P.D.E.A's

Prof. Ramkrishna More Arts, Commerce, Science College

Akurdi Pune-411044

Affiliated to

Savitribai Phule Pune University [SPPU]

B.Sc. Mathematics / B.Sc. Honors Mathematics

(Three Years B.Sc. and Four Years B.Sc, **Honors** Program)

Choice Based Credit System [CBCS]

Under

Autonomy and NEP-2024 Pattern

From Academic Year 2026-2027

Syllabus

Third Year Graduate (T.Y.B.Sc.)Mathematics

Board of Studies in Mathematics

(Prof. Ramkrishna More College Akurdi, Pune-411044)

Preamble of the Syllabus:

B.Sc Mathematics program is designed to bridge the gap between IT industries and academic industries by incorporating the latest development into the curriculum and to give students a complete understanding within a structured framework. This is intended to provide a broad framework within which help to create an academic base that responds to the need of the students to understand the basic of Mathematics and their applications. The curriculum framework is designed and formulated in order to acquire and maintain standards of achievement in terms of knowledge, understanding and skills in Mathematical Science and their applications, critical thinking and developing skills for problem solving and initiating research which are competitive globally. This program is for candidates who wish to explore new emerging technologies using computer languages and Mathematical software . It wii provide the necessary skills to make the successful candidate proficient in software development, research innovations, paving the way for self-employment. The curriculum is oriented more towards programming and software. Ability to apply the algorithmic principles, mathematical foundations and computer science theory for designing computer-based systems.

Rules and Regulations

1. **National Credit Framework (NCF):** For creditisation and integration of all higher education qualifications leading to a certificate/diploma/degree with **multiple entry and exit options**, college will refer to National Credit Framework (NCF) which encompasses the qualification frameworks for higher education, vocational and skill education and school education, namely National Higher Education Qualification Framework (NHEQF), National Skills Qualification Framework (NSQF) and National School Education Qualification Framework (NSEQF) respectively.

2. **Structure of Four years multidisciplinary UG Programme and Five Years Integrated Multidisciplinary Master's Degree Programme with Multiple Entry and Exit Options at Different Levels:**

   (i) Students will have the flexibility to enter four years multidisciplinary Under Graduate Programme in odd semesters and exit a programme after the successful completion of even semesters as per their future career needs.

   (ii) Students will get a Certificate after a One year programme (minimum 40 Credits), a Diploma after two years (minimum 80 Credits), a Bachelor's degree after three years (minimum 120 Credits), and a Bachelor's degree with Research or Honours after Four years (minimum 160 Credits).

3. **Qualification Type and Credit Requirements of Four Years Multidisciplinary Degree Programme with Multiple Entry and Exit Options:**

   Details of qualifications, minimum credit requirements, exit credit courses, year and semester are as under.

Level	Qualification Title	Credit Requirements		Semester	Year
		Minimum	Maximum		
4.5	UG Certificate	40	44	2	1
5.0	UG Diploma	80	88	4	2
5.5	Three Year Bachelor's degree	120	132	6	3
6.0	Bachelor's degree with Research/Honours with Major	160	176	8	4
7.0	Master's Degree	200	220	10	5
8.0	Ph.D	—	—	—	—-

(ii) An exit 6-credit bridge course(s) lasting two months, including at least 6-credit job specific internship/apprenticeship that will help the graduates acquire job-ready competencies required to enter the workforce will be an additional requirement for the award of the undergraduate Certificate/ Diploma/ three year Bachelor's Degree.

(iii) On exit, the students will have the option to re-enter the programme in the college, or in a different higher education institution. Re-entry at various levels for lateral entrants in academic programmes should be based on the earned and valid credits as deposited and accumulated in the Academic Bank of Credits (ABC) through Registered Higher Education Institutions (RHEI) and proficiency test records.

(iv) Eligibility for admission to the fourth year of four-year Honours with Research Degree Programmes as per UGC guidelines: Minimum CGPA of 7.5 or minimum 75 % at three-year degree.

(v) PG curriculum, as illustrated below, have flexibility a) One-year Post- Graduate Diploma (PGD), b) Two year Post-graduate Programme and c) 5 Years Master's degree programmes with multiple Entry and Exit options at different levels.

a) **Post-Graduate Diploma (PGD):** Programme duration- One year (2 semesters) after any bachelor's degree, min. 40 credits.

(i) UGC: 1-Year (2 semesters) Post-Graduate Diploma (PGD) after 3- years Bachelor's degree: Level 6.0

(ii) UGC: 1-Year (2 semesters) PGD after 4 years Bachelor's degree (Honors/ Research): Level 6.5

b) **Master's Degree:**
UGC: 2-Years (four semesters) Master's Degree after obtaining a 3- years Bachelor's degree, Minimum 40 credits/year, second year devoted entirely to research, PG – 2nd year: Level 6.5
OR
1-Year (two semesters) Master's Degree after obtaining a 4-year Bachelor's degree (Honours/Research): Minimum 40 credits: Level 6.5

c) **Level 8 represents Ph. D. Research Degree**.

d) **A 5-year Integrated Bachelor's and Master's programme shall have a minimum of 220 credits**.

e) **Master's and doctoral programmes, while providing rigorous research-based specialization, should also provide opportunities for multidisciplinary work, in academia, government, research institutions, and industry**.

4. **Lateral Entry/ Re-entry at higher Levels after exit from lower levels of four years multidisciplinary UG degree programme:**

(i) The credit points earned and accumulated shall be used to determine the eligibility for taking admission to various programs at multiple levels, subject to fulfilment of the broad principles laid down under NCrF.
Students who leave with a Certification, Diploma, or a Basic Bachelor's Degree will be eligible to re-enter the programme at the exit level to complete or progress to the next level through lateral entry mode. Depending upon the academic and physical facilities available, the State Universities/ Autonomous Colleges (Higher Education Institutions or HEI) may earmark specific seats/ intake for lateral entry into the second year/ third year/ fourth year of a four years multidisciplinary UG degree programme as approved by Professional Standard Setting Bodies (PSSB/Govt. of Maharashtra/ statutory council of affiliating University plus any consequential vacancies caused by exits to an ongoing programme (four-year Degree Programme and Integrated Master's or second year Master's). Lateral entry or Re-entry is open to those students if he/she has either –
(a) successfully completed the first year/second year/third year of the particular four years multidisciplinary degree programme in any ABC registered HEI with valid credits in ABC and re-entering into the second year/third year/fourth year, respectively of the same four years degree programme of any ABC registered HEI, within stipulated/ permissible period of years as decided by Statutory Councils of that HEI
OR
(b) Already successfully completed a multidisciplinary four-year first- degree programme and is desirous of and academically capable of pursuing another multidisciplinary four years first-degree programme in an allied subject.

(ii) A student will be allowed to enter/re-enter only at the odd semester. Re-entry at various levels for lateral entrants in academic programmes should be based on the earned and valid credits as deposited and accumulated in Academic Bank of Credits (ABC) through Registered Higher Education Institutions (RHEI) and proficiency test records. However, in terms of the admission eligibility

requirements, the student shall belong to the same faculty/ discipline in terms of Major Subject i.e., the Major subject of his earlier Programme and the Major subject of the new Programme for which he is seeking admission must be from the same faculty/discipline. Reservation for lateral entry will be executed as per the Government of Maharashtra norms.

5. **Distribution of Credits across Multidisciplinary Four Years Degree Program:**

(i) Four-year multidisciplinary degree programme with Honours/ Specialization Degree will have Internship and Core /Major Courses with a minimum of 22 credits per sem. in the Fourth Year.

(ii) Four-year multidisciplinary degree programme with Research will have Research Projects, Seminars, Dissertations and Internships with a minimum of 22 credits per Sem. in the Fourth Year.

(iii) Students shall select a **'Major or Core Subject/ Discipline' and a 'Minor Subject/Discipline' from the lists of various Subject Combinations and Options provided the Colleges**. In general, for the four years multidisciplinary bachelor's degree programme, the distribution of credits will be as follows:
(a) Disciplinary/interdisciplinary Major/ Core Subject (minimum of 68 credits)- Mandatory and Elective Courses
(b) Disciplinary/interdisciplinary Minor Subject (maximum of 22 credits)
(c) Skill based/Vocational studies corresponding to the Major/ Core Subject (8 credits)
Field projects/internship/apprenticeship/community engagement and service corresponding to the Major/ Core Subject (14-22 credits) with a maximum of six credits per Semester
(e) Generic/ Open Electives through Baskets of Elective Courses (12 credits)
(f) Ability Enhancement Courses including Languages, Literature and Environmental Studies (12 credits) In-built modules on the Indian Knowledge System (IKS) in Major/ Core Subject at Level 4.5 – 2 credits
(h) Value-based Education, Life Skills and Professional Ethics: Co- curricular Courses such as Sports and Culture, NSS/NCC and Fine/ Applied/Visual Arts (8 credits).
Student can earn some credits (SEC/VSC/GE/OE) in the form of online from-

(i) The National Skills Qualifications Framework (NSQF) organizes qualifications for Vocational and Skill Courses in a series of 8 levels based on professional knowledge, professional skills, core skills and responsibilities, in the increasing order of complexity and competency.

