations, equivalence classes and partitions of a set, definition of functions, one-one, onto and bijective functions, composition of functions, inverse of a function, image and inverse.	6
III	Countability of sets, finite sets, countable sets and uncountable sets with examples, comparing cardinality, sets with same cardinality, Schroder-Bernstein theorem, Cantor's theorem.	6
IV	Arithmetic and order properties of integers, law of trichotomy, induction principle(s), the well-ordering principle, proof of equivalence of the above statements, prove various statements using both induction and well ordering.	6
V	Partial and total orders, chains, upper bound, maximal and minimal elements, Zorn's lemma, axiom of choice and equivalence of the above statements.	6
	Text Books: 1. A. Kumar, S. Kumaresan, B. K. Sarma, A Foundation Course in Mathematics, Narosa Publishing House, 2018. **References:** 1. A. Shen and N. K. Vereshchagin, Basic Set Theory, AMS Students Mathematical Library, 2002. 2. Michael L. O'Leary, A First Course in Mathematical Logic and Set Theory, Wiley and Sons, 2016.	

Mapping of Program Specific Outcomes 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

Semester IV
Course Code: MAT5041 **Credit: 4**

Group Theory

Course Outcome (CO)
On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand the basic concept groups, subgroups, quotient groups, automorphisms and isomorphisms	Remember / Understand
CO 2	solve problems using properties of groups and homomorphisms	Apply
CO 3	examine the converse part of Lagrange's theorem and characterization of normal Subgroups	Analyze
CO 4	evaluate the values of certain number theoretic functions using group theory	Evaluate
CO 5	construct new groups from known groups using quotient groups and fundamental theorem of homomorphism	Create

Syllabus

Units	Content	Hrs.
I	Introduction to groups, definition and examples of groups, like permutation groups, Dihedral groups, matrix groups, elementary properties of groups, subgroups, subgroup tests.	12
II	Cyclic groups, properties of cyclic groups, classification of subgroups of cyclic groups, permutation groups, cycle Notation, properties of permutations.	12
III	Properties of cosets, Lagrange's theorem and consequences, normal subgroups, quotient groups, applications of quotient groups.	12
IV	Group homomorphisms, properties of homomorphisms, Isomorphisms, the first isomorphism theorem, correspondence theorem.	12
V	Cayley's theorem and generalized Cayley's theorem, properties of isomorphisms, automorphisms.	12
	Text Book: 1. J. A. Gallian, Contemporary Abstract Algebra, Nineth Edition, Cengage Learning India Private Limited, 2019. **References:** 1. M. Artin, Algebra, Prentice-Hall of India, 1991. 2. I. N. Herstein, Topics in Algebra, Second Edition, John-Wiley & Sons,1975. 3. J. B. Fraleigh, A First course in Abstract Algebra, Seventh Edition, Pearson Education, 2003. 4. D. S. Dummit and R. M. Foote, Abstract Algebra, Third Edition, Wiley, 2004. 5. C. Lanski, Concepts in Abstract Algebra, American Math. Society, Indian Edition, Universities Press, 2010.	

Mapping of Program Specific Outcomes with Course Outcomes

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

Course Code: MAT5042 **Credit: 4**

Sequences and Series

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand the definitions of sequences, series, limit, infimum and supremum	Remember / Understand
CO 2	examine the convergence and divergence of sequences and series using various tests	Apply
CO 3	be familiar with the properties of various types of sequences, series and Archimedean property	Analyze
CO 4	find the limits of convergent sequences and convergent series	Evaluate
CO 5	investigate the infimum, supremum, limit infimum and limit supremum	Create

Syllabus

Units	Content	Hrs.
I	Introduction to real numbers, infimum and supremum, least upper bound property, Archimedean property in R, Q is dense in R, existence of n^{th} root of unity (without proof).	12
II	Sequences of real numbers, definition of a sequence and subsequence, limit of a sequence, the algebra of limits, convergent sequences and their properties, divergent sequences, oscillating sequence.	12
III	Bounded sequences, monotone sequences, behavior of monotonic sequences, operations on convergent sequences, operations on divergent sequences, limit supremum and limit infimum, Cauchy sequences.	12
IV	Series of real numbers, convergence and divergence, series with non-negative terms, comparison test, Cauchy's root test, ratio test, integral test and the number e.	12
V	Alternating series, Leibnitz's test, Dirichlet's test, Abel's test, absolute convergence and conditional convergence.	12
	Textbooks: 1. R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, John Wiley and Sons (Asia) P. Ltd., 2000. (Unit I) 2. R. R. Goldberg, Methods of Real Analysis: Oxford and IBH Publishing, 2020. (Units II-V) **References:** 1. E. D. Bloch, The Real Numbers and Real Analysis, Springer, 2011. 2. E. Fischer, Intermediate Real Analysis, Springer Verlag, 1983. 3. K. A. Ross, Elementary Analysis- The Theory of Calculus Series- Undergraduate Texts in Mathematics, Springer Verlag, 2003.	

Mapping of Program Specific Outcomes 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	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

Course Code: MAT5043 **Credits: 4**

Probability and Statistics

Course Outcomes (CO)

On completion of the course the student will be able to

	Course Outcome	Level
CO1	quantify the uncertainness in various real-life situations using the knowledge of probability	Remember / Understand
CO2	model and predict various events as discrete random variables	Apply
CO3	model and predict various events as continuous random variables	Analyze
CO4	estimate the basic statistics in a practical situation and to give a conclusive inference from the available resources	Evaluate
CO5	test different hypothesis and to establish the validity of the proposed hypothesis with statistical evidence	Create