(ii) University Grants Commission (Credit Framework For Online Learning Courses through Study Webs of Active-Learning for Young Aspiring Minds) Regulations, 2021, **permits up to 40 per cent of the total courses being offered in a particular programme in a semester through the Online Learning Courses offered through the Study Webs of Active-Learning for Young Aspiring Minds (SWAYAM) platform**.

6. **Examination and Assessment Process:**

(i) The basic principle of the credit framework is that credits are a function of the successful completion of a program of study/ vocational education/ training and assessment. No credit can be earned by the student unless the student is assessed for the achievement of the desired competencies and outcome of a program.

(ii) Exit options are provided with certification, diploma and basic Bachelor's degrees to the students at the end of the second, fourth and sixth semesters of a four years multidisciplinary degree programme. Students will receive a Bachelor's degree with Honours/ Research on successfully completing of all eight semesters of the UG Program either at a stretch or with opted exits and re-entries. For the smooth success of four-year multidisciplinary degree programme with multiple

entry and exit systems, the examination mode will be based on the combination of innovative trends in formative (informal and formal tests administered during the learning process) and summative (evaluation of student learning at the end of an instructional unit) examination modes. This is in line with the UGC Report on 'Evaluation Reforms in Higher Educational Institutions (2019)'.

(iii) **Evaluation of each students in each course will be done as follows:**

a. Each theory or practical course will be of 2 credits = 50 mark

b. Internal evaluation 40 % weightage (20 mark)

c. External evaluation 60 % weightage (30 marks)

d. Students should secure 40% marks in each type of evaluation for successful completion of a course (student should secure at least 8 marks in internal and 12 marks in external evaluation).

(iv) **Evaluation Pattern**.

a. Internal evaluation - Two written test, each of 20 marks will be conducted i. e. two tests on two modules. 1st assignment after completing 6 weeks of teaching and 2nd on completion of 13th week of teaching. Question paper should be designed so that evaluation of CO, PO, PSO can be performed. 10 marks out of 20 will be assigned from these written tests. Remaining 10 marks will be assigned from other types of evaluation such as seminars, orals, poster presentation, open book challenging tests, surprise test, objective test on whole syllabus of the course (at least 40 questions of objective type must be designed), etc. for 5 marks at least two different types technique must be utilized.

b. External Evaluation - External evaluation will be done at the end of semester. For theory, 30 marks written examination will be conducted and time of examination will be 2-hours.

7. **Declaration of Results:**

(i) Declaration of result is based on the Semester Grade Point Average (SGPA) earned towards the end of each semester or the Cumulative Grade Point Average (CGPA) earned at the completion of all eight semesters of the programme and the corresponding overall alpha-sign or letter grades as given in Table 2. If some candidates exit at the completion of the first, second or third year of the four years Undergraduate Programmes, with Certificate, Diploma or Basic Degree, respectively, then the results of successful candidates at the end of the second, fourth or sixth semesters shall also be classified on the basis of the CGPA obtained in the two, four, six or eight semesters, respectively. Successful candidates at the end of the tenth semester of the integrated Master's Degree Programmes shall also be classified on the basis of CGPA obtained in the ten semesters of the Programmes. Likewise, the successful candidates of one year or two semesters Master's Degree Programme are also classified on the basis of the CGPA of two semesters of the Master's Degree Programme. **Table-2: Grades on degree certificate/mark sheet will be assigned to the students as per the following table**

Semester GPA/ Program CGPA Semester/Program	% of Marks	Alpha-Sign / Letter Grade Result
9.00-10.00	90-100	O (outstanding)
8.00 - ¡9.00	80.00 – ¡90.00	A+ (Excellent)
7.00 - ¡8.00	70.00-¡80.00	A (Very Good)
6.00 - ¡7.00	60.00-¡70.00	B+ (Good)
5.50 - ¡6.00	55.00-¡60.00	B (Above Average)
5.00 - ¡5.50	50.00-¡55.00	C (Average)
4.00 - ¡5.00	40.00-¡50.00	P (Pass)
Below 4.00	¡ 40	F (Fail)
Ab	———	Absent

(ii) A student obtaining Grade F shall be considered failed and will be required to reappear in the examination. For non-credit courses 'Satisfactory' or "Unsatisfactory' shall be indicated instead of the letter grade and this will not be counted for the computation of SGPA/CGPA.

8. **Award of Major and Minor Degree:**

(i) A student pursuing four-year multidisciplinary UG programme will be awarded an appropriate Honours/ Research degree in Major/ Core Subject on completion of VIII Semester with the minimum of 176 credits if he secures in that Subject at least 50% of the total credits for that programme. He shall thus study the specific number of Mandatory Core Courses, Core Electives, Vocational and Skill Courses and Field projects/ Internships connected to Core Subjects in eight semesters so as to cover at least 50% of the total credits.

(ii) In case of Research Degree, a student shall pursue research project and write dissertation in that Major in the VII and VIII semesters.

On the basis of above rules and regulations under NEP-2020 following course frame work is adopted by the Prof. Ramkrishna More Arts, Commerce and Science College, Akurdi, Pune- 411044 for the completing of four years honours degree in Major and Minor subjects.

9. **Distribution of Credits across Four Years Degree Programmes:** In general, for the four years' bachelor's degree programme, the distribution of credits will be as follows: (a) Major (Core) Subject comprising Mandatory and Elective Courses:

i. Minimum 50% of total credits corresponding to Three/Four - year UG Degree- Mandatory Courses offered in all Four years;

ii. 2 credit course on Major Specific IKS shall be included under Major;

iii. Elective courses of Major will be offered in the third and/or final year.

iv. Vocational Skill Courses, Internship/ Apprenticeship, Field Projects, Research Projects connected to Major first to fourth year. **(b) Minor Subject: 18-20 Credits**

i. The Minor subjects may be from the different disciplines of the same faculty of DSC Major (Core) or they can be from different faculty altogether.

ii. The credits of Minor subjects shall be completed in the first three years of UG Programme.

(c) Generic/ Open Elective Courses (OE): 10-12 credits

i. It is to be offered in I and/or II year

ii. Faculty-wise baskets of OE shall be prepared by University/ Autonomous Colleges.

iii. OE is to be chosen compulsorily from faculty other than that of the Major.

(d) Vocational and Skill Enhancement Courses (VSEC): 14-16 credits Vocational Skill Courses (VSC): 8-10 credits, including Hands on Training corresponding to the Major and/or Minor Subject:

i. To be offered in first to three years; Wherever applicable vocational courses will include skills based on

ii. advanced laboratory practical of Major

(e)Skill Enhancement Courses (SEC): 06 credits

i. To be offered in I and II year;

ii. To be selected from the basket of Skill Courses approved by University/ Autonomous Colleges

10. **(f) Ability Enhancement Courses (AEC), Indian Knowledge System (IKS) and Value Education Courses (VEC): 14 Credits**
    - **AEC: 08 credits**

i. To be offered in I and II year

ii. English: 04 Credits

iii. Modern Indian Language: 04 credits

iv. To be offered from the Basket approved by the College; The focus for both languages should be on linguistic and communication skills.
    - **IKS: 2 Credits**

i. To be offered in I Year

ii. Courses on IKS to be selected from the basket of IKS courses approved by the Colleges
    - **VEC: 04 Credits**

i. To be offered in I year

ii. Value Education Courses (VEC) Environmental Science Education (Compulsory), Understanding India, and Digital and Technological Solutions.

11. **(g) Field Projects/ Internship/ Apprenticeship/ Community Engagement and Service corresponding to the Major (Core) Subject, Co-curricular Courses (CC) and Research Project**

- Internship/Apprenticeship corresponding to the Major (Core) Subject: 8 Credits
- Field Projects/Community Engagement and Service corresponding to the Major (Core) Subject: minimum 4-6 credits
- To be offered in II, and III years of UG Degree Programmes.
- Co-curricular Courses (CC) such as Health and Wellness, Yoga education sports, and fitness, Cultural Activities, NSS/NCC and Fine/ Applied/ Visual/ Performing Arts: 8 credits. To be offered in I and/or II year

(f) Research Projects: 12 credits

To be offered in the final year for 4-year Honours with Research UG Degree The UGC Regulations, 2021 permit up to 40% of the total courses being offered in a particular programme in a semester through the Online Learning Courses offered through the SWAYAM platform and/or other State Level Common Platforms which can be developed in due course with the participation of different Universities/ HEIs.