Syllabus

Units	Content	Hrs.
I	Arithmetic mean, geometric mean, harmonic mean, median, mode, standard deviation, quartile deviation, percentiles, expectation, variance, covariance, correlation, regression, properties of correlation, regression coefficients.	12
II	Probability, random experiment, sample point, event and probability, rules of probability, conditional probability, independence of events, Bayes' rule, applications.	12
III	Discrete random variables: Definition, sum and linear composite of random variables, mean, variance, Bernoulli, binomial, geometric and negative binomial distributions, hypergeometric distribution, Poisson distribution, applications.	12
IV	Continuous random variables: Definition, uniform and exponential distributions, normal distribution and its properties, standard normal distribution, transformation from a general normal distribution to standard normal, checking for normality of data, applications.	12
V	Hypothesis testing: Hypothesis, simple and composite, null and alternative, test of hypothesis, type I and type II errors, level and power of a test, p-value, tests for mean and standard deviation, test for proportion, one tail or two tails, applications.	12
	Text Books: 1. S.C. Gupta, V.K. Kapoor, Fundamentals of Mathematical Statistics (A Modern Approach), Tenth Edition, Sultan Chand and Sons, 2000. (Unit I) 2. R. E. Walpole, R. H. Myers, S. L. Myers and K.Ye, Probability & Statistics for Engineers & Scientists, Ninth Edition, Prentice Hall, 2012. (Units II-V) **References:** 1. Douglas C. Montgomery Arizona State University George C. Runger, Applied Statistics and Probability for Engineers, Fifth Edition, John Wiley & Sons, 2011. 2. A.D. Aczel, and J. Sounderpandian Complete Business Statistics, Seventh Edition, McGraw-Hill, Irwin, 2008. 3. M.L. Samuels, and J.A. Witmer, Statistics for the life sciences,	

	Third Edition, Prentice Hall, 2003. 4. H.E. Van Emden, Statistics for terrified Biologists, Blackwell Publishing, 2008. 5. R. Barlow, Statistics - A guide to the use of statistical methods in the Physical Sciences, Wiley, 1999.	

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

Course Code: MAT5044 **Credits: 3**

Vector Calculus

Course Outcomes (CO)

On completion of the course the student will be able to

	Course Outcome	Level
CO1	understand the concepts of vectors, derivatives and integration	Remember / Understand
CO2	solve problems on vector differentiation and integration in two- and three-dimensional spaces	Apply
CO3	examine the extreme values of functions of two variables, solenoidality, irrotationality, conservativeness of a given vector field and verify Gauss, Green's and Stokes theorems	Analyze
CO4	determine Hessian matrix, area, arc length, surface area and volume of surface of revolution, and evaluate double and triple integrals	Evaluate
CO5	compile the application of line, surface and volume integrals	Create

Syllabus

Units	Content	Hrs.
I	Differentiability, total differential, chain rule. directional derivative, gradient of a scalar field, geometrical meaning, tangent plane, Hessian matrix, extreme values and saddle point for function of two variables.	9
II	Operations with vectors, scalar-valued functions over the plane and the space, vector function of a scalar variable, divergence and curl of a vector field, solenoidal field, irrotational field and conservative field, scalar and vector potentials.	9
III	Laplacian of a scalar field, standard identities involving curl, divergence, gradient and Laplacian operators.	9
IV	Line integral, surface integral, surface area, applications.	9
V	Volume Integral, volumes of surface of revolution, triple integrals in rectangular, cylindrical and spherical coordinates.	9
	Text Books: 1. G. B. Thomas and R.L. Finney, Calculus and Analytic Geometry, Ninth Edition, Pearson, Noida, 2019. (Unit I, V) 2. E. Kreyszig, Advanced Engineering Mathematics, Eighth Edition, John Wiley & Sons, Singapore, 2006. (Unit II, III, IV) **References:** 1. H. M. Schey, Div, Grad, Curl, and All That: Informal text on Vector Calculus, W. W. Norton & Co., New York, 1973. 2. M. Spiegel and S. Lipschutz, Vector Analysis, McGraw Hill Publications, 2017. 3. G. B. Thomas and R.L. Finney, Calculus and Analytic Geometry, Ninth Edition, Pearson, Noida, 2019. 4. A. E. Taylor and W. R. Mann, Advanced Calculus, John Wiley & sons, New York, 1972.	

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: MATSE02 **Credits: 3**

Numerical Methods

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	demonstrate the theory about polynomials and accuracy about numerical methods	Remember/ Understand
CO 2	solve algebraic and transcendental equations and study the rate of convergence	Apply
CO 3	analyze the properties about polynomials to develop methods to perform integration and differentiations	Analyze
CO 4	evaluate numerically the approximate solution of ordinary differential equations	Evaluate
CO 5	formulate numerical procedure when real world problems are modelled by the system and understand how the iteration gives approximate solution to the system	Create

Syllabus

Units	Content	Hrs.
I	Algebraic and transcendental equations, bisection method, iteration method, Regula-Falsi method, secant method, Newton-Raphson's method, error analysis, rate of convergence.	9
II	System of equations, linear system (direct methods), Gauss elimination, pivoting strategies, vector and matrix norms, error estimates and condition number, LU decomposition, linear system (iterative methods), Gauss-Jacobi and Gauss-Seidel, Convergence analysis, eigenvalue problem, power method, Jacobi for a real symmetric matrix.	9
III	Lagrange's interpolation, error analysis, Newton's divided differences, Newton's finite difference interpolation, optimal points for interpolation, piecewise polynomial interpolation, piecewise linear and spline interpolation	9
IV	Numerical differentiation based on interpolation, finite differences.	9
V	Numerical integration, Newton Cotes formulae, Gaussian quadrature, Trapezoidal rule, Simpson's rules, error analysis, quadrature rules for multiple integrals.	9
	Text Books: 1. K.E. Atkinson, An Introduction to Numerical Analysis, Wiley, 1989 **References:** 1. R. L. Burden, J. D. Faires, Numerical Analysis, 9th Edition, Cengage Learning, 2011. 2. D. Kincaid and W. Chenney, Numerical Analysis: Mathematics of Scientific Computing, Brooks/Cole Pub. 2nd Edition, 2002. 3. G.M. Phillips and P.J. Taylor, Theory and Applications of Numerical Analysis, 2nd Edition, Elsevier, New Delhi, 2006. 4. A. Quarteroni, F. Saleri and P. Gervasio, Scientific computing with MATLAB and Octave, Springer, 2006. 5. S. D. Conte, and C. de Boor, Elementary Numerical Analysis, Third Edition, McGraw-Hill Book Company, 1983. 6. B. Bradie, A Friendly Introduction to Numerical Analysis, First Edition, Pearson Education, New Delhi, 2007.	

Mapping of Program Specific Outcomes with Course Outcomes

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

SEMESTER – V

Subject Code: MAT5051 **Credits:4**

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 operators like self-adjoint operators, normal operators	Create

Syllabus

Units	Content	Hrs.
I	Vector spaces, subspaces, examples, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces.	12
II	Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations. Isomorphisms, isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix.	12
III	Dual spaces, dual basis, double dual, transpose of a linear transformation and its matrix in the dual basis, annihilators.	12
IV	Eigen spaces of a linear operator, diagonalizability, invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator.	12
V	Inner products and norms, Gram Schmidt orthogonalization process, orthogonal complements.	12
	Text Book: 1. S. Axler, Linear Algebra Done Right, Second Edition, Springer, 1997. **References:** 1. S. H. Friedberg, A. J. Insel and L. E. Spence, Linear Algebra, Fifth Edition, Pearson, 2022. 2. S. Kumaresan, Linear Algebra - A Geometric Approach, Twelfth reprint, Prentice Hall of India, 2011. 3. G. Strang, Linear Algebra and its applications, Eighth Indian reprint Indian Edition, Cengage Learning, 2011. 4. K. Hoffman and R. Kunze, Linear Algebra, Second Edition, Prentice Hall of India, 2003. 5. I. N. Herstein, Topics in Algebra, Wiley Eastern Ltd., Second	

	Edition, 2006. 6. S. Lang, Introduction to Linear Algebra, Second Edition, Springer, 2005. 7. D. C. Lay, Linear Algebra and its Applications, Third Edition, Pearson Education Asia, Indian Reprint, 2007.	

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

Course Code: MAT5052 **Credit: 4**

Real Analysis

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	learn and understand the definitions of open set, closed set, continuous functions, integrable functions, differentiable functions, connected and compact metric spaces and convergence of sequence of functions	Remember / Understand
CO 2	find elementary examples and obtain the elementary results on the various kinds of sets, functions and spaces	Apply
CO 3	learn the detailed proofs of the simple theorems on metric spaces, continuous functions, differentiable functions, integrable functions and convergence of sequence of functions	Analyze
CO 4	solve problems on these topics in real analysis	Evaluate
CO 5	providing non-trivial examples and counter examples in real analysis and to provide the proofs of the moderate theorems under graduate level	Create

Syllabus

Units	Content	Hrs.
I	Recall (Ordered set, infimum and supremum, Archimedean property, denseness of rationals in reals), metric space, limit point, interior point, open sets and closed sets, interior and closure, open set relative to a subspace.	12
II	Compact set in a metric space, Bolzano Weierstrass property, Heine-Borel theorem, equivalence of compactness in R^k, perfect set, connected set in a metric space, connected set in R.	12
III	(Recall convergent, Cauchy, bounded sequences and series) Cauchy sequence, diameter of a set, complete metric space, limit infimum and limit supremum, some special sequences, series of non-negative terms, summation by parts, absolute convergence, addition and multiplication of series, Merten's theorem, Riemann's rearrangement theorem.	12
IV	Limit of a function between metric spaces, properties of limits, continuous functions, equivalences of continuity, properties of continuous function, uniform continuity, example of a continuous function which is not uniformly continuous.	12
V	Continuity on compact set, continuity and connected set, intermediate value theorem, right and left limits, discontinuities, monotone functions, infinite limits and limit at infinity.	12
	Text Book: 1. W. Rudin, Principles of Mathematical Analysis, Third Edition, McGraw-Hill Inc., New York, 1976. **References:** 1. R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, Third Edition, Wiley International Student Edition, 2001.	

	2. R. R. Goldberg, Methods of Real Analysis, John Wiley & sons, Second Edition. (Indian Edition - Oxford and IBH Publishing Co, New Delhi, 2020). 3. T. Apostol, Mathematical Analysis, Second Edition, Narosa Publishing House, 1985. 4. A. Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2014. 5. K. A. Ross, Elementary Analysis: The theory of Calculus, Springer International Edition, Indian Reprint, New Delhi, 2004.	

Mapping of Program Specific Outcomes with Course Outcomes

	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	1	1	1	0	0	1	1

Course Code: MAT5053 **Credit: 4**

Optimization Techniques

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand the history, properties and principles of operations research and linear programming.	Remember/ Understand
CO 2	improve the problems solving skills related to the scientific methods of operations research.	Apply
CO 3	learn the modeling and solutions of linear programming problem	Analyze
CO 4	model the assignment and transportation problems and their methods of solutions.	Evaluate
CO 5	model the real-life sequencing problems, theoretical models and their solutions	Create

Syllabus

Units	Content	Hrs
I	The linear programming problem: Problem formulation, graphical method, definitions of bounded, unbounded and optimal solutions, linear programming in matrix notation, definitions of basic, non-basic variables, basic solutions, slack variables, surplus variables and optimal solution, simplex method of solution of a linear programming problem, big M-technique.	12
II	Two phase simplex method, degeneracy and cycling, revised simplex method, duality theory, formulation of dual problem, duality theorems, primal dual method, dual simplex method, sensitivity analysis.	12
III	Balanced and unbalanced transportation problems, feasible solution, basic feasible solution, optimum solution, degeneracy in a transportation problem, mathematical formulation, North-West corner rule, Vogel's approximation method, method of matrix minima, algorithm of optimality test.	12
IV	Balanced and unbalanced assignment problems, restrictions on assignment problem, mathematical formulation, formulation and solution of an assignment problem (Hungarian method), degeneracy in an assignment problem.	12
V	Sequencing problem, n jobs through 2 machines, n jobs through 3 machines, two jobs through m machines, n jobs through m machines, definition of network, event, activity, critical path, total float and free float, difference between CPM and PERT, problems.	12
	Text Book: 1. K. Swarup, P. K. Gupta and Man Mohan, Operations Research, Ninth Edition, Sultan Chand & Sons, Chennai, 2001. **References:** 1. S. I. Gauss, Linear Programming, Second Edition, McGraw Hill Book Company, New York, 1964. 2. A. Ravindran, D. T. Phillips and J. J. Solberg, Operation research: Principles and Practice, Second Edition, John Wiley & Sons, 1987.	