Abbreviations:

Generic/ Open Electives: GE/OE; Vocational Skill and Skill Enhancement Courses: VSEC; Vocational Skill Courses: VSC; Skill Enhancement Courses: SEC; Ability Enhancement Courses: AEC; Indian Knowledge System: IKS; Value Education Courses: VEC; OJT: On Job Training: Internship/ Apprenticeship; Field projects: FP; Community engagement and service: CEP; Co-curricular Courses: CC; Research Methodology-RM; Research Project: RP

Note: The Credit Distribution Table given above is illustrative only. The Universities/ Autonomous Colleges may suitably modify within the broader framework of credit distribution across six verticals.

12. **Graduate and Honors Degree Course Framework under Autonomy as per NEP-2020 Science If not mentioned, each proposed course (theory/practical) is of 2 credits.**

Level / Difficulty	Sem	Subject-1	Subject-2	GE/OE	SEC	IKS	AEC	VEC	CC	Total
Certificate										
4.5 / 100	**I**	(2+2)T+2P Credits	(2+2)T+2P Credits	2T	2T/P	2T (General)	2T	2T	0	22
	II	(2+2)T+2P Credits	(2+2)T+2P Credits	2T/P	2T/P	0	2T	2T	2	22
Exit option: Award of UG Certificate in Major with 44 credits and an additional 4 credits core NSQF course/ Internship OR Continue with Major and Minor **Continue option:** Student will select one subject among the (subject 1, subject 2 and subject 3) as major and another as minor and third subject will be dropped.										
Diploma										
Level / Difficulty	**Sem**	**Credits Related to Major**				**Subject-2**	**GE/OE**	**SEC**	**IKS**	**AEC**	**VEC**	**CC**	**Total**
		Major Core	**Major Elective**	**VSC**	**FP / CEP / OJT**								
5.0 / 200	**III**	(2+2)T+2P Credits	0	2T	2 FP	2T+ 2P	2T	0	2T **(Major Specific)**	2T	0	2	22
	IV	(2+2)T+2P Credits	0	2P	2 CEP	2T + 2P	2T/P	2T/P	0	2T	0	2	22
Exit option: Award of UG Diploma in Major and Minor with 88 credits and an additional 4 credits core NSQF course/ Internship OR Continue with Major and Minor													
Three years Graduation Degree													
5.5 /300	**V**	(2+2+2+2)T+ (2+2)P credits	(2+2)T + 2P	2P	2 FP	0	0	0	0	0	0	0	22
	VI	(2+2+2+2)T+ (2+2)P credits	2T + 2P/T	2T	4 OJT	0	0	0	0	0	0	0	22
	Total Credits	**48**	**10**	**8**	**10**	**20**	**8**	**6**	**4**	**8**	**4**	**6**	**132**

Vocational Skill Courses;
GE/OE: Generic/ Open Electives;
SEC: Skill Enhancement Courses;
CC: Co-curricular Courses
AEC: Ability Enhancement Courses,
IKS: Indian Knowledge System;
VEC: Value Education Courses
FP – Field Project;
CEP – Community Engagement Project;
RM – Research methodology;
RP - Research Project; OJT – On Job training;

Definitions:

1. **One semester** = 15 weeks
2. **1-credit theory** = 15 hours i.e. for 1 credit, 1 hour per week teaching is to be performed. 15 hours of 1-credit are splinted as 12 hours actual teaching + 3 hours Tutorial (practice problem solving sessions, repeated discussion on difficult topics, discussion on student's difficulties, questions discussion and internal evaluation)

1-credit practical = 30 hours. Thus, 1 credit practical = 2 contact hours in laboratory

3. per week. 30 hours splinted as 24 hours actual table work and 6 hours for journal competition, oral on each practical and other internal evaluation.

4. Each theory course of any type (major, minor, VSC, VEC, OE/GE, VEC, SEC, CC, etc.) is of 2 credits.

a. Theory per semester: Contact hours = 24 teaching + 6 tutorials (problem solving sessions, repeated discussion on difficult topics, difficult solution, questions discussion and internal evaluation)

b. Each course will be of two modules, One module = 15 hours

c. Each module may consist of one or more than one chapter.

5. Each practical course of any course is of 2 credits = 60 hours per semester

a. Minimum 12 laboratory sessions will be conducted in one semester.

b. Each laboratory sessions will be of 4 hours.

Structure of the course B. Sc. Mathematics: Major, Major Elective and VSC Courses

Sem	Course Type	Course Code	Generic Name	Title of the Paper
V	Major	MTMAT-351	Mathematics theory paper-11	Metric Spaces
		MTMAT-352	Mathematics theory paper-12	Real Analysis-I
		MTMAT-353	Mathematics theory paper-13	Group Theory
		MTMAT-354	Mathematics theory paper-14	Ordinary Differential Equations
		MTMAP-355	Mathematics practical paper-5	Mathematics Practical V (Based on Metric Spaces and Group Theory)
		MTMAP-356	Mathematics practical paper-6	Machine Learning-I
	Major Elective	MTMET-351A	Mathematics Elective theory paper-1	Financial Mathematics-I
		MTMET-352A	Mathematics Elective theory paper-2	Operations Research
		MTMET-353A	Mathematics Elective theory paper-2	Laplace Transform
		MTMEP-351B	Mathematics Elective practical paper-1	Financial Mathematics-I using Python
		MTMEP-352B	Mathematics Elective practical paper-2	Laplace Transform
	VSC (Related to Major)	MTVSP-351	Vocational Mathematics Practical-2	Scientific Writing Using LaTeX
	RP	MTRPP-351		Research Project
VI	Major	MTMAT-361	Mathematics theory paper-15	Complex Analysis
		MTMAT-362	Mathematics theory paper-16	Real Analysis-II
		MTMAT-363	Mathematics theory paper-17	Ring Theory
		MTMAT-364	Mathematics theory paper-18	Partial Differential Equations
		MTMAP-365	Mathematics practical paper-7	Optimization Technique
		MTMAP-366	Mathematics practical paper-8	Machine Learning-II
	Major Elective	MTMET-361A	Mathematics Elective theory paper-3	Financial Mathematics-II
		MTMET-362A	Mathematics Elective theory paper-4	Differential Geometry
		MTMEP-361B	Mathematics Elective practical paper-3	Financial Mathematics-II using Python
		MTMEP-362B	Mathematics Elective Practical paper-4	Differential Geometry with Python
	VSC (Related to Major)	MTVST-361	Vocational Mathematics Theory-2	Number Theory
	OJT	MTOJP-361		On Job Training

Program Outcomes:

PO1: Knowledge: The learner is encouraged to use various mathematical methods (analytical and numerical) and experimental methods as an application to the acquired concepts and principles that help in studying various branches of sciences.

PO-2: Problem Analysis: Well equipped with an understanding of the analytical methods involved, they are in a position to interpret and analyse results obtained from experiments and draw suitable conclusions against their supported data acquired.

PO-3: Designing Solutions: Having acquired knowledge of mathematical subjects, students are trained to think out of the box, design and conduct an experiment or a series of experiments that demonstrate their understanding of the mathematical methods and processes involved.

PO-4: Communication: Ability to share ideas and insights while seeking and benefitting from knowledge.

PO-5: Project management and finance: Demonstrate knowledge and understanding of the Mathematical principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO-6: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern Mathematical and IT tools including prediction and modelling to Industrial activities with an understanding of the limitations.

PO-7: Self-Directed and Life-Long learning: Work independently, identify appropriate resources required for a project, and manage a project through to completion. Exhibit subject-specific transferable knowledge in Mathematics relevant to job trends and employment opportunities.

PO-8:Environment and Sustainability: Understand the issues of environmental contexts and sustainable development.

PO-9: Critical Thinking: Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.

PO-10: Science and Society: Learners are encouraged to take up specific projects such as impact of salinity on fresh water wells in an adopted village, and provide effective solutions.

Program Specific Outcomes:

PSO-1: Demonstrate educational skills in areas of Analysis, Geometry, Algebra, Mechanics, Differential Equations, etc.

PSO-2: Help the students to enhance their knowledge in soft skills and Computing skills.