	3. F. S. Hillier and G. J. Lieberman, Introduction to Operations Research, McGraw Hill, Eighth Edition, 2001.	

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	0
CO3	1	1	1	1	0	1	1	0
CO4	1	1	0	0	1	1	0	1
CO5	1	1	1	0	1	1	0	1

Subject Code: MAT5054 **Credits: 4**

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	(Review of Natural numbers, arithmetic and order properties) Divisibility, division algorithm, prime numbers, GCD and LCM, Bezout's identity. Euclid's algorithm, fundamental theorem of arithmetic, linear Diophantine equations.	12
II	Congruences, residue classes, arithmetic of congruences, Chinese remainder theorem, congruences with a prime-power modulus, the arithmetic of Z_p, pseudoprimes and Carmichael numbers, solving congruences mod p^e.	12
III	Euler phi function, multiplicative functions, Euler's theorem, Fermat's theorem, group of units.	12
IV	Arithmetical functions, the Mobius function, Euler Totient function, the Dirichlet product of arithmetical functions, Dirichlet inverses, the mobius inversion formula, the Mangoldt function.	12
V	Completely multiplicative functions, Dirichlet multiplication, the inverse of a completely multiplicative function, Liouville's function $\lambda(n)$, the divisor functions, generalized convolutions, formal power Series, the Bell series of an arithmetical function, Bell series and Dirichlet multiplication, derivatives of arithmetical functions, the Selberg Identity.	12
	Text Books: 1. G. A. Jones and J. M. Jones, Elementary Number Theory, Springer,1998. (Units I-III) 2. T. Apostol, Introduction to Analytic Number Theory, Narosa Publications, New Delhi, 2010. (Units IV,V) **References:** 1. D. M. Burton, Elementary Number Theory, Seventh edition, Universal Book, New Delhi, 2001. 2. H. S. Davenport, Multiplicative Number Theory, Third edition, Springer, 2000. 3. K. Ireland and M. Rosen, A Classical Introduction to Modern Number Theory, Springer Verlag, New York, 1972. 4. I. Niven and H. S. Zuckerman, An Introduction to the Theory of	

	Numbers, Fifth edition, Wiley Eastern Ltd, New Delhi, 1989.	

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

Course Code: MAT5055 **Credit: 3**

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.	9
II	Generating functions for permutations, distributions of distinct objects into non-distinct cells, partitions of integer, elementary relations.	9
III	Recurrence relations, linear recurrence relations with constant coefficients, solution by the technique of generating functions, recurrence relation with two indices.	9
IV	The principle of inclusion and exclusion, general formula, derangements, permutations with restrictions on relative positions.	9
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.	9
	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

SEMESTER – VI

Subject Code: MAT5061 **Credits: 4**

Ring Theory

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand the basic concept of rings, integral domain, fields and ideals	Remember/ Understand
CO 2	solve problems using properties of rings	Apply
CO 3	examine the characterization of fields	Analyze
CO 4	find the irreducible polynomial over the field of rational numbers and given an ideal is maximal or not in a commutative ring	Evaluate
CO 5	investigate the given natural number can be written as the product of prime factors (unique up to isomorphism)	Create

Syllabus

Units	Content	Hrs.
I	Introduction to rings, motivation and definition of rings, examples of rings, properties of rings, subrings, definition and examples of integral domains, fields, characteristic of a ring.	12
II	Ideals, factor rings, prime ideals and maximal ideals, definition and examples of ring homomorphisms, properties of ring homomorphisms, the field of quotients.	12
III	Polynomial rings, the division algorithm and consequences, principal ideal domain, factorization of polynomials, reducibility tests, Eisenstein's criterion, irreducibility.	12
IV	Unique factorization in Z[x], divisibility in integral domains, irreducible and prime, PID implies irreducible equals prime.	12
V	Unique factorization domains, PID implies UFD, F[x] is a UFD, Euclidean domains, ED implies PID, ED implies UFD.	12
	Text Book: 1. J. A. Gallian, Contemporary Abstract Algebra, Nineth Edition, Cengage Learning India Private Limited, 2019. **References:** 1. M. Artin, Algebra, Prentice-Hall of India, 1991. 2. I. N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975. 3. D. S. Dummit and R. M. Foote, Abstract Algebra, Third Edition, John Wiley and Sons, 2004.	

Mapping of Program Specific Outcomes with Course Outcomes

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

Course Code: MAT5062 Credits: **4**

Complex Analysis

Course Outcomes (CO)

On completion of the course the student will be able to

	Course Outcome	Level
CO1	learn and understand the basics of analytic functions	Remember / Understand
CO2	solve problems using Cauchy's integral formula and Cauchy's residue theorem	Apply
CO3	check the analyticity of a given function, apply C-R equations to find the harmonic conjugate, find the radius of convergence of a power series	Analyze
CO4	compute Laurent series expansion and classify the types of singularities, the number of zeroes of a polynomial in an annulus with centre zero	Evaluate
CO5	find a linear fractional transform with a given values at three specific points, cross ratios, and to check if the given three points are on a line or a circle	Create

Syllabus

Units	Content	Hrs.
I	(Quick Review: Complex numbers and geometrical representations, Cauchy-Schwarz inequality principal argument of a complex number, n^{th} root of a complex number). The complex plane, topological aspects of the complex plane, stereographic projection, the point at infinity, analytic polynomials, power series, differentiability and uniqueness of power series, analyticity and the Cauchy-Riemann equations, the functions e^z, sin z, cos z.	12
II	Line integrals and their properties, the closed curve theorem for entire functions, the Cauchy integral formula and Taylor expansion for entire functions, Liouville theorems and the fundamental theorem of algebra, the Gauss-Lucas theorem.	12
III	The power series representation for functions analytic in a disc, the uniqueness, mean-value, maximum-modulus theorem, the converse of Cauchy's theorem: Morera's theorem.	12
IV	Classification of isolated singularities, Riemann's principle, the Casorati-Weierstrass theorem, Laurent expansions, winding numbers, the Cauchy residue theorem, applications of the residue theorem.	12
V	Evaluation of definite integrals by contour integral techniques, introduction to conformal mapping, special mappings.	12
	Text Book: 1. J. Bak and D. J. Newman, Complex Analysis, Third Edition, Springer International Edition, Indian Reprint, 2010. **References:** 1. J. W. Brown and R. V. Churchill, Complex Variables and Applications, McGraw Hill, 2008. 2. S. Ponnusamy, Foundations of Complex Analysis, Second Edition, Narosa Publishing House, 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	0	1	0
CO2	1	1	0	1	1	1	1	1
CO3	1	1	1	1	0	1	1	1
CO4	1	1	0	1	0	0	1	1
CO5	1	1	1	1	1	1	1	1

Course Code: MAT5063 **Credit: 4**

Graph Theory

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand the concept of graphs, subgraphs and graph isomorphisms	Remember / Understand
CO 2	demonstrate Cayleys's formula to count the spanning trees of K_n	Apply
CO 3	distinguish between connectivity and edge connectivity, between vertex coloring and edge coloring	Analyze
CO 4	determine Eulerian graphs, planar graphs and chromatic polynomial of a given graph	Evaluate
CO 5	translate real-world problems in to graph theoretic models	Create

Syllabus

Units	Content	Hrs.
I	Graphs, subgraphs, isomorphism of graphs, degrees of vertices, paths and connectedness, automorphisms, vertex cuts, edge cuts, connectivity, edge-connectivity, blocks.	12
II	Trees, counting the number of spanning trees, Cayley's formula, Eulerian graphs.	12
III	Hamiltonian graphs, necessary conditions, Dirac's theorem, closure of a graph, a criterion for Hamilton graphs using closure of a graph, Chvatal's theorem.	12
IV	Edge colorings, vertex colorings, critical graph, properties of critical graphs, Mycielski's construction, chromatic polynomials.	12
V	Planar and nonplanar graphs, Euler's formula and its consequences, K_5 and $K_{3,3}$ are nonplanar graphs, dual of a plane graph, the Four-color theorem (without proof), the Heawood Five-color theorem, Kuratowski's theorem (without proof).	12
	Text Book: 1. R. Balakrishnan and K. Ranganathan, A Text book of Graph Theory, Second Edition, Springer, 2012. **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 L earning Private Ltd, New Delhi, 2011.	

Mapping of Program Specific Outcomes with Course Outcomes

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

Subject Code: MAT5064 **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 theory behind the solutions of differential equations	Analyze
CO 4	evaluate the solutions of differential equations with variable coefficients	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	Mathematical models, existence and uniqueness theorem for first order ordinary differential equations, Picard's iteration, continuity theorem. Second-order differential equations with constant coefficients, linear dependence and independence, a formula for the Wronskian, the non-homogeneous equation.	12
II	Second-order differential equations with variable coefficients, homogeneous equation, initial value problems, Wronskian and linear independence, reduction of the order of a homogeneous equation, method of variations of parameters, method of judicious guessing (or method of undetermined coefficients) for the non-homogeneous equation.	12
III	Singular points, Euler equation, regular singular points, method of Frobenius, equal roots, and roots differing by an integer.	12
IV	Bessel equation, Legendre equation, Laguerre equation, Hermite equation, Chebyshev equations, higher order equations.	12
V	Algebraic properties of solutions of linear systems 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.	12
	Text Book: 1. M. Braun, Differential Equations and their applications, Fourth Edition, Springer, 1993. **References:** 1. E. A. Coddington, An Introduction to Ordinary Differential Equations, Dover, 1961. 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.	

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

Semester VII
Subject Code: MAT5071 **Credits: 4**

Algebra

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	The isomorphism theorems, composition series, transpositions, alternating groups, group actions, permutation representations.	12
II	Groups acting on themselves by left multiplication Cayley's theorem, group acting on themselves by conjugation, the class equation, automorphisms, the Sylow theorems, the simplicity of A_n.	12
III	Direct and semi-direct products, abelian groups, the fundamental theorem of finitely generated abelian groups.	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 over PID, Noetherian modules.	12
	Text Books: 1. D. S. Dummit and R.M. Foote, Abstract Algebra, Third Edition, Wiley, 2004. (Units I – III) 2. N. Jacobson, Basic Algebra I, Second Edition, Dover, 2009. (Units IV-V) **References:** 1. C. W. Curtis, Linear Algebra, Springer 1984, Indian reprint, 2004. 2. M. Artin, Algebra, Prentice Hall India, 1996. 3. J. Rotman, Galois Theory, Springer, 1998. 4. S. Lang, Algebra, Third edition, Addison-Wesley, 1993. 5. I. N. Herstein, Topics in Algebra, Second Edition, John-Wiley &Sons, 1975.	

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: MAT5072 **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	Differentiable functions, local extremums, mean-value theorems, continuity of derivatives, L'Hospital's rule (statement only), derivatives of higher order and Taylor's theorem, derivatives of vector valued functions.	12
II	Definition and existence of Riemann integral, properties of the integral, integration and differentiation, rectifiable curves.	12
III	Point-wise convergence, examples of sequences (f_n) which do no preserve the properties of f_n, uniform convergence and continuity, uniform convergence and integration, uniform convergence and differentiation, existence of everywhere continuous and nowhere differentiable functions.	12
IV	Lebesgue outer measure, properties of outer measure, Lebesgue measurable sets, properties of measurable sets, sigma algebra of measurable sets, Borel sets, measurable function definition and properties, existence of non-measurable set, existence of measurable non Borel set.	12
V	Simple function, definition and properties of integral of simple functions, definition and properties of integral of non-negative measurable functions, definition and properties of integral of extended real valued measurable functions, Fatou's lemma, monotone convergence theorem, dominated convergence theorem and its applications.	12

	Text Books: 1. W. Rudin, Principles of Mathematical analysis, Third Edition, McGraw-Hill Inc., New York, 1976. (Units I - III) 2. G. de Barra, Measure theory and integration, New Age International, New Delhi, 1981. (Units IV - V) **References:** 1. T. Apostol, Mathematical Analysis, Second Edition, Narosa Publishing House, 1985. 2. R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, Third Edition, Wiley International Student Edition, 2001. 3. K. A. Ross, Elementary Analysis: The theory of Calculus, Springer International Edition, Indian Reprint, 2004. 4. H. L. Royden, Real Analysis, Third edition, Macmillan publishing company, New York, 1988.	