PSO-3: Fulfil one's learning requirements in mathematics, drawing from a range of contemporary research works and their application in diverse areas of Mathematical Sciences

SEMESTER-V

Mathematics Theory Paper-11

Course Code: MTMAT-351 **Course Type: Theory**
Course Name: Metric Spaces **Hours: 30**
Credits: 2

Module-I

Unit 1: Basic Notions [07 Hours]

1. Definition and examples
2. Open Balls and Open Sets
3. Properties

Unit 2: Convergence [08 Hours]

1. Convergent Sequences
2. Limit points
3. Cauchy Sequences and Completeness

Module-II

Unit 3: Continuity [08 Hours]

1. Continuous Functions
2. Equivalent Definitions of Continuity
3. Limit of a Function
4. Open and Closed Maps

Unit 4: Compactness and Connectedness [07 Hours]

1. Compact Spaces and their Properties
2. Connected Spaces

Recommended Book:
Topology of Metric Spaces, S. Kumaresan, Narosa Publishing House (2nd edition), 2011.

Reference Books:
1. **Metric Spaces**, Satish Shirali and Harikrishnan L. Vasudeva.

2. **Introduction to Metric and Topological Spaces**, W.A.Sutherland .
3. **Metric Spaces**, P.K.Jain and Khalil Ahmad.

Course Outcomes:

CO1: Understand the introductory concepts of metric spaces.

CO2: Define the convergent sequence.

CO3: Correlate these concepts to their counterpart modern analysis by studying examples.

CO4: Learn to analyze mappings between spaces.

CO5: Attain background for advanced courses in real analysis, functional analysis, and topology.

CO6: Appreciate the abstractness of the concepts such as open balls, closed balls, compactness, connectedness etc. beyond their geometrical imaginations.

SEMESTER-V

Mathematics Theory Paper-12

Course Code: MTMAT-352 **Course Type: Theory**
Course Name:Real Analysis-I **Credits: 2**
Hours: 30

Module-I

Unit 1: Logic and Set Theory **[05 Hours]**

1. Set Theory and Venn Diagrams
2. Relations and Functions
3. Countable and Uncountable Sets

Unit 2:Sequences of Real Numbers **[10 Hours]**

1. Definition of sequence and subsequence
2. Limit of a sequence
3. Convergent sequences
4. Divergent sequences
5. Bounded sequences
6. Monotone sequences

Module-II

Unit 3: Operations on convergent sequences and Limit Superior, Limit Inferior **[05 Hours]**

1. Operations on convergent sequences
2. Operations on convergent sequences
3. Limit superior and limit inferior
4. Cauchy sequences

Unit 4: Series of Real Numbers **[10 Hours]**

1. Convergence and divergence
2. Series with nonnegative terms
3. Alternating series

4. Conditional convergence and absolute convergence
5. Tests for absolute convergence
6. Series whose terms form a non-increasing sequence

Recommended Book:
Methods of Real Analysis, Second Edition, Richard R. Goldberg, John Wiley and Sons,Inc

Reference Book:
1. **Real Analysis and Foundations**, Second Edition, Steven G. Krantz, Chapman and Hall/CRC.
2. **Principle of Mathematical Analysis**, Walter Rudin.
3. **Introduction to Real Analysis**, Bartle and Sherbert.

Course Outcomes:

CO1: To learn the basic facts in logic and set theory.

CO2: To define sequence in terms of functions from N to a subset of R.

CO3: To understand several properties of the real line.

CO4: To recognize bounded, convergent, divergent, Cauchy and monotonic sequences.

CO5: To calculate limit superior, limit inferior of sequences and the limit of a bounded sequence.

CO6: To use the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.

SEMESTER-V

Mathematics Theory Paper-13

Course Code: MTMAT-353 **Course Type: Theory**
Course Name:Group Theory **Credits: 2**
Hours: 30

Module-I

Unit 1: Groups [05 Hours]

1. Binary Operation
2. Isomorphic Binary Structures
3. Groups

Unit 2: Subgroups [10 Hours]

1. Subgroups
2. Subgroup Tests
3. Cyclic Groups
4. Classification of Subgroups of Cyclic Groups
5. Properties of Cyclic Groups
6. Examples

Module-II

Unit 3: Permutations [05 Hours]

1. Groups of Permutations
2. Orbits
3. Cycles
4. Alternating Groups
5. Cosets and the Theorem of Lagrange

Unit 4: Homomorphism and Factor Groups [10 Hours]

1. Definition and Examples of Homomorphisms
2. Isomorphism
3. Properties of Homomorphism

4. The First Isomorphism Theorem
5. Normal Subgroups
6. Factor Groups
7. Factor Group Computations and Simple Groups

Recommended Book:
Joseph. A. Gallian, Contemporary Abstract Algebra,(4th Edition), Narosa Publishing House.

Reference Book:
1. **John B. Fraleigh**, A First Course in Abstract Algebra, Seventh Edition, Pearson. Sections: 2,3,4,5,6,8,9,10, 13,14,15.
2. **Basic Abstract Algebra**,P.B. Bhattacharya, S.K. Jain and S.R. Nagpal, Second Ed., Foundation Books, New Delhi, 1995
3. **Abstract Algebra**,David S. Dummit and Richard M. Foote
4. **Fundamentals of Group Theory**, Steven Roman

Course Outcomes:

CO1: Define mathematical objects that are groups, and classify them as abelian, cyclic and permutation groups, etc.

CO2: State fundamental theorem of homomorphism.

CO3: learn about structure preserving maps between groups and their consequences.

CO4: Explain the significance of the notion of cosets, normal subgroups, and factor groups.

CO5: Analyze consequences of Lagrange's theorem.

CO6: Apply the concept of group, cyclic groups, Groups of Permutations to find its applications.

SEMESTER-V

Mathematics Theory Paper-14

Course Code: MTMAT-354 **Course Type: Theory**
Course Name:Ordinary Differential Equations **Credits: 2**
Hours: 30

Module-I

Unit 1:Linear Differential Equations with constant coefficients [7 Hours]

1. Constant coefficient homogeneous equations
2. Characteristic equations
3. Particular solution
4. Initial value problem
5. Shortcut methods to find particular solutions

Unit 2:Non -Homogeneous Linear Equations [8 Hours]

1. Principle of superposition
2. Method of undetermined coefficients
3. Method of reduction of order
4. Method of variation of parameters

Module-II

Unit 3:Series Solutions of Linear Second Order Equations [6 Hours]

1. Review the properties of power series
2. Series solution near an ordinary point
3. Regular singular points
4. Euler equations

Unit 4: System of Equations [09 Hours]

1. Introduction to system of differential equations
2. Linear systems: basic theory of homogeneous linear systems, constant coefficient
3. Homogeneous systems
4. Applications of system of differential equations

Recommended Book:

Differential Equations by George F. Simmons, Steven G. Krantz, Tata McGrawHill.

Reference Book:

1. **An Introduction to Ordinary Differential Equations**
E.A. Coddington, (Prentice Hall)
2. **Ordinary Differential Equations**,V. I. Arnold
3. **Advanced Differential Equations** , M. D. Raisinghania
4. **A Course in Ordinary Differential Equations**,B. Rai, D. P. Choudary and H. I. Freedman.

Course Outcomes:

CO1: Describe the genesis of ordinary differential equations.

CO2: Illustrate Second order with variable coefficient, reduction of order method and nth order differential equations

CO3: Find solution of homogeneous linear systems with constant coefficients.

CO4: Deduce and find solution of linear differential equations.

CO5: Solve DE by variable separable method, can solve exact DE by finding integrating factor.

CO6: Generalize use of power series to solve linear differential equations.

SEMESTER-V

Mathematics Practical Paper-5

Course Code: MTMAP-355 **Course Type: Practical**
Course Name:Mathematics Practical V (Based on Metric Spaces and Group Theory)
Credits: 2 **Hours: 60 Practical: 12**

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1. **Practical No.1:** Convergent Sequences
2. **Practical No.2:** Limit Points
3. **Practical No.3:** Cauchy Sequences and Completeness
4. **Practical No.4:** Continuous Functions
5. **Practical No.5:** Compact Spaces
6. **Practical No.6:** Connected Spaces
7. **Practical No.7:** Binary Operation and Groups
8. **Practical No.8:** Subgroups and cyclic groups
9. **Practical No.9:** Groups of Permutations
10. **Practical No.10:** Cosets and the Theorem of Lagrange
11. **Practical No.11:** Factor Group Computations and Simple Groups
12. **Practical No.12:** Alternating Groups

Reference Book:

1. **Contemporary Abstract Algebra**, Joseph. A. Gallian, ,(4th Edition), Narosa Publishing House.
2. **Topology of Metric Spaces** , S. Kumaresan, Narosa Publishing House (2nd edition), 2011.

Course Outcomes:

CO1: To learn the basic facts in convergence sequences.

CO2: To calculate limit points.

CO3: To use convergence for Cauchy and completeness of sequences.

CO4: learn about structure preserving maps between groups and their consequences.

CO5: explain the significance of the notion of cosets, normal subgroups, and factor groups.