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: MAT5073 **Credits: 4**

Ordinary and Partial Differential Equations

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	understand the fundamental relation between the solutions of differential equation, eigenvalues and eigenfunctions	Remember/ Understand
CO 2	apply the different techniques to study qualitative behavior of solutions of ordinary differential equations	Apply
CO 3	classify the second-order 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 to take a research career in the area of partial differential equations	Create

Syllabus

Units	Content	Hrs.
I	Qualitative theory of ordinary differential equations, stability of linear system, stability of equilibrium solutions, the phase-plane, qualitative properties of orbits, phase portraits.	12
II	Self-adjoint eigenvalue problems, Sturm-Liouville systems, eigenvalues and eigenfunctions, eigenfunction expansions.	12
III	Well-posed problems in the sense of Hadamard for partial differential equations, geometrical interpretation of a first-order equation, classification of integrals, method of characteristics, Pfaffian differential equations, compatible systems, Charpit's method, Jacobi's method, initial value problems.	12
IV	Classification of second order partial differential equations, canonical forms. D'Alembert's formula for wave equation, uniqueness, stability of solutions to the initial value problem for one-dimensional wave equation, Duhamel's principle for non-homogeneous wave equation.	12
V	Laplace equation, Green's identities, uniqueness of solutions to Dirichlet and Neumann boundary value problems, fundamental solutions, uniqueness. Fundamental solution of heat equation, Cauchy problem for homogeneous heat equation, Duhamel's principle for non-homogeneous heat equation, uniqueness.	12
	Text Books: 1. M. Braun, Differential Equations and their applications, Fourth Edition, Springer, 1993. (Unit I - II) 2. T. Amaranath, An elementary course in partial differential equations, Narosa Publishing House, 2003. (Unit - III) 3. L. C. Evans, Partial Differential Equations, AMS, Second Edition, 2010. (Unit IV -V) **References:** 1. T. Myint-U, Ordinary Differential Equations, Elsevier, North-Holland, 1978. 2. S. L. Ross, Differential Equation, Fourth Edition, John Wiley & Sons, 1984.	

	3. A. K. Nandakumaran, P. S. Datti and R. K. George, Ordinary Differential Equations: Principles and Applications, Cambridge University Press, 2017. 4. T. Myint-U, and L. Debnath, Linear Partial Differential Equations for Scientists and Engineers, Fourth Edition, Birkhauser, 2007. 5. F. John, Partial differential equations, Fourth Edition, Springer-verlag, New York, 1991.	

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

Course Code: MAT5074 **Credit: 4**

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 lemma, Tietze extension theorem, Urysohn metrization theorem, Tychnoff theorem	Evaluate
CO 5	construct examples and counter examples of various topological properties	Create

Syllabus

Units	Content	Hrs.
I	Definition of topological space, examples, basis, sub basis, order topology, continuous functions, product topology, subspace topology, closed sets, closures, limit points, cluster (accumulation) points, interior, boundary of a set, metric topology.	12
II	Quotient topology, connectedness, components, locally connectedness, path-connectedness, locally path-connectedness.	12
III	Compactness, tube lemma, compact subspaces of real line, characterization of compact metric spaces, locally compactness, one-point compactification.	12
IV	Countability axioms, T_1-spaces, Hausdorff spaces, regular spaces, completely regular spaces, Normal spaces, Uryosohn lemma, Tietze extension theorem.	12
V	Urysohn metrization theorem, Tychonoff theorem, Stone-Cech compactification, homotopy, fundamental groups.	12
	Text Book: 1. J. R. Munkres, Topology, Second Edition, Prentice Hall of India, 2000. **References:** 1. G. F. Simmons, Introduction to Topology and Modern analysis, McGraw-Hill, 1963. 2. S. Kumaresan, Topology of Metric Spaces, Second Edition, Narosa Publishing, 2011. 3. K. D. Joshi, Introduction to General Topology, Second Edition, NewAge International Publishers, 1983. 4. M. A. Armstong, Basic Topology, Springer International Edition, 2005. 5. 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

Semester VIII

Subject Code: MAT5081 **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 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	Operators on complex vector spaces, generalized eigenvectors, characteristic polynomial, Cayley Hamilton theorem, minimal polynomial, Jordan decomposition, Jordan form, rational canonical form.	12
II	Fields, field extensions, finite extension, algebraic extension, roots of polynomials, splitting field.	12
III	More about roots, simple extension, splitting field of a polynomial, Galois theory, Galois group, fixed field, theorem on symmetric polynomials, normal extension.	12
IV	Fundamental theorem of Galois theory, Solvability by radicals, Abel's theorem.	12
V	Finite fields, ruler and compass construction, Wedderburn's theorem on finite division rings.	12
	Text Books: 1. S. Axler, Linear Algebra Done Right, Second Edition, Springer, 1997. (Unit I) 2. I. N. Herstein, Topics in Algebra, Wiley Eastern Ltd., Second Edition, 2006. (Unit II-V) **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. D. S. Dummit and R. M. Foote, Abstract Algebra, Third Edition, Wiley, 2004. 4. S. Kumaresan, Linear Algebra - A Geometric Approach, Twelfth reprint, Prentice Hall of India, 2011. 5. G. Strang, Linear Algebra and its applications, Eighth Indian reprint	

	Indian Edition, Cengage Learning, 2011. 6. C. W. Curtis, Linear Algebra, Springer 1984, Indian reprint, 2004. 7. P. M. Cohn, An introduction to Ring Theory, Springer,1999. 8. P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, Basic abstract algebra, Second Edition, Cambridge University Press, Indian Edition by Foundation Books, 1995. 9. P. R. Halmos, Finite Dimensional Vector Spaces, Springer,1974 10. 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: MAT5082 **Credits: 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, completeness of 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, open 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, Riesz 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
	Text Book: 1. G. F. Simmons, Introduction to Topology and Modern analysis, McGraw-Hill, 1963. **References:** 1. B. V. Limaye, Functional Analysis, Second Edition, New Age International, 1996. 2. B. Bollabas, Linear Analysis, an introductory course, Cambridge University Press, 1994. 3. E. Kreyzig, Introductory Functional Analysis with applications, Wiley Classics Library, 2001. 4. M. Thamban Nair, Functional Analysis: A First Course, Prentice-Hall of India, New Delhi, 2002. 5. 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: MAT5083 **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
	Text Books: 1. T. M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1996. (Units I - III) 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. (Units IV - V) **References:** 1. W. Rudin, Principles of Mathematical Analysis, Wiley International Edition, 1985. 2. M. Spivak, Calculus on Manifolds, W. A Benjamin, New York, 1965. 3. 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