CO6: analyse consequences of Lagrange's theorem.

SEMESTER-V

Mathematics Practical Paper-6

Course Code: MTMAP-356	**Course Type: Practical**
Course Name:Machine Learning-I	**Practical: 12**
Credits: 2	**Hours: 60**

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1. **Practical No.1:** Introduction to Python, Python Data Types-I
2. **Practical No.2:** Python Data Types-II
3. **Practical No.3:** Control statements in Python-I
4. **Practical No.4:**Control statements in Python-II
5. **Practical No.5:**Python collection type – List
6. **Practical No.6:**Data handling with Panda – 1
7. **Practical No.7:**Data handling with Panda – 2
8. **Practical No.8:**Data visualization with Matplotlib
9. **Practical No.9:**Introduction to scikit-learn
10. **Practical No.10:**End to end model implementation-1
11. **Practical No.11:**End to end model implementation-2
12. **Practical No.12:**End to end model implementation-3

Reference Book:

1. **Hands-on Machine Learning with Scikit-Learn, Keras and Tensorflow**,AurelienHeron,Sections: 1, 2.

2. **Python for Data Analysis**, Wes McKinney (O' Reilly publication)Chapter -4:4.1, 4.2,4.3, 4.5, Chapter -5: 5.1, 5.2, 5.3, 5.4, 5.5, Chapter-8:8.1, 8.2, 8.3 .

3. **Think Python,How to Think Like a Computer Scientist**, Allen Downey,, Green Tea Press Needham, Massachusetts, 2015, Sections - 1, 2, 3, 5, 8, 10 .

Course Outcomes:

CO1: Identify machine learning techniques suitable for a given problem.

CO2: Describe the use of Numpy Array and Matrices.

CO3: Discover and visualize data to gain insights.

CO4: Evaluate the ability to write database applications in Python.

CO5: Justify about basic concepts of Machine Learning.

CO6: Solve the problems using various machine learning techniques.

SEMESTER-V

Mathematics Elective Theory Paper-I

Course Code: MTMET-351A **Course Type: Theory**
Course Name:Financial Mathematics-I **Credits: 2**
Hours: 30

Module-I

Unit 1:Basic Concepts [8 Hours]

1. Arbitrage
2. Return and Interest
3. The Time Value Of Money
4. Bonds , Shares And Indices
5. Models And Assumptions

Unit 2: Deterministic Cash Flows-I [07 Hours]

1. Net Present Value
2. Internal Rate of Return
3. A Comparison of IRR and NPV
4. Bonds: Price and Yield
5. Clean and Dirty Price

Module-II

Unit 3: Deterministic Cash Flows-II [09 Hours]

1. Price Yield Curves
2. Duration
3. Term Structure of Interest Rates
4. Immunisation
5. Convexity
6. Callable Bonds

Unit 4: Annuity Theory [6 Hours]

1. Future and Present Values of Simple Ordinary Annuities
2. Amortization Theory
3. Annuities with Varying Payments and Interest Rates
4. Applications of Annuities

Recommended Book:

1.**The Calculus Of Finance** , Amber Habib (Mathematical Sciences Foundation New Delhi)

Reference Book:

2.**An Introduction to Mathematical Finance with Applications**, Arlie O. Petters , Xiaoying Dong (Springer Publications)

3. **Options, Futures, and Other Derivatives**,John C. Hull.

4. **Financial Calculus: An Introduction to Derivative Pricing** , Martin Baxter and Andrew Rennie

5.**Mathematics for Finance: An Introduction to Financial Engineering**, Marek Capiński and Tomasz Zastawniak.

Course Outcomes:

CO1: Define Bonds, Shares and Indices.

CO2: Describe Net Present Value and Internal Rate of Return.

CO3: Demonstrate understanding of concepts relating to functions and annuities.

CO4: Demonstrate understanding of basic concepts in linear algebra, relating to linear equations, matrices, and optimization.

CO5: demonstrate understanding of basic concepts in linear algebra, relating to linear equations, matrices, and optimization

CO6: Explain applications of Annuities.

SEMESTER-V

Mathematics Elective Theory Paper-2

Course Code: MTMET-352A **Course Type: Theory**
Course Name:Operation Research **Credits: 2**
Hours: 30

Module-I

Unit 1:Modeling with Linear Programming [05 Hours]

1. LP Model with two or more variables
2. Solution of LP Model by Graphical Method

Unit 2:The Simplex Method and Duality [10 Hours]

1. LP Model in equation form
2. Transition from graphical to algebraic solutions
3. The Simplex method
4. Definition of the dual problem
5. Primal dual relationship

Module-II

Unit 3:Transportation Model [08 Hours]

1. Definition of the Transportation model
2. North West Corner
3. Least Cost Method
4. Vogel's Approximation Method
5. Modi Method for optimization

Unit 4:The Assignment Model [07Hours]

1. Definition of the Assignment Model
2. The Hungarian method
3. Simplex explanation of the Hungarian method

Recommended Book:
Operations Research, J K Sharma, (Theory and Applications, Latest Edition), Macmillan India Ltd.

Reference Book:
1. **Operation Research**, M.D. Taha, (Theory and Applications, 9th edition)
2. **Operations Research**, Kanti Swarup, P. K. Gupta and Man Mohan

3. **Operations Research**,Hillier and Lieberman (McGraw-Hill).
4. **Operations Research**, R. Panneerselvam.

Course Outcomes:

CO1: Define linear programming, transportation problem, simplex method.

CO2: State Dual problem, Hungarian method.

CO3: Use North West, Least cost, VAM to find solution of transportation problem.

CO4: Find solution of simplex method.

CO5: Describe graphical method of LPP.

CO6: Apply some algorithm to find the assignment problem.

SEMESTER-V

Mathematics Elective Theory Paper-3

Course Code: MTMET-353A **Course Type: Theory**
Course Name:Laplace Transform **Credits: 2**
Hours: 30

Module-I

Unit 1: The Laplace Transform-I [08 Hours]

1. Definition, Laplace Transform of some elementary functions
2. Sufficient condition for existence of Laplace Transform
3. Some important properties of Laplace Transform

Unit 2: The Laplace Transform-II [07 Hours]

1. Methods of finding Laplace Transform: Direct Method, Series Method
2. Evaluation of Integration
3. Some Special Functions

Module-II

Unit 3: The Inverse Laplace Transform [10 Hours]

1. Definition, Some inverse Laplace Transform
2. Some important properties of Inverse Laplace Transform
3. Methods of finding inverse Laplace Transforms: Partial Fraction Method and Series Method
4. The Heaviside's Expansion formula
5. Evaluation of Integration

Unit 4: Applications to Differential Equations [05 Hours]

1. Ordinary Differential Equations with constant coefficients
2. Ordinary Differential Equations with variable coefficients
3. Simultaneous Ordinary Differential Equations

Recommended Book:

1. **Schaum's Outline Series - Theory and Problems of Laplace Transform**, Murray R.Spiegel. Unit 1: Chapter 1, Unit 2: Chapter 2, Unit 3: Chapter 3 (Excluding Applications to Mechanics

Reference Book:

1.**Transforms and Applications Handbook** ,Alexander D. Poularikas (Ed.)
2. **Integral Transforms**, I. N. Sneddon.
3. **Theory of Integral Transforms** , Rosenheinrich
4. **Advanced Engineering Mathematics**,Erwin Kreyszig

Course Outcomes:

CO1: Define Laplace transform of a function and Inverse Laplace transform of a function.

CO2: Discuss the Laplace transform of derivatives, integrals and periodic functions.

CO3: Apply the Method of Laplace transforms to solve initial-value problems for linear differential equations with constant coefficients.

CO4: Illustrate Laplace transforms techniques for solving ODE‘s.

CO5: Evaluate the Inverse Laplace Transforms of functions and implement it in Convolution theorem and Heaviside theorem.

CO6: Write Taylor‘s and Laurent‘s series expansions of complex function.

SEMESTER-V

Mathematics Elective Practical Paper-1

Course Code:MTMEP-351B	**Course Type: Practical**
Course Name:Financial Mathematics-I with python	**Practical: 12**
Credits: 2	**Hours: 60**

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1. **Practical No.1:** Return and Interest
2. **Practical No.2:** Time Value of Money
3. **Practical No.3:** Model and Assumptions
4. **Practical No.4:** Net present value and Internal Rate of Return
5. **Practical No.5:** Bonds, Shares and Indices
6. **Practical No.6:** Price and Yield
7. **Practical No.7:** Duration
8. **Practical No.8:** Term Structures of Interest Rate
9. **Practical No.9:** Convexity and Callable Bonds
10. **Practical No.10:** Future and Present Values of Simple Ordinary Annuities
11. **Practical No.11:** Amortization Theory
12. **Practical No.12:** Annuities with Varying Payments and Interest Rates

Recommended Book:

The Calculus Of Finance , Amber Habib (Mathematical Sciences Foundation New Delhi)

Recommended Book:
1.**Quantitative Finance with Case Studies in Python** ,Chris Kelliher
Reference Book:
1.**Stochastic Finance with Python**, Avishek Nag
2. **Introduction to Financial Derivatives with Python** ,Elisa Alòs and Raúl Merino.
3. **Python for Finance: Mastering Data-Driven Finance**,Dmytro Zherlitsyn
4.**Financial Theory with Python: A Gentle Introduction**, Yves Hilpisch.

Course Outcomes:

CO1: Define Bonds, Shares and Indices.

CO2: Describe Net Present Value and Internal Rate of Return.

CO3: Demonstrate understanding of concepts relating to functions and annuities

CO4: Demonstrate understanding of basic concepts in linear algebra, relating to linear equations, matrices, and optimization

CO5: Justify about basic concepts of Financial Mathematics.

CO6: Explain applications of Annuities.

SEMESTER-V

Mathematics Elective Practical Paper-2

Course Code:MTMEP-352B	**Course Type: Practical**
Course Name:Laplace Transform	**Practical: 12**
Credits: 2	**Hours: 60**

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1. **Practical No.1:** The Laplace Transform
2. **Practical No.2:** : Methods of finding Laplace Transform: Direct Method, Series Method
3. **Practical No.3:** Evaluation of Integration
4. **Practical No.4:** inverse Laplace Transform
5. **Practical No.5:** Some important properties of Inverse Laplace Transform
6. **Practical No.6:** Methods of finding inverse Laplace Transforms: Partial Fraction Method and Series Method
7. **Practical No.7:** Evaluation of Integration
8. **Practical No.8:** The Heaviside's Expansion formula
9. **Practical No.9:** Ordinary Differential Equations with constant coefficients
10. **Practical No.10:** Ordinary Differential Equations with variable coefficients
11. **Practical No.11:** Simultaneous Ordinary Differential Equations
12. **Practical No.12:** Differential Equations

Recommended Book:

1. **Schaum's Outline Series - Theory and Problems of Laplace Transform**, Murray R.Spiegel. Unit 1: Chapter 1, Unit 2: Chapter 2, Unit 3: Chapter 3 (Excluding Applications to Mechanics

Reference Book:

1.**Transforms and Applications Handbook** ,Alexander D. Poularikas (Ed.)
2. **Integral Transforms**, I. N. Sneddon.
3. **Theory of Integral Transforms** , Rosenheinrich
4. **Advanced Engineering Mathematics**,Erwin Kreyszig

Course Outcomes:

CO1: Define Laplace transform of a function and Inverse Laplace transform of a function.

CO2: Discuss the Laplace transform of derivatives, integrals and periodic functions.

CO3: Apply the Method of Laplace transforms to solve initial-value problems for linear differential equations with constant coefficients.

CO4: Illustrate Laplace transforms techniques for solving ODE's.

CO5: Evaluate the Inverse Laplace Transforms of functions and implement it in Convolution theorem and Heaviside theorem.

CO6: Write Taylor's and Laurent's series expansions of complex function.

SEMESTER-V

Vocational Mathematics Practical-2

Course Code:MTVSP-351	**Course Type: Practical**
Course Name:Scientific Writing Using Latex	**Practical: 12**
Credits: 2	**Hours: 60**

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1. **Practical No.1:** Introduction to Latex
2. **Practical No.2:** Fonts, Sections, Labelling and Alignment in Latex
3. **Practical No.3:** New Lines, Paragraphs, Blank Space and Dashes in Latex
4. **Practical No.4:** Listing Texts
5. **Practical No.5:** Tabbing Texts
6. **Practical No.6:** Table thought the Tabular and Tabularax environment
7. **Practical No.7:** Figure insertion
8. **Practical No.8:** Mathematical operators, expressions and equation writing in Latex.
9. **Practical No.9:** Alignment and numbering a set of equations
10. **Practical No.10:** Text and blank space in math-mode
11. **Practical No.11:** Conditional expressions, evaluation and splitting equations
12. **Practical No.12:** Vectors, Matrices, Ovelining and underling equations

Recommended Book:

Latex in 24 Hours, A Practical Guide for scientific writing, Dilip Datta, Springer International Publishing AG,2017.

Reference Book:

1. **LaTeX: A Document Preparation System**,Leslie Lamport
2. **The LaTeX Companion**, Frank Mittelbach, Michel Goossens, et al.
3. **LaTeX Beginner's Guide**, Stefan Kottwitz
4. **LaTeX Graphics with TikZ**, Stefan Kottwitz

Course Outcomes:

CO1: To visualize Latex, document presentation system for high quality Typesetting.

CO2: Give examples to Format words, lines and paragraphs, create lists in Latex.

CO3: Write mathematical expressions and equations.

CO4: Explain the features of Latex.

CO5: Frame tabular and array environment within Latex.

CO6: Construct complex mathematical formulae using Latex.

SEMESTER-VI

Mathematics theory paper-15

Course Code: MTMAT-361 **Course Type: Theory**
Course Name:Complex Analysis **Credits: 2**
Hours: 30

Module-I

Unit 1: Analytic functions [8 Hours]

1. Functions of a Complex Variables
2. Limits, Theorems on limits, Limits involving the point at infinity, Continuity, Derivatives, Differentiation formulas
3. Cauchy- Riemann Equations, Sufficient Conditions for differentiability
4. Polar coordinates, Analytic functions, Harmonic functions

Unit 2: Elementary Functions [7 Hours]

1. The Exponential functions
2. The Logarithmic function, Branches and derivatives of logarithms, Some identities involving logarithms
3. Complex exponents, Trigonometric functions

Module-II

Unit 3: Integrals [10 Hours]

1. Derivatives of functions, Definite integrals of functions
2. Contours, Contour integral, Examples
3. Upper bounds for Moduli of contour integrals, Anti-derivatives
4. Cauchy-Goursat Theorem, Simply and multiply Connected domains Cauchy integral formula, Derivatives of analytic functions

Unit 4: Residues and Poles [5 Hours]

1. Isolated singular points, Residues
2. Cauchy residue theorem, residue at infinity, types of isolated singular points, residues at poles

Recommended Book:
Complex Variables and ApplicationsJ.W. Brown and R.V. Churchill, C, International Student Edition, 2009. (Eighth Edition).

Reference Book:
1. **Complex Analysis**, S. Ponnusamy,, Second Edition (Narosa).

2. **Complex Analysis**, S. Lang, (Springer Verlag).
3. **Functions of One Complex Variable** , John B. Conway.
4. **Complex Analysis**, Elias M. Stein and Rami Shakarchi

Course Outcomes:

CO1: Tell the significance of differentiability of complex functions leading to the understanding of Cauchy-Riemann equations.

CO2: Explain the concept of logarithmic functions and branches.

CO3: Evaluate the contour integrals and understand the role of Cauchy-Goursat theorem and the Cauchy integral formula.

CO4: Classify the nature of singularities, find residues and apply Cauchy Residue theorem to evaluate integrals.

CO5: Evaluate complex integrals using the residue theorem.

CO6: Create background for advanced courses in real analysis, functional analysis, and topology.

SEMESTER-VI

Mathematics theory paper-16

Course Code: MTMAT-362 **Course Type: Theory**
Course Name:Real Analysis-II **Credits: 2**
Hours: 30

Module-I

Unit 1: Riemann Integration [08 Hours]

1. Sets of Measure zero
2. Definition of the Riemann Integral
3. Existence of the Riemann Integral
4. Properties of the Riemann Integral
5. Fundamental Theorems of Calculus

Unit 2: Improper Integrals [07 Hours]

1. Improper Integrals on Closed and Bounded Intervals
2. Tests for Convergence of Positive Integrands
3. Improper Integrals on Unbounded Intervals and Tests for their Convergence
4. Tests for Convergence of the Integral of Product

Module-II

Unit 3: Sequences of Functions [07 Hours]

1. Pointwise convergence of sequences of functions
2. Uniform convergence of sequences of functions
3. Consequences of uniform convergence

Unit 4: Series of Functions [08 Hours]

1. Convergence and uniform convergence of series of functions
2. Integration and differentiation of series of functions

Recommended Book:
Methods of Real Analysis , Second Edition, Richard R. Goldberg, John Wiley and amp; Sons, Inc.