Discipline Specific Elective Courses

Subject Code: MATEC01 **Credits:4**

Integral Equations and Calculus of Variations

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	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	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	Introduction, fundamental properties of eigenvalues and eigenfunctions for symmetric kernels, Hilbert-Schmidt theorem, solution of a symmetric integral equation.	12
IV	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 conditions for weak/strongextremum.	12
V	Direct methods in variational problems: Minimizing sequence, Direct Methods, Euler's finite difference methods, The Ritz method, Kantorovich's method.	12
	References: 1. R. P. Kanwal, Linear Integral Equations: Theory & Technique, Second Edition, Birkhäuser, 2013. 2. L. Elsgolts, Differential Equations and the Calculus of Variations, MIR Publishers, Moscow, 1970. 3. I. M. Gelfand and S. V. Fomin, Calculus of Variations, PrenticeHall, New Jersey, 1963. 4. F. B. Hildebrand, Methods of Applied Mathematics, Dover,	

	NewYork, 1992. 5. F. G. Tricomi, Integral Equations, Dover Publications, 1985 6. Weinstock, Calculus of Variations, with Applications to Physics and Engineering, McGraw-Hill, New York, 1952.	

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: 3**

Design and 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, recurrence relations and closed form solution, tools and techniques for summation, manipulation of sum, floor and ceiling functions, finite and infinite calculus, problem solving using tools.	9
II	Number theory an applied perspective, divisibility, introduction to relations and functions, mod and congruence relation, application of congruence, independent residues.	9
III	Permutation, permutation of multi sets, combination, application of permutation and combination, combinatorial properties of permutations.	9
IV	Design and analysis of algorithms with examples like Euclid algorithm etc.,	9
V	Sorting, insertion sort, divide and conquer approach, merge sort, quick sort, asymptotics and analysis, complexity theory, polynomial time, complexity classes, class P, NP, NPC, reducibility, NP completeness problems, scientific computing with open-source R.	9
	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 theorem and 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 $GL(n,\mathrm{R})$, Examples of subgroups of $GL(n,\mathrm{R})$, polar decomposition in $GL(n,\mathrm{R})$, 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: 3**

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 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),	9
II	Axioms of congruence, Consequences of the axioms of congruence, Axiom of Continuity (Archimedes's axiom), compatibility of the axioms, Independence of the axioms of parallels.	9
III	Non-euclidean geometry, Independence of the axioms of congruence, Independence of the axiom of continuity. Non-archimedean geometry.	9
IV	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.	9
V	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.	9
	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, 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: 3**

Mechanics

Course Outcome (CO)

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

	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.	9
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.	9
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.	9
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.	9
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.	9
	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 Sarkovskii's theorem	Remember / Understand
CO 2	discuss on the concept of attracting, repelling periodic points and understand the theory of bifurcation 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**

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

Course Code: MATEC16 **Credit: 4**

Fractional Differential Equations

Course Outcome (CO)

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

	Course Outcome	Level
CO 1	Remember the Laplace transform and inverse Laplace transform for differential equations	Remember/ Understand
CO 2	Apply Caputo and Riemann- Liouville fractional integrals and derivatives to find the relation	Apply
CO 3	Analyze the equations with constant and matrix coefficient of a fractional differential equation	Analyze
CO 4	Evaluate the appropriate methods to solve the fractional Differential Equations	Evaluate
CO 5	Create the mathematical modelling of fractional order differential equations and analyzing the stability analysis	Create

Syllabus

Units	Content	Hrs.
I	Brief history, Tautochrone Problem, Mittag-Leffler (ML) function, properties of ML function, recurrence relations and operations on ML function, Wright functions, Laplace transform, inverse Laplace transform, fixed point theorems, examples.	12
II	Fractional calculus, preliminaries, Riemann-Liouville fractional integrals and derivatives, Caputo fractional derivatives, analysis on fractional operators, relation in between RL and Caputo fractional derivative, Laplace transform of fractional operators, examples.	12
III	Fractional differential equations, motivation, equation with constant coefficient, equation with matrix coefficient, nonlinear equations, nonlinear damped equations, examples.	12
IV	Existence and uniqueness theorem for linear and nonlinear fractional differential equations (FDE). Successive approximation and Laplace transform method to solve FDE in homogeneous and non homogeneous case, stability analysis.	12
V	Fractional modelling, physical models, biological models, system biological models, biochemical kinetics, enzyme kinetics	12
	References: 1. K. Deithelm, The Analysis of Fractional Differential Equations, Springer, Berlin, 2010. 2. K.S. Miller and B. Ross, An Introduction to the Fractional Calculus and Fractional Differential Equations, John Wiley, New York, 1993. 3. K. B. Oldham and J. Spanier, The Fractional Calculus, Academic Press, New York, 1974. 4. I. Podlubny, Fractional Differential Equations, Academic Press, New York, 1999. 5. S. G. Samko, A. A. Kilbas and O. I. Marichev, Fractional Integrals and Derivatives (Theory and Applications), Gordon and Breach	

	Science Publishers, Amsterdam, 1993. 6. B. Ingalls, Mathematical Modelling in Systems Biology: An Introduction, MIT Press, Cambridge, 2013. 7. K. Balachandran, An Introduction to Fractional Differential Equations, Industrial and Applied Mathematics, Springer Nature, Singapore Pte Ltd.,2023. 8. A.A. Kilbas, H.M. Srivastava, J.J. Trujillo, Theory and Applications of Fractional Differential equations, North Holland Mathematics Studies, 2006.	