Reference Book:
1. **Introduction to Real Analysis** , Eighth Edition, S.K. Mapa, Sarat Book House.
2. **Real Analysis**, H. L. Royden and P. M. Fitzpatrick.
3. **Real Analysis**, Modern Techniques and Their Applications — Gerald B. Folland.
4. **Real Mathematical Analysis**, Charles C. Pugh.

Course Outcomes:

CO1: Describe some of the families and properties of Riemann integrable functions.

CO2: Discuss the applications of the fundamental theorems of integration.

CO3: Explain beta and gamma functions and their properties.

CO4: Distinguish between pointwise and uniform convergence of a sequence of functions.

CO5: Illustrate the effect of uniform convergence on the limit function with respect to continuity, differentiability, and integrability.

CO6: Solve Integration and differentiation of series of functions.

SEMESTER-VI

Mathematics theory paper-17

Course Code: MTMAT-363 **Course Type: Theory**

Course Name:Ring Theory **Credits: 2**

Hours: 30

Module-I

Unit 1: Rings and Fields [07 Hours]

1. Ring, Subring, Fields
2. Divisors of zero, Integral Domain, The Characteristics of a Ring
3. The Field of Quotients of an Integral Domain

Unit 2: Rings of Polynomials and Factorization [08 Hours]

1. Polynomials in an determinate
2. The Evaluation Homomorphism Zeros
3. Factorization of a Polynomial over a Field: The Division Algorithm in F[x]
4. Irreducible Polynomials, Uniqueness of Factorization in F[x]

Module-II

Unit 3: Ideals and Factor Rings [05 Hours]

1. Homomorphism, Properties of Homomorphism
2. Ideals, Factor Ring, Fundamental Homomorphism Theorem
3. Maximal Ideal, Prime Ideal, Ideal Structure in F[x]

Unit 4: Factorization [10 Hours]

1. Unique Factorization Domain, Principal Ideal Domain, Gauss Lemma
2. Euclidean Norm, Euclidean Domain, Euclidean Algorithm
3. Gaussian Integers, Multiplicative Norm

Recommended Book:
A First Course In Abstract Algebra, John B. Fraleigh, 7th Edition, Pearson.

Reference Book:
1. **Basic Abstract Algebra**, P.B. Bhattacharya, S.K. Jain and S.R. Nagpal, Second Ed., Foundation Books, New Delhi, 1995.
2. **Contemporary Abstract Algebra**, Joseph. A. Gallian, (4th Edition), Narosa Publishing House.
3. **Abstract Algebra**, David S. Dummit and Richard M. Foote, 3rd Edition, Jonh Wiley and Sons,

Inc. 3.
4. **Introduction to Commutative Algebra** , M. F. Atiyah and I. G. Macdonald.

Course Outcomes:

CO1: Define The fundamental concept of Rings, Fields, subrings, integral domains.

CO2: Predict fundamental theorem of homomorphism.

CO3: Discuss detail about polynomial rings, fundamental properties of finite field extensions, and classification of finite fields.

CO4: explain the significance of Factor Ring, The Characteristics of a Ring.

CO5: Appreciate the significance of unique factorization in rings and integral domains.

CO6: Develop the concept of rings to find its applications.

SEMESTER-VI

Mathematics theory paper-18

Course Code: MTMAT-364 **Course Type: Theory**

Course Name:Partial Differential Equations **Credits: 2**

Hours: 30

Module-I

Unit 1: First order Partial Differential Equation [07 Hours]

1. Curves and Surfaces
2. Genesis of first order P.D.E.
3. Classification of first order partial differential equations
4. Classification of integrals

Unit 2: First order Linear Differential Equation [08 Hours]

1. Linear Equations of the first order
2. Solution of Linear Equations of the first order
3. Curl
4. Pfaffian differential equations

Module-II

Unit 3: Second order Partial Differential Equation [09 Hours]

1. Origin of second order P.D.E.
2. Linear P.D.E. with constant coefficient
3. Method to solving linear P.D.E.
4. Undetermine Coefficient
5. Variation of Parameter
6. Reduction Method

Unit 4: Method to solving linear P.D.E. [06 Hours]

1. Classification of second order P.D.E
2. Method of Separation of Variables
3. Canonical Forms
4. Complete and Particular Integrals

Recommended Book:
An Elementary Course in Partial Differential Equations , T. Amarnath ,2nd Edition.

Reference Book:
1. **Partial Differential Equations for Engineers and Scientific**, J.N. Sharma ,Kehar Singh, , 2nd Edition Narosa Publications.
2.**Elements of Partial Differential Equations**, I. N. Sneddon
3.**Introduction to Partial Differential Equations** , Sankara Rao
4. **Partial Differential Equations: Analytical and Numerical Methods** , Mark S. Gockenbach

Course Outcomes:

CO1: Define first order Partial Differential Equations.

CO2: Classify Partial Differential Equations.

CO3: Compute the formation and solution of PDEs of first and second order.

CO4: Calculate particular integral and complete integral.

CO5: Predict canonical form of partial differential equations.

CO6: Solve linear partial differential Equations using various methods.

SEMESTER-VI

Mathematics Practical paper-7

Course Code: MTMAP-365	**Course Type: Practical**
Course Name:Optimization Technique	**Credits: 2**
Hours: 60	**Practical: 12**

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1. **Practical No.1:** CPM and PERT
2. **Practical No.2:** Critical Path Computations
3. **Practical No.3:** PERT networks
4. **Practical No.4:** Construction of the time schedule
5. **Practical No.5:** Solutions of Pure strategy Game theory
6. **Practical No.6:** Solutions of Mixed strategy Game theory
7. **Practical No.7:** Graphical solution of games
8. **Practical No.8:** Optimal solution of two persons zero sum game
9. **Practical No.9:** Replacement I
10. **Practical No.10:** Replacement II
11. **Practical No.11:** Sequencing Problems I
12. **Practical No.12:** Sequencing Problems II

Recommended Book:
Operations Research ,Theory and Applications,, K Sharma, second edition, 2006.

Reference Book:
1. **Operation Research**, Hamdy A. Taha, (Eighth Edition, 2009), Prentice Hall of India Pvt. Ltd, New Delhi.
2.**Optimization Methods in Operations Research**, K. V. Mittal and C. Mohan
3. **Optimization in Operations Research**, Ronald L. Rardin.
4. **Optimization Techniques** , A. K. Malik.

Course Outcomes:

CO1: Define types of game and Some basic terminologies.

CO2: Explain a sequencing Problem for various jobs and machines.

CO3: Develop fundamentals of Network Analysis using CPM and PERT.

CO4: Analysing on optimization.

CO5: Apply matrices in game theory.

CO6: Develop the concept of Sequencing Problems.

SEMESTER-V

Mathematics Practical Paper-8

Course Code: MTMAP-366	**Course Type: Practical**
Course Name:Machine Learning-II	**Practical: 12**
Credits: 2	**Hours: 60**

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1. **Practical No.1:** Introduction to Python, Python Data Types-I
2. **Practical No.2:** Python Data Types-II
3. **Practical No.3:** Control statements in Python-I
4. **Practical No.4:**Control statements in Python-II
5. **Practical No.5:**Python collection type – List
6. **Practical No.6:**Data handling with Panda – 1
7. **Practical No.7:**Data handling with Panda – 2
8. **Practical No.8:**Data visualization with Matplotlib
9. **Practical No.9:**Introduction to scikit-learn
10. **Practical No.10:**End to end model implementation-1
11. **Practical No.11:**End to end model implementation-2
12. **Practical No.12:**End to end model implementation-3

Reference Book:

1. **Hands-on Machine Learning with Scikit-Learn, Keras and Tensorflow**,AurelienHeron,.
2. **Python for Data Analysis**, Wes McKinney (O' Reilly publication).
3. **Think Python,How to Think Like a Computer Scientist**, Allen Downey,, Green Tea Press Needham, Massachusetts, 2015.

Course Outcomes:

CO1: Explain advanced machine learning concepts including ensemble methods, kernel methods, and probabilistic learning models.

CO2: Apply deep learning architectures such as Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) to solve real-world problems.

CO3: Implement unsupervised and semi-supervised learning techniques for clustering, dimensionality reduction, and feature extraction.

CO4: Analyze and evaluate the performance of machine learning models using appropriate validation techniques and performance metrics.

CO5: Design and develop machine learning solutions using modern libraries and frameworks such as TensorFlow, Keras.

CO6: Demonstrate the ability to address practical challenges in machine learning including overfitting, scalability, interpretability, and ethical considerations.

SEMESTER-VI

Mathematics Elective Theory Paper-4

Course Code: MTMET-361A **Course Type: Theory**

Course Name:Financial Mathematics-II **Credits: 2**

Hours: 30

Module-I

Unit 1: Random Cash Flows-I [08 Hours]

1. Random Returns
2. Portfolio Diagrams and Efficiency
3. Feasible Set

Unit 2: Random Cash Flows-II [07 Hours]

1. Markowitz Model
2. Capital Asset Pricing Model
3. Security Market Line
4. Capital Market Line

Module-II

Unit 3: Forwards And Futures [06 Hours]

1. Forwards and Futures
2. Forwards and Futures Price
3. Value of A Futures Contract
4. Method of Replicating Portfolios
5. Hedging with Futures

Unit 3:Options [09 Hours]

1. Call Options
2. Put Options
3. Put-Call Parity
4. Binomial Options Pricing Model
5. Pricing American Options
6. Factors Influencing Option Premiums
7. Options on Assets with Dividents

8. Dynamic Hedging

9. Risk-Neutral Valuation

Recommended Book:

1.**The Calculus Of Finance** , Amber Habib (Mathematical Sciences Foundation New Delhi)

Reference Book:

2.**An Introduction to Mathematical Finance with Applications**, Arlie O. Petters , Xiaoying Dong (Springer Publications)

3. **Options, Futures, and Other Derivatives**,John C. Hull.

4. **Financial Calculus: An Introduction to Derivative Pricing** , Martin Baxter and Andrew Rennie

5.**Mathematics for Finance: An Introduction to Financial Engineering**, Marek Capiński and Tomasz Zastawniak.

Course Outcomes:

CO1: Define Random cash flow, Feasible set, Forwards and Futures and Options.

CO2: Describe Capital Asset Pricing Model.

CO3: Explain the Lognormal Model.

CO4: Illustrate the Call options, Put options.

CO5: Explain the concept of VaR.

CO6: Apply Markowitz Model to calculate risk.

SEMESTER-VI

Mathematics Elective Theory Paper-5

Course Code: MTMET-362A **Course Type: Theory**

Course Name:Differential Geometry **Credits: 2**

Hours: 30

Module-I

Unit 1: Curves in the plane and in space [08 Hours]

1. What is a curve? Arc-length
2. Reparameterization
3. Level curves vs. Parametrized curves
4. Curvature
5. Plane curves
6. Space Curves

Unit 2: Global Properties of curves [07 Hours]

1. Simple closed curves
2. The Isoperimetric Inequality
3. The Four Vertex Theorem

Module-II

Unit 3: Surfaces in three dimensions [08 Hours]

1. What is a Surface?
2. Smooth Surfaces
3. Tangents, Normals and Orientability
4. Examples of Surfaces

Unit 4: The first and second fundamental form [07 Hours]

1. Lengths of curves on surfaces
2. Isometries of Surfaces
3. Conformal mappings of surfaces
4. Surface area
5. A Theorem of Archimedes
6. The Second Fundamental Form

Recommended Book:
Differential Geometry,John A. Thorpe, Springer International Edition, Indian Reprint 2004.

Reference Book:
1. **Elementary Differential Geometry** ,Andrew Pressley, Springer International Edition,Indian Reprint 2004. Chapters: 1, 2, 3, 4.1 - 4.4, 5 and 6. 1.
2. **Elementary Differential Geometry**,Barrett O'Neill.
3. **Differential Geometry of Curves and Surfaces**, Manfredo P. do Carmo.
4. **Differential Geometry: Curves**,K. Struik.

Course Outcomes:

CO1: Recall and articulate basic concepts such as Parametric and Cartesian curves, surfaces. Define curves, graph and surfaces

CO2: Classify curves as planar curves and space curves using torsion

CO3: Explain second Fundamental theorem.

CO4: Create different equiareal diffeomorphisms .

CO5: Examine plane curves. Evaluate their signed curvature and classify the curves

CO6: Discuss the relation between the area and the first fundamental form.

SEMESTER-VI

Mathematics Elective Practical Paper-3

Course Code:MTMEP-361B	**Course Type: Practical**
Course Name:Financial Mathematics-II with python	**Practical: 12**
Credits: 2	**Hours: 60**

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1. **Practical No.1:** Random Returns
2. **Practical No.2:** Feasible Set
3. **Practical No.3:** Markowitz Model
4. **Practical No.4:** Forwards and Futures
5. **Practical No.5:** Forwards and Futures Price
6. **Practical No.6:** Call options, Put options
7. **Practical No.7:** Put-Call Parity
8. **Practical No.8:** Binomial Options Pricing Model
9. **Practical No.9:** Options on Assets with Dividents
10. **Practical No.10:** Factors Influencing Option Premiums
11. **Practical No.11:** Dynamic Hedging
12. **Practical No.12:** Risk-Neutral Valuation

Recommended Book:

1.**Quantitative Finance with Case Studies in Python** ,Chris Kelliher

Reference Book:

1.**Stochastic Finance with Python**, Avishek Nag

2. **Introduction to Financial Derivatives with Python** ,Elisa Alòs and Raúl Merino.

3. **Python for Finance: Mastering Data-Driven Finance**,Dmytro Zherlitsyn

4.**Financial Theory with Python: A Gentle Introduction**, Yves Hilpisch.

Course Outcomes:

CO1: Define Random cash flow, Feasible set, Forwards and Futures and Options.

CO2: Describe Capital Asset Pricing Model.

CO3: Explain the Lognormal Model.

CO4: Illustrate the Call options, Put options.

CO5: Explain the concept of VaR.

CO6: Apply Markowitz Model to calculate risk.

SEMESTER-VI

Mathematics Elective Practical Paper-4

Course Code: MTMEP-362B	**Course Type: Practical**
Course Name: Differential Geometry with python	**Practical: 12**
Credits: 2	**Hours: 60**

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1. **Practical No.1:** Curves in the plane and in space
2. **Practical No.2:** Level Curves and Graph
3. **Practical No.3:** Curvature
4. **Practical No.4:** Plane curves and Space Curves
5. **Practical No.5:** Surface and Smooth surfaces
6. **Practical No.6:** Tangents, Normals and Orientability
7. **Practical No.7:** Lengths of curves on surfaces
8. **Practical No.8:** Isometries of Surfaces
9. **Practical No.9:** Conformal mappings of surfaces
10. **Practical No.10:** Surface area
11. **Practical No.11:** Equiareal maps and a Theorem of Archimedes
12. **Practical No.12:** The Second Fundamental Form

Reference Book:

1. **Geometry and Visualization with Python**,Nick Hynes
2. **Python for Differential Geometry and Relativity**, Bernard F. Schutz and James Vickers
3. **Computational Differential Geometry for Curves and Surfaces** , Gabriel Taubin and Denis Zorin.
4. **Programming for Computations — Python**,A Gentle Introduction to Numerical Simulations with Python, Svein Linge and Hans Petter Langtangen

Course Outcomes:

CO1: Recall and articulate basic concepts such as Parametric and Cartesian curves, surfaces. Define curves, graph and surfaces

CO2: Classify curves as planar curves and space curves using torsion

CO3: Explain second Fundamental theorem.

CO4: Create different equiareal diffeomorphisms .

CO5: Examine plane curves. Evaluate their signed curvature and classify the curves .

CO6: Discuss the relation between the area and the first fundamental form.

SEMESTER-VI

Vocational Mathematics Theory-2

Course Code: MTVST-361 **Course Type: Theory**
Course Name:Number Theory **Credits: 2**
Hours: 30

Module-I

Unit 1: Divisibility [06 Hours]

1. Introduction
2. Divisibility
3. Prime

Unit 2: Congruences [09 Hours]

1. Congruences
2. Solution of Congruences
3. The Chinese Remainder Theorem

Module-II

Unit 3:Greatest integer function [06 Hours]

1. Greatest integer function
2. Arithmetic functions
3. The Mobius Inversion formula

Unit 4: Quadratic Reciprocity [09 Hours]

1. Quadratic residues
2. Quadratic reciprocity
3. The Jacobi Symbol
4. Diophantine equations

Recommended Book:
An Introduction to Theory of Numbers,I. Niven, H. Zuckerman and H.L. Montgomery, 5th Edition, John Wiley and Sons.

Reference Book:
1. **Elementary Number Theory** , David M. Burton (Second Ed.), Universal Book Stall, New Delhi, 1991
2. **An Introduction to the Theory of Numbers** ,G. H. Hardy and E. M. Wright.
3. **Introduction to Analytic Number Theory** , Tom M. Apostol.

4. **Problems in Elementary Number Theory**, H. W. Lenstra and B. M. M. de Weger.

Course Outcomes:

CO1: Define divisibility, greatest integer functions and quadratic residues.

CO2: Discuss congruence relation.

CO3: Illustrate theorems on divisibility, theorems on congruences.

CO4: Solve and verify problems in divisibility, congruences.

CO5: Examine different techniques of numerical calculations.

CO6: Classify different types of congruence equations.