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	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: MATEC17 **Credit: 3**

Numerical Methods for Differential Equations

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	Single-step methods, Euler's method, Taylor series method, Runge-Kutta methods, multistep methods, convergent and stability analysis.	9
II	Finite difference approximations to derivatives, notations, finite difference method, linear problems with Dirichlet and non-Dirichlet boundary conditions, nonlinear problems.	9
III	Poisson equation on a rectangular domain, Dirichlet boundary conditions, non-Dirichlet boundary conditions, convergence analysis.	9
IV	The heat equation with Dirichlet boundary conditions: forward, backward, and Crank-Nicolson method, absolute stability, non-Dirichlet boundary conditions.	9
V	Advection equation: Upwind differencing, convection-diffusion equation, wave equation	9
	References: 1. K. Atkinson, W. Han and D. Stewart, Numerical Solution of Ordinary Differential Equations, John Wiley & Sons, 2009 2. B. Bradie, A friendly introduction to numerical analysis, Pearson Education, 2007. 3. R. L. Burden and J. D. Faires, Numerical Analysis, Ninth Edition, Cengage Learning, 2011. 4. G. D. Smith, Numerical Solution of P.D.E., Oxford University Press, New York, 1995. 5. 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

Subject Code: MATEC18 **Credits: 2**

Numerical Analysis - Lab

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	remember program for simple arithmetic operations with scalars, vectors and matrices.	Remember/ Understand
CO 2	implement computer program to solve algebraic and transcendental equations	Apply
CO 3	test the problem by producing two-dimensional and three-dimensional plots	Analyze
CO 4	select computer algorithm to solve differential equations	Evaluate
CO 5	develop a computer algorithm to analyze the consistency, stability and convergence of a numerical methods.	Create

Syllabus

Units	Content	Hrs.
	Laboratory Assignments (not limited to): 1. To find the roots of the Algebraic and Transcendental equations using Bisection method, Regula-Falsi method, Newton-Raphson method, Secant method and Iterative method 2. To solve the system of linear equations using Gauss elimination method, Gauss Jacobi method, Gauss-Seidal method and Gauss Jordan method 3. To determine the Eigen values and Eigen vectors of a Square matrix. 4. To find the largest eigenvalue of a matrix by power method. 5. To implement Numerical Integration using Trapezoidal rule. 6. To implement Numerical Integration using Simpson 1/3 rule. 7. To implement Numerical Integration Simpson 3/8 rule 8. To implement Newton's Forward/Backward Interpolation formula 9. To implement Gauss Forward/Backward Interpolation formula 10. To implement Newton's Divided Difference formula 11. To implement Langrange's Interpolation formula 12. To find numerical solution of ordinary differential equations by Euler's method, Runge-Kutta method and Adams-Bashforth method 13. To plot error between the exact and numerical solutions	60
	References: 1. A. Quarteroni, F. Saleri and P. Gervasio, Scientific computing with MATLAB and Octave, Springer-verlag, Berlin, 2010. 2. S. L. Campbell, J. P. Chancelier and R. Nikoukhah, Modeling and Simulation in Scilab/Scicos, Springer, 2009. 3. S. Nagar, Introduction to Scilab: For engineers and scientists, APress, 2017. 4. S. Linge and H. P. Langtangen, Programming for Computations -	

	MATLAB/Octave: A Gentle Introduction to Numerical Simulations with MATLAB/Octave, Springer Open, 2016. 5. J. Kiusalaas, Numerical methods in engineering with Python 3, Cambridge University Press, 2013. 6. R. A. Mezei, An introduction to SAGE programming with applications to SAGE interacts for Numerical Methods, John Wiley & Sons, 2016. 7. K. E. Atkinson, An Introduction to Numerical Analysis, Wiley, 1989.	

Mapping of Program Specific Outcomes with Course Outcomes

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	0	0	1	0	0	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

Multidisciplinary/Open 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 else if 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, 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

Subject Code: MATOE05 **Credits: 3**

Mental Math – Math Tricks for Calculations

Course Outcome (CO)

On completion of the course the students will be able to

	Course Outcome	Level
CO 1	realize your mental ability without seeking support from technology including a calculator	Remember/ Understand
CO 2	do math in their mind faster than they ever thought possible	Apply
CO 3	describe various tricks and methods to do math mentally by improving their memory	Analyze
CO 4	bring an exciting, entertaining view of what can be done with numbers and the art of rapid mental calculation	Evaluate
CO 5	venture their mind that will impress their friends, colleagues, and teachers	Create

Syllabus

Units	Content	Hrs.
I	Mental Ability: A Historical orientation, Classical Greek, Alexandrian, Hindus and Arabs aspects of mathematics. Logic and Mathematics, statements, Negation statements, Contrapositive statement and Converse of statements.	9
II	Methods for Mental Math: Object number mapping and various tricks to memorize; Table of 100 objects numbering from 1- 100, Tricks to memorize or remember intermediate numbers during addition and multiplication.	9
III	Mental Exercise: Methods of Mental reasoning, Various tricks for performing addition and multiplications mentally, Creation of local memory for higher arithmetic.	9
IV	Theory and tricks behind Puzzles: Sudoku, Logic, deductive reasoning to eliminate impossible values in cells based on the existing numbers in their row and column, Sudoku as collection of permutations in S_9, Nonograms- different techniques to solve this type of logical problems.	9
V	Applying logic to word puzzles: Methods of reasoning to solve puzzles like deductive and inductive reasoning. Guesstimate: to estimate without sufficient data, estimate based on guess work or conjecture to arrive at an estimate with a reasonable error.	9
	References: 1. Shakuntala Devi, Puzzles to Puzzle you, Orient Paperbacks (1976), SBN-9788122200140. 2. Peter Hollins, Painless Mental Math -Painless Mental Math: Quick, Easy, and Useful Ways to Become a Human Calculator, India Penguin (2025), ISBN-100143473875 3. Sam Aaron, Sudoku Solving Techniques, CreateSpace Independent Publishing Platform (2013), ISBN-10: 1493624520 4. Arthur Benjamin, Michael Shermer, Secrets of Mental Math, ISBN-10: 9780307338402 5. Peter Hollins, Painless Mental Math - Painless Mental Math: Quick, Easy, and Useful Ways to Become a Human Calculator, India Penguin (2025), ISBN-10: 0143473875	

